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Indus FOREVER

Detailed Ecological Assessment of Fauna, including Limnology Studies at Keti Bunder

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JE MAINTIENDRAI

Indus For All Programme

WWF - Pakistan

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List of tables

List of figures

List of maps and images

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.
GEMS	Global Environmental Monitoring System
GIS	Global Information System
GPS	Global Positioning Stationing
GRN	Grainivore
ha	Hectare
Ha	Hectare
HRB	Herbivore
ID	Index of Density
IDER	Indus Delta Ecoregion
IEP	Indus Eco-region Programme
IFAP	Indus For All Programme
INS	Insectivore
IUCN	The World Conservation Union
KB	Kalri Baghar
KTS	Keti Shah
LBOD	Left Bank Outfall Drain
LC	Less common
LC	Least Concern
M	Meters
m	Meters
MAF	Million Acre Feet
Mg	Magnesium
Mm	Millimeters
mm	Millimeters
NC	Nocturnal
NC	Nocturnal
NGO	Non Government Organization

Ni	Nickel
No.	Number
NR	Natural Resources
NT	Near Threatened
NTU	Nephlometric Turbidity Units
NWFP	North West Frontier Province
P	Protected
Pb	Lead
PF	Pai Forest
PMNH	Pakistan Museum of Natural History
ppt	particles per thousand
R	Rare
RBOD	Right Bank Outfall Drain
RD	Reduced Distance
RD	Reduced Distance
RNE	Royal Netherlands Embassy
S	Sighting
SEPA	Sindh Environmental Protection Agency
SFD	Sindh Forest Department
SO_4	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

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

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

This detailed ecological assessment is planned under of the completion of Programme Output A.1.2.3 – "Detailed ecological assessment of Keti Bunder"

Keti Bunder: Keti Bunder is located at a distance of about 200 km SE of Karachi in Thatta district of Sindh province. It is a Taluka (Tehsil) of Thatta district and consists of a total of 42 dehs (cluster of villages) that spread over a total area of 60,969 hectare. It is believed that the sea has engulfed 28 dehs and the total affected area in Keti Bunder is around 46,137 hectare (WWF 2004). Hoekstra *et al.* (1997) mentioned that Keti Bunder Tehsil includes a total of 19 Dehs and 29 villages while total human population is around 12,000.

Historically Keti Bunder was a port city before the construction of any dams and barrages on Indus river. At that time the river was navigable up to Thatta and even upwards.

At present, it is one of the major towns along the Pakistan coastline that is facing environmental degradation and loss of livelihood opportunities for the locals. Local elders mention that the location of Keti Bunder town has changed thrice during the past 70 years due to progressive intrusion of the seawater. There are four major creeks in the area viz. Chann, Hajamro, Khobar and Kangri with innumerable small creeks. For sweet water (drinking and farming), Keti Bunder and other coastal region depend entirely on Indus River and its distributaries.

It is located in Indus Delta experiencing warm monsoon climatic regime. Mild winters extend from November to February while summer season extends from March to October. Most of the annual precipitation falls during monsoon, which is erratic in distribution. Mean annual rainfall is 220 mm. January is the coolest month with minimum temperature of 9.5 ^{o}C while in June – July minimum and maximum temperatures range from 23 ^{o}C – 26^{o}C and from 30^{o}C - 36^{o}C, respectively. Humidity is generally higher in the morning than in the afternoon. It also varies from place to place depending upon the proximity to the sea. Wind is another important feature of coastal zone. It is variable and is faster during summer (7.4 to 20.5 km/h) than winter (Qureshi 1985).

Before construction of upstream barrages, river water used to reach the tail end during low tides round the year. However, upstream dams and barrages have

considerably reduced the river flow to the extent that Kharo Chan and Shah Bunder area that had good agrarian economy in the past and produced plenty of high quality red rice, are now facing acute water shortage. During aabkalani (flood season), water is stored in ponds for subsequent human and livestock use. The agriculture has now deteriorated due to water logging and salinity of lands. During off season (May to August), local people were dependent on agriculture practices in the past and fish during other months of the year (Qureshi 1985). Scarcity of fresh water in the area from the Indus and seawater intrusion into the land has been degrading the area.

The earlier authors have described two systems of mangrove management; formal and non-formal. In the formal system, Forest Department issues permits to local communities in 'Protected Forests' in exercise of their customary rights for collection of wood and livestock grazing against a nominal fee. However, neither such fee has been collected for the last 15 years nor access been denied to any body except replanted areas (Hoekstra et al.1997). In non-formal system of management, Jat community being more influential in exploitation of vegetation and fish resources of mangrove ecosystem have sub divided the mangrove areas of Keti Bunder among villagers. An island allocated to a particular village is permanently utilized by the village for grazing camels. When such islands become devoid of vegetation due to continuous grazing, they are allocated another island.

Large mammals: Almost all the potential sites around Keti Bunder were searched to locate the existing large mammals and the GPS coordinates at different locations were noted. Different sampling sites around Keti Bunder during summer and winter surveys are given in Fig. 14 and Fig. 15 respectively. These figures also show the distribution of large mammals around Keti Bunder. GPS coordinates taken during summer and winter surveys are given in Appendix III and Appendix IV respectively.
Spending eight days in the field (four days during summer survey and four days during winter survey) and applying all the possible direct and indirect observation methods, a total of 83 animals of 14 mammalian species, belonging to four orders (Carnivora, Artiodactyla, Cetacea and Pholidota) were recorded from Keti Bunder. Out of 14 recorded species of large mammals, 10 were observed directly while the remaining four were recorded on the basis of indirect evidences like tracks and interviews of locals and wildlife watchers from Sindh Wildlife Department

Small mammals: During the survey for small mammals, a total of forty-three species of small, medium and large were observed across the four sites, twenty belonging to medium and large mammals and twenty-three belonging to small mammals. Out of the 23 small mammal species 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. Regarding large mammals, after spending eight days in the field and applying most of the possible direct and indirect observation methods the team recorded a total of 83 animals of 14 mammalian species, belonging to four orders were recorded.

Reptiles and amphibians: During the surveys for reptiles and amphibians, out of 45 amphibian and reptilian species, possibly occurring in the area, 27 species were observed or collected by the team. The remaining species have been recorded through secondary data obtained through discussions with the local

inhabitants and WWF members and consulting the previous literature citations. The amphibians are represented by three species belonging to three genera and two families. Among the reptiles, chelonians are represented by four species belonging to four genera and two families. Lizards are the second dominant group of herpetiles, represented by 18 species belonging to 12 genera and six families. Snakes out numbered all the groups of reptiles in the study area and are represented by 20 species belonging to 17 genera and seven families.

Birds: The locations visited were: agriculture and fruit areas, inland coastal belt and creek areas. The main bird habitats are: coastal areas, agricultural fields, small forest areas having *Mesquite, Salvadora, Capparis, Typha* and *Phragmites* spp., fruit farms, marshes and the creek area. The main creek area comprises of Hajamro, Chann, Khober and Bhoori creeks. The main habitat here is the mangrove forest. 68 species of birds were recorded in the summer surveys while 91 species were recorded in the winter surveys. Out of 68 species recorded in the summer surveys, 22 species were of water birds, 6 birds of prey and 25 passerines along with Pigeons, Doves, Pygmas, Kingfishers, Parakeets, Cuckoos, Bee-eaters and woodpeckers.
Blue Rock Pigeon, Common Myna and Common Babbler were quite common.
3 over-summering birds viz Curlew, Redshank and Osprey were also recorded. ied Crested Cuckoo was the summer breeding visitor.36 species were common,6 less common 25 scarce and 1 abundant. A total of 91 pecies of birds were recorded in the winter surveys out of these, 49 species were resident, and 31 species were winter visitors. 8 were irregular year-round visitors and 3 were passage migrants. 48 species were common, 36 less common, 5 scarce and 2 rare. The important species recorded were: Painted Stork, Black-headed Ibis, Common Quail, Black-bellied Tern, Rufous-fronted Prinia, Paradise Flycatcher and Rosy Pastor.

Zooplankton: Keti Bunder has been a huge resource of ecologically as well as economically imperatively crustaceans and this area still provides a big platform for their breeding and dispersal at a remarkably massive level. It is therefore important to briefly edify about some of the significant biological aspects of these creatures.

In Keti Bunder the prawn population has decreased tremendously over the recent years. The Locals of the area told that this decrease is up to fifty percent and this is mainly due to the constantly increasing fishermen community, equally damaging is the impact of the illegal netting through the notorious nets ‘Boola‘ and ‘Gujja’ which indiscriminately trap all types of fishery resources including the small and medium sized fish, prawn and crabs. Prawn population has also dramatically decreased especially in the winter in Keti Bunder. In winter, owing to the heavy influx of migratory birds and carnivorous fish which both feed on prawns, the prawn population decreases dramatically. Somehow the prawn population tends to stabilize in summer when the migratory birds return and the hunting is reduced. This trend is repeated with similar pattern every winter. The locals validated this observation with their annotations and recollections

Crab population has also been declining continuously since the last decade. As the fish population has already fallen in the area, the fishermen have now swiftly shifted their focus on the crabs along with the prawns and this has eventually disrupted the ecological balance of these economically vital crustaceans of the area. One adult crab is sold for 12 rupees per male specimen and 10 rupees for every female specimen owing to the difference of the sizes in the two sexes. In winter the fishermen community tends to avoid the fishing practices due to the

low temperature although the water influx in the area increases comparatively. Due to the massive reduction in the crab catch, sometimes a single crab is also sold up to 100 rupees per specimen during winter. Mangroves line approximately eight percent of the world's coastline and are distributed along approximately one-quarter of the world's tropical coastlines, covering a surface area of 181 000 km2 (Spalding et al., 1997). These ecosystems can withstand frequent inundation by seawater and flourish in saline conditions. While the value of the goods and services provided by these ecosystems varies, poor coastal communities are particularly dependent on the resources uniquely available in the harsh yet fertile environment of mangrove ecosystems. Yet, despite their usefulness and unique niche at the margin of the land and the sea, mangroves are under heavy stress. (Burke *et al*. 2002).

The mangroves found in the Keti Bunder and surroundings are facing the similar rather severe situations due to multiple social and ecological reasons and this is leading to a tremendous and rapid decline in the invaluable biodiversity involving many species of crabs, shrimps and other economically important invertebrates of Pakistan. The rapid and visible decline in the mangroves cover over the last two decades is an obvious alarm to the enormous yet ecologically fragile ecosystem of this area, which may ultimately result in some drastic declines in the invaluable invertebrate species depending on this ecosystem. Effectively palpable efforts need to be undertaken in order to capitalize the currently available resources in such a way that not only the huge prawn fisheries practices in the area survive and improve qualitatively but also the resources be conserved and enhanced in terms of quantity for the future generations.

Marine fisheries: After the limits of Kotri Barrage a small village Keti Bunder is located in Thatta district. Keti Bunder is situated in the Ochto mouth of the Indus, which enters the sea through the Hajamoro Creek, 10 meters from the settlement. The area consists of mud flats and crisscrossed with water channels, giving the place an appearance of a marsh. Towards the west coast of Keti Bunder on the opposite bank of Ochto River, there is vegetation of mangrove plants *Avicennis marina*, wild rice Oryza grass and shrub Salsola. Towards the land sand dunes are visible to miles. Most of the mangroves plantations are lost. Dense mangroves cover about 2631 hectares; medium mangrove cover 1996 hectares and the sparse mangrove cover 3588 hectares. Presently with the great deal of efforts made by WWF mangroves nurseries appear at sites selected by the WWF, some small seedlings are apparent from far off. The area has significant biodiversity value, especially by the wintering activities of avifauna, migratory Flamingos, Pelicans and cranes that stop over for feeding, resting and roosting purpose. In monsoon the area is rich by the great treasure of traditional Palla *Tenualosa ilisha* fish, migrating from sea towards Indus River.

Physico-chemical properties of water: The water quality analysis of surface drain from agriculture land and waste water coming from Keti Bunder Town does not meet the National Environment Quality Standards, however, it indicates it is not a serious threat for the Keti Bunder area, because of very low quantity of agricultural and municipal drainage (waste) water. The water quality analysis of the creek areas has shown that all parameters except the phenol and nickel are within acceptable limits for marine life including mangrove and fish species.. The pollution of nickel and phenol is attributed to the municipal and industrial waste of Karachi entering in the sea. There is no major source of pollution in Keti Bunder study area. The water quality analysis of sub surface water (hand pump) used by the locals living in the creek area for drinking purposes has indicated that the

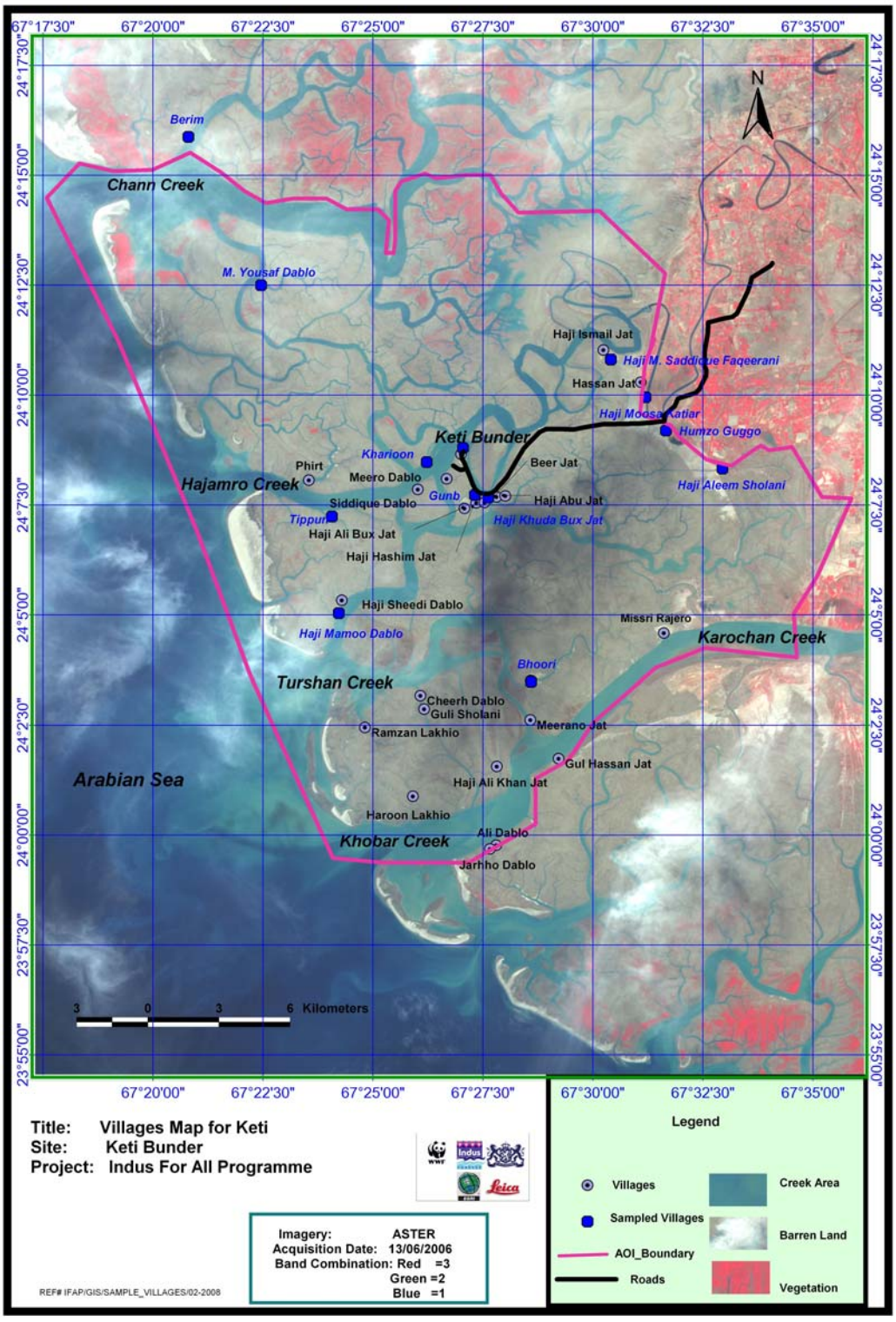
water quality is not of acceptable standards, as it is influenced by the sea. The Total Dissolved Solids (TDS), salt concentration (calcium + magnesium chlorides), nickel and phenol were found higher than the WHO Drinking Water Quality Standards. However, the remaining parameters are within the WHO safe limits.

Adequate amount of fresh water (10 maf) flows along with silt containing nutrients is vital for the survival of the mangrove forest and its habitat. It would also reduce coastal land erosion by sediment nourishment along the eroded coastal areas. The fresh water availability in the Indus delta has been continuously decreasing for years. Consequently, fish breeding and shrimp species has been affected and the migration of the famous Palla fish upstream has been hampered. Therefore, enforcement of local governmental regulations and sustainable development of mangroves are necessary. Also the involvement of local communities in the sustainable management and protection of their coastal resources, including the nearby mangrove forests should be ensured.

Chapter 1: Introduction

1.1 Introduction to Keti Bunder

Map 1 – Location of Keti Bunder, District Thatta



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Historically Keti Bunder was a port city before the construction of any dams and barrages on Indus River. At that time the river was navigable up to Thatta and even upwards. At present, it is one of the major towns along the Pakistan coastline that is facing environmental degradation and loss of livelihood opportunities for the locals. Local elders mention that the location of Keti Bunder town has changed thrice during the past 70 years due to progressive intrusion of the seawater. There are four major creeks in the area viz. Chann, Hajamro, Khobar and Kangri with innumerable small creeks. For sweet water (drinking and farming), Keti Bunder and other coastal region depend entirely on Indus River and its distributaries.

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Image 1 – View of Kei Bunder town

Image 2 – Village in creeks at Keti Bunder

Before construction of upstream barrages, river water used to reach the tail end during low tides round the year. However, upstream dams and barrages have considerably reduced the river flow to the extent that Kharo Chan and Shah Bunder area that had good agrarian economy in the past and produced plenty of high quality red rice, are now facing acute water shortage. During aabkalani (flood season), water is stored in ponds for subsequent human and livestock use. The agriculture has now deteriorated due to water logging and salinity of lands. During off season (May to August), local people were dependent on agriculture practices in the past and fish during other months of the year (Qureshi 1985).

Scarcity of fresh water in the area from the Indus and seawater intrusion into the land has been degrading the area.

Communities in and around main creeks in Keti Bunder area have cattle, buffaloes and camels. Camels have popularly supposed to have aversion to water and not to thrive in damp areas but in Delta region, camels feed on mangrove foliage, wading in the mud and swim in the creeks (Hoekstra et al. 1997). Faqirani Jat community in Keti Bunder kept majority of the camels. During monsoon season, camels of inland communities are also grazed in creeks area. According to one estimate there are about 5000 camels in mangrove areas (Hoekstra et al. (1997), however, Qureshi (1985) reported a total of 16,000 in the entire Delta region. Correct estimates are still required particularly in creeks adjacent to Keti Bunder where lot of camel grazing is obvious. Camels are generally kept to raise cash income through sale of one year old males. These animals are also kept for sacrifices on Eid festival. Milking of camels is generally for family consumption. Camels generally browse *Avicennia marina* foliage, however, in Kharochan area they also graze on grasses growing on mud flats. In mangrove area, camels are not herded and they keep on grazing free. Drinking water to camels is provided through boats. Camels stay permanently in mangroves year-round except for two months (June – July) when they are moved to some high lying areas near the sea for mating. Some of the herders reported to move camels to an open area during June/July due to presence of biting flies in mangroves (Hoekstra et al.1997)

The earlier authors have described two systems of mangrove management; formal and non-formal. In the formal system, Forest Department issues permits to local communities in 'Protected Forests' in exercise of their customary rights for collection of wood and livestock grazing against a nominal fee. However, neither such fee has been collected for the last 15 years nor access been denied to any body except replanted areas (Hoekstra et al.1997). In non-formal system of management, Jat community being more influential in exploitation of vegetation and fish resources of mangrove ecosystem have sub divided the mangrove areas of Keti Bunder among villagers. An island allocated to a particular village is permanently utilized by that village for grazing camels. When such islands become devoid of vegetation due to continuous grazing, they are allocated another island.

1.1.1 State of natural resource

- **Natural Vegetation:** Keti Bunder being a deltaic region mainly consists of Mangrove forests. These forests are managed by Sindh Forest Department. They fall under the category of "Protected Forests" vide West Pakistan Government Notification No. S.O.A. (X) F&A/581X-(32) dated August 29, 1958 and the land, water Lakes and dhoras in Keti Bunder falling under the jurisdiction of this notification are regarded as Wildlife Sanctuary vide Government of Sindh Wildlife & Forest Department Notification No. WL&FT (DCF-GEN-269).77 dated September 25, 1977.

  In Keti Bunder, mangroves cover an area of 40,874 ha out of which 14,733 ha area falls under dense mangroves while remaining area constitutes normal and sparse vegetation (Qureshi 1985). Dense forests are found in narrow stretches or in blocks along creeks with profuse growth of Avicennia marina locally known as Timer. Qureshi (1985) mentioned that eight species of mangroves have been reported to occur in the area but four species have been lost from Indus Delta including Keti

Bunder during the past 70 years. Of the remaining species, only Avicennia marina constitutes major mangrove spp proportion i.e., 95% on the islands of the creeks while others such as *Rhizophora mucronata*, *Ceriops tagal* and *Aegiceras corniculata* have only 5% spread on the islands of the creeks. The locals use mangrove trees for fodder and fuel wood, camel browsing and hut making. Mangroves are the breeding ground for variety of fish shrimps, crabs and other invertebrates. They are also of great significance as a source of nutrients for fisheries. Hence, the livelihood of the community is correlated with the health of mangrove and is important to the local and national economy.
The inland areas also mostly have halophytic vegetation consisting of Chenopods, Tamarix species and Salvadora persica.

- **Agriculture:** Although agricultural practices are not very common, yet vegetable, betel leaf, sugarcane, wheat, fruits (chiku, banana, mango, water melon) are grown in the inland area of Keti Bunder taulka.

1.1.2 Livelihood and social aspects

- **Social fabric:** Majority of population are fishermen and belong to Baloch, Jat, Memon, Shiekh, Dabla, Solangi, Syed and Gug tribes. Traditionally agriculture, livestock and fishing were three major sources of livelihood of the community of this area. Due to reduction in freshwater supplies and seawater intrusion into the land, the agriculture of inland areas is on decline causing high pressure on fishing, grazing and exploitation of mangroves for fuel and timber. Presently there are three dominant sources of livelihood which include fishing about 90%, agriculture and livestock rearing about 8% and services in various sectors about 2%. The women of the area have more freedom as compared to other agricultural and pastoral communities; however, they are not involved in livelihood activities and are responsible mainly for household chores and the livestock. People are mostly illiterate and their economic conditions look poor. Mostly the population resides on the creek banks or near inland. The education level of people is very low and their hygienic conditions are not satisfactory.

  Indus for All Programme carried out socio-economic assessment in 34 villages of Keti Bunder situated inside creeks as well over inland area. A quick view of the village profiles indicates that predominance of fishing and net making occupations are most obvious of these villages. Village Faqiriani Jat is famous for camel rearing and also has well known for artisans who undertake boat painting and engine repairing work. Due to out-migration of households from Hajamro and Chann creeks to inland areas, a new village Meero Dablo (36 HH) has come into existence just outside the Keti Bunder protective bund and in front of the Forest Department's jetty. Bhoori village is famous for the buffaloes due to prevalence of pastures occupied by palatable grass species. Dablo is the major caste group, especially in creek villages followed by Jat; a camel herder tribe and Sholani Baloch; a farming tribe. Trading community is represented mainly by the Memons of Keti Bunder.

- **Education**
  There is only one high school located in Keti Bunder. Electricity is available at Keti Bunder and two inland villages. It is also available at Tippin (a village in Hajamro creek) mainly through a wind turbine erected

by WWF - Pakistan. The area is totally deprived of any water supply system, except for Bhoori village which has 10 hand pumps providing sweet water because the village is located in Khobar creek; which is currently the main course of Indus River falling in the Arabian Sea. Communities purchase drinking water on comparatively high prices thus facing an added stress on their subsistent livings.

A recent socio-economic study undertaken by Indus for All Programme revealed that the average household size of Keti Bunder area has 6.6 members. About one-fifth of households have only 3 members and such households were predominant at Keti Bunder. The study also revealed that about 78.4% households are engaged in fishing followed by daily labor, business and other miscellaneous occupations. In creek areas a fraction of the households (1 – 2%) possess small and large ruminants.

- **Resources**
  Proportion of family members engaged in different occupations depicts that 3% households possess poultry birds. The study examined that local population heavily rely on natural resources such as drinking water (94%), fish (88%), fuel wood (75%), and pastures (37%), a majority of the households in creeks and inland areas believe that natural resources such as drinking water, fish and forests have declined over the past five years. About 48% of respondents agreed that irrigation water resources have depleted during the last five years. Over 70% of respondents agreed that the fisheries have declined, while 64% agreed that forest resources have sharply depleted during the last 5 years. Depletion of fisheries, being the primary source of livelihood, was perceived to be highest at Keti Bunder (87% of respondents).

1.2 Rationale and Objectives

1.2.1 Large Mammals Survey

1.2.1.1 Rationale

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

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

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

1.2.1.2 Objectives of the study:

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

1.2.2 Small mammal survey

1.2.2.1 Rationale

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

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

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

1976). Harris (1971) has estimated that 0.17-5.01% of the net primary production was transferred to the rodent trophic level.

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

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

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

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

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

The most significant role of small mammals may be their effect on the chemical composition of soils, particularly the addition and incorporation of nitrogen. Soil

chemical composition can be altered by the addition of excreta and by the upward displacement of nutrients through the soil profile.

Small mammals function as secondary consumers in the ecosystem by preying on invertebrates and on other mammals, which may have direct impacts on prey production. Insectivorous species may exert a regulatory effect on invertebrate populations; small mammals consumed a high percentage of invertebrate populations in nearly all grassland sites studied by French et al. (1976). Carnivores have been shown to influence prey species densities. Hayward and Phillipson (1979) estimated that weasels consumed as much as 14% of the small mammal production, resulting in a reduction in the impact of small mammals on the rest of the ecosystem. Secondary consumption may indirectly influence primary production. Plant consumption by invertebrate herbivores may be reduced by the insectivorous feeding habits of small mammals. Destruction of large numbers of insect larvae by shrews has been reported by Buckner (1964). Small mammal predation may serve to reduce invertebrate species that are themselves predators of phytophagous insects. Small mammals also affect Land bird species. Nest predation by small mammals is the major cause of nest failure in passerines and nesting success of land birds.

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

1.2.2.2 Objectives of the study:

a. To provide a detailed ecological assessment and systematic account of small mammal of the programme sites and their buffer zones.
b. Collect data from the field on species occurrence, abundance and diversity in the study areas;
c. Collect and review secondary data on the small mammal species of the study sites, using the available literature and knowledge of local inhabitants.
d. Prepare a taxonomical checklist of all the species with their English and local names and their status in the study sites.
e. Identify threatened mammalian species in the Indus for All Programme, WWF Pakistan sites and recommend conservation measures;
f. Study the behaviour of various species of rodents and other associated groups in relation to habitat and diet in the study sites.

g. Assessment of impacts of environmental changes and human population pressure on potential mammalian species and their habitats. Associated mitigation steps are also to be suggested.
h. Provide photographs, where possible, of the small mammal species.
i. Compile a report on the consultancy addressing all the above-mentioned issues.
j. To identify the key species of small mammals inhabiting the area.
k. To identify impact of small mammals on the overall livelihood of the people.

1.2.3 Reptiles and amphibians survey

1.2.3.1 Rationale

Amphibians and reptiles are very important animals among the vertebrates. Amphibians show the transition from aquatic to terrestrial life. Reptiles, the animals that invaded land, were the first fully terrestrial forms of life. Apart from their impressive evolutionary history, they beautifully demonstrate different concepts of physiological and behavioral adaptations to different climates, from tropical forests to hot deserts and marine to fresh -water. They do not have the ability to travel long distances like birds and mammals. In response to any local environmental changes they respond quickly and therefore may act as excellent biological indicators.
Amphibians and reptiles are important components of any living system and play a key role in the interlocking web of nature. At one end they prey upon insects and other invertebrates and therefore regulate the population of these animals and on the other hand they are also a major source of food for other carnivore species (birds and mammals). Their position in the ecological niche is so vulnerable that the survival and collapse of the whole energy cycle depends upon the presence and absence of the amphibians and reptiles. The existence and sustainable use of this biological resource is therefore imperative around the study sites.

Despite the fact that amphibian and reptiles are an important biological resource, very little attention has been paid to them, in Pakistan. The major hurdle presumably is the lack of expertise and awareness in this particular field. Moreover, our society in general and rural folk in particular is mostly repulsive and afraid of reptiles. The results of the present study will enable us to know about the natural wealth of all the Programme sites in terms of amphibians and reptiles. Furthermore, the status of all the species of amphibians and reptiles will be evaluated so that in any adverse circumstances the conservation strategies could be suggested.

1.2.3.2 Objectives of the study:

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

a. Collect and review secondary data on the reptile and amphibian species of the study sites, using the available literature and local inhabitants.
b. Collect data from the field on species occurrence, abundance and diversity in the study areas.
c. Prepare a taxonomical checklist of all the species with their English and local names and their status in the study sites.
d. Identify threatened amphibian and reptile species in the IFAP sites and recommend measures to improve the situation.

e. Study the behaviour of various species of amphibians and reptiles in relation to habitat and diet in the study sites.

f. Assessment of impacts from environmental changes and human population pressure on potential reptilian and amphibian species and their habitats and to suggest associated mitigation measures.

g. Provide photographs, where possible, of the amphibian and reptile species.

h. Compile a report on the consultancy addressing all the above-mentioned issues.

1.2.4 Birds survey

1.2.4.1 Rationale

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

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

1.2.4.2 Objectives of the study:

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

1.2.5 Marine fisheries

1.2.5.1 Objective

a) Enlist and describe existing resident and migratory fish resources, their abundance, diversity and habitats in the study area
b) Prepare a taxonomical checklist of all the species with their English and local names and their status in the core and buffer zones
c) Help in developing GIS based information regarding occurrence and distribution of fish fauna.

d) Document the anticipated changes to resident and migratory fish population in the study area.
e) Document and describe fish species of "special concern" regarding the economic and ecological perspectives found in the study area
f) Suggest suitable methods of monitoring fish in the core and buffer zones of the study area.
g) Conduct a local survey of the fishermen to assess the trends of fish production for the last ten years.
h) Develop simple indicators for assessing the population trends of the fish that can be applied by the local staff in future.
i) Study the suitability or otherwise of the conventional fish ladders used in barrages and recommend the suitable measures for safe passage of all and critical fish fauna including Blind Indus dolphin.
j) Describe and assess potential anthropogenic impacts on fish species found in the study area
k) Submit a comprehensive baseline reports and monitoring plan to the team Leader.

1.2.6 Phytoplankton

1.2.6.1 Rationale

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

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

It is believed that the first living cell that appeared on planet earth emerged from the ocean. In all its form, life has developed from the growth of mono-cellular algae. About 90% of the species of marine autotrophs are algae and about 50% of the global photosynthesis is algal derived thus every second molecule of oxygen we inhale come from algae and algae reuse every second molecule of carbon dioxide we exhale (Melkinian 1995). The importance of algae and their consumption for human is well known since 300 BC in China and Japan. These two countries are the major algae/sea weed cultivators, producers and

consumers in the world such as the Indian Ocean region countries like Malaysia, Indonesia, Singapore, Thailand, and Korea. Algae/sea weeds are used in salad, jelly, soup. In Pakistan algae/sea weeds consumption is negligible so there is need for awareness of algae as a source of health, basic food as they are rich and an easily available source of vitamins, minerals and trace elements.

1.2.6.2 Objectives of the study:

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

1.2.7 Zooplankton

1.2.7.1 Rationale

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

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

Invertebrates live in a vast range of habitats, from forests and deserts to caves and seabed mud. In oceans and freshwaters they form part of the plankton, which comprise of an immense array of tiny living organisms that drift in the surface currents. Invertebrates are also found in the soil beneath and in the air above our heads. Some use wings to propel but others, particularly the smallest invertebrates, float on the slightest breeze. These tiny invertebrates form clouds of aerial plankton that drift unseen through the skies. (Hawking, J.H et al 2006)

Aquatic invertebrates are an important source of food for birds, mammals, amphibians, reptiles, fish, and other invertebrates. Changes in terrestrial and aquatic habitats lead to changes in invertebrate assemblages, which in turn increase, decrease, or change food supplies for other animals. As impacts occur in a stream, species richness (number of species) decreases but the population size of some species may increase. Further, large-sized species are usually

replaced by small species (e.g., Wallace and Gurtz 1986). Conversely, when the stream condition improves, larger invertebrate species replace small species (Grubaugh and Wallace 1995). Such changes can have critical impacts on species that depend on invertebrates for a food supply.

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

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

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

1.2.7.2 Objectives of the study

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

a. Collect and review secondary data on the invertebrates of the above-mentioned area, with the help of available literature and local community.
b. Collect data from the field on species occurrence, abundance and diversity in the study areas.
c. Prepare a taxonomical checklist of the invertebrate groups found in the desired reservoir
d. Study the ecology and behavior of various groups of invertebrates with special reference to crustacean fauna of the desired area (if any)
e. Assessment of impacts from environmental changes and human population pressure on economically important invertebrates and their habitats.
f. Provide photographs, where possible, of the impetrative invertebrate species collected from inside and around the Reservoir.
g. Compile a report addressing all the above-mentioned issues.

1.2.8 Physicochemical properties of water

1.2.8.1 Objectives of the study:

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

1.3 Literature Review

1.3.1. Large Mammals

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

The creeks in Keti Bunder are a part of the North Arabian Sea and lies within the Indian Ocean Sanctuary, set up by the International Whaling Commission to protect cetacean population. Information on marine cetaceans along Pakistan coast is very sparse and very little data has been published. Ahmed & Ghalib (1975) reported occurrence of nine mammalian species. Roberts (1997) lists thirteen species of marine cetaceans from coastal waters of Pakistan based on personal communications with different people on sightings. Further evidence suggests that there is an undocumented high diversity of cetaceans in Pakistani waters. There has been no comprehensive survey of cetaceans in Pakistan and only recently University Marine Biological Station (UMBS), University of London, Millport, U.K. in partnership with WWF – P and Centre of Excellence in Marine Biology (CEMB); University of Karachi started cetacean surveys on Pakistan coast and offshore. WWF Pakistan is undertaking surveys of dolphins and porpoise in Korangi – Phitti creek system in Karachi with support from the Ocean Park Conservation Foundation.
No study on terrestrial mammals has been undertaken in the area. Roberts (1997), Ahmad and Ghalib (1978) have worked on the distribution and status of mammals in Pakistan but did not mention particular occurrence in Keti Bunder area. Ahmad et al (1988) worked on the vertebrate fauna of mangrove swamps of Sindh and recorded 5 species of mammals, including marine and terrestrial mammal but they did not describe the mammals occurring exclusively in the nearby terrestrial area of mangrove forests.

No researchers or wildlife managers have exceptionally dealt with the mammalian fauna of Chotiari Reservoir or its environs. However, WAPDA carried out an

Environmental Impact Assessment of the area through Consultants in 1992 (EIA Report 1993). Later, they also conducted studies for Environmental Management and Monitoring Plan of Chotiari 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.

1.3.2 Small Mammals

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

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

1.3.3 Reptiles and amphibians

The herpeto-fauna of Indus for All Programme, WWF Pakistan areas was little studied by early herpetologists (Murray, 1884, 1886; Boulenger, 1890, 1920; Smith, 1933, 1935, 1943; Minton, 1966; Mertens, 1969; Dubois & Khan, 1979; Khan, 1979, 1980). Comprehensive studies have not been undertaken and herpeto-fauna remains marginally explored. This is because the areas are very wide, extremely difficult with very limited infrastructure and other facilities. The conditions were even worse in the past and did not encourage the scientists to venture for studies. Amphibians and reptiles are cold-blooded animals and therefore are more sensitive to the environmental conditions as compared to birds and mammals. However, in the recent past, Khan (1989, 1992, 1993, 1997, 1998, 2006), Baig (1988 a, b, c; 1989, 1990, 1992, 1996, 1997, 1998, 2001 a, b, 2002); Khan and Baig, (1988, 1992); Khan and Tasnim (1989, 1990); Baig &

Böhme (1991, 1996); Baig and Gvozdik (1998); Auffenberg & Rehman (1993); Woods *et al*. (1997) and Shah and Baig (2001) attempted to explore the herpeto-fauna of different areas of Pakistan and published their findings, which were surprisingly, either new to the science or extended the range of several species which were reported only from the neighboring countries of Pakistan.

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

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

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

1.3.4 Birds

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

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

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

Roberts et al (1986) have given a checklist of Birds of Karachi and Lower Sind.

Tom Robert's two volumes of Birds of Pakistan comprise of the first complete account of the avifauna of the country. The first volume contains detailed descriptions of 347 non-passeriformes and the second volume deals with 313 species of passerines.

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

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

1.3.5 Marine fisheries

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

1.3.6 Phytoplankton

Phytoplankton community structure in lakes appear to be well studied (Smith, 1990). Unfortunately in Pakistan except the work on Nazneen (1974) and Bri and Nazneen (1979), most of the research works concern with phytoplankton algae of temporary and permanent ponds. More over these studies are devoted only to the one species richness and many do not cover the entire seasonal variability. Many studies on phytoplankton of water bodies of this region appear not to be well documented from an ecological point of view. The knowledge of temperate lakes and their phytoplankton is much greater that that of tropical and sub-tropical lakes. Tropical lakes appear to have different plankton community structure from temperate lakes and are mostly populated by submerged and emergent macrophytes.

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

discussed by several authors and attributed to different factors, shading allelopathy and competition for nutrients (Welch and Cooke, 1987: Engel, 1998 and Mitchell, 1989)

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

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

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

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

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

1.3.7 Zooplankton

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

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

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

1.3.8 Physico-chemical properties of water

In Pakistan, there are several potential sources to contaminated water. Bacteriological contamination of drinking water has been reported to be one of the most serious problems throughout the country in rural as well as urban areas (Abid & Jamil, 2005; Kahlown, Tahir, & Sheikh, 2004; Jehangir, 2002; Sun-OK, Shin-Ho, Nasir, & Noor-us-Saba, 2001). Another strong source for ground water and ponds / wetlands contamination is chemical pollution from toxic substances from the industrial effluents, pesticides, nitrogenous fertilizers, arsenic and other chemicals (Din, Hussain, Naila, Shabbir, Rana, Anwar, Saeed, & Zumra, 1997; Tahir, Chandio, Abdullah, & Rashid,1998; Sajjad & Rahim,1998; Hussain & Mateen, 1998; Sial & Mehmood,1999; Latif, Akram, & Altaf,1999; Chandio,1999; and Tahir, 2000). In addition, excessive monsoon rains, floods, herbicides, fungicides, untreated municipal waste, sewage breakdowns, and coastal water pollution due to waste discharges and oil spills are extremely hazardous which pollute water.

An abundant supply of good, clean water must support a variety of beneficial uses. These include drinking water for domestic use and stock watering; industrial, commercial, agricultural, irrigation, and mining use; fish and wildlife

maintenance and enhancement; recreation; generation of electrical power; and preservation of environmental and aesthetic values.

Water quality factors are important in freshwater aquaculture systems. Water quality determines not only how well fish will grow in an aquaculture operation, but whether or not they survive. Fish influence water quality through processes like nitrogen metabolism and respiration. Some water quality factors are more likely to be involved with fish losses as dissolved oxygen, temperature, and ammonia. Others, such as pH, alkalinity, hardness and clarity affect fish, but usually are not directly toxic.

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

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

Pakistan is largely arid and semi-arid, receiving less than 250 mm annual rainfall, with the driest regions receiving less than 125 mm of rain annually. It has a diverse landscape, with high mountain systems, fragile watershed areas, alluvial plains, coastal mangroves, and dune deserts. The flora and fauna are mainly Palaerctic and Indomalayan. 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: Materials and methods

2.1 Large Mammals

2.1.1 Team composition

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

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

2.1.2 Point surveys

In this method, observation points were established along roads, edges of ponds or marshes, at a higher place or at any other location suitable for viewing the habitat. For a period of 15 to 60 minutes at each observation point, the observer recorded all sightings of the mammals at that site and then calculated an index of abundance of each species as the number of animals seen per hour of observation (Brower *et. al* 1990).

2.1.3 Roadside Counts

Usually it is difficult to locate a large mammal by walking in its habitat, as it can smell the human from a long distance. Hence, the method of roadside counts was applied to locate and to have population estimates of different mammalian species.

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

At Keti Bunder, this method was applied to locate different mammalian species. About 25 km area along the banks of *Door* water channel, along dirt road near Khaaro Chan where River Indus falls into the sea and along different embankments near different villages in Keti Bunder was searched for different mammals.

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.

At Keti Bunder and Keenjhar 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 in Pai forest for the estimation of Hog deer and Indian wild boar, in Chotiari for foxes and at Keenjhar for jackals and in Keti Bunder for estimating the population of hump-backed dolphin.

At Keti Bunder, this technique was applied for observing the Cetaceans (dolphins and porpoises) in different creeks. For this purpose, three different transects (starting and stopping points) were taken on a motor boat driven at a speed of 7 km/h in different creeks. The length of each transect was 4 km while the width was 250 m on either side of the boat. Two observers and one recorder worked simultaneously and each observer watched 90º in an arc sweeping one quarter on front view from the boat. Binoculars (10x40) were used for observations and the data were recorded on the Cetacean Sighting Recording Protocol

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.

In Keti Bunder as most of the area consists of forests, agricultural lands and coastal areas therefore, this technique was applied only to establish the presence of different mammals.

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 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

One hour plot searches were made in Goth Aman Sammo of Keti Bunder. The area is flat and sandy – cum muddy beds with some xerophytic plants such as Calotropis and Tamarix sp. Burrows, fecal material and other tracks and tresses were identified. Traps were deployed at Goth Pir Dino Shah. Twenty Sherman traps were set near the village under Salvadora trees, 10 traps were set in Banana fields and 10 traps were set in Pir Dino Shah Orchard.

The following sites were identified and used for sampling:

Table 1 – Locations used for sampling in Keti Bunder

	Northing	Easting	Location name
1	24 11 757	67 33 349	Rana mori/Jhalo
2	24 13 550	67 32 084	
3	24 11 757	67 33 349	Karo Kooa
4	24 10 549	67 33 316	Sehar
5	24 11 757	67 33 349	G.M Gulri hotel
6	24 11 757	67 33 349	
7	24 07 765	67 38 273	
8	24 11 757	67 33 349	Dando/ Tar
9	24 07 765	67 38 273	Pir Dino Shah Goth
10	24 07 765	67 38 273	G.M Gulri hotel
11	24 07 765	67 38 273	
12	24 07 765	67 38 273	Dando/ Tar

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 (HOW MUCH IN MG). Care was taken to make sure that the bait was placed on the platform fitted on the rear side of the trap.

2.2.2 Traps and trapping procedure

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

2.2.3 Data collection

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

2.3 Reptiles and amphibians

2.3.1 Survey method

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

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

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

2.3.2 Active searching

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

These places were deliberately uncovered to search for the eggs and tadpoles of amphibians in aquatic habitats or to reveal the presence of the amphibians and reptiles hiding under these covers. Active searching was carried out in all the locations with a focus on suitable microhabitats. In winter, studies were conducted, prior to the start of the hibernation period of most of the amphibians and reptiles. Most of the active searching was only possible and limited to the pre-dusk time in winter, as the low night temperatures hindered the activities of the herpetiles.

Searching for the nocturnal species of amphibians and reptiles was carried out in exposed areas of their potential habitats on the ground, along the path or the pond/stream bank. Night survey in some of the rocky terrain around the Keenjhar Lake was difficult as there was always a likelihood of venomous snakes, as the author did face; so, long shoes, hand lamps and powerful torches were used for this purpose.

2.3.3 Trapping

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

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

2.3.4 Signs

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

2.3.5 Collection

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

2.3.6 Data Records

The species collected or observed during the survey were photographed with a digital camera and necessary field data were recorded. The coordinates and elevations were recorded with the help of GPS. The voucher specimens collected were subsequently transported to the Pakistan Museum of Natural History (PMNH) laboratory for future reference.

2.3.7 Preservation

The amphibian or reptile specimens were arranged in a tray or ice-cream container in a position, which showed the features important for identification, e.g. mouth wedged open, one hind leg extended and fingers and toes spread.

Preservatives such as 10 % formalin solution or 50-70 % alcohol or methylated spirits solution in water was added to just cover the specimens, and the container was then covered and left until the specimens were set. In case of larger specimens, a slit was made in the belly and preservative injected to preserve the internal organs. This step was omitted in case of frogs as they have thin and permeable skins, but in case of reptiles, the preservative was injected into their bodies as their skin is impermeable and does not allow any solution to get into. For this purpose normal syringes were used.

The specimen was stored in the same preservative in a water-tight jar. A waterproof label was added to the jar, giving details of place, date and collector’s name. A label was tied to the specimen written with permanent Indian ink or simple carbon pencil. The same details were stored with tadpole specimens, which don’t need to be set, just dropped into preservative.

2.3.8 Identification of species

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

2.3.9 Data analysis

There are several numerical indices in use, which quantitatively describe different levels of diversity and evenness in samples collected from different localities or at

different times from the same environment. One such commonly used diversity index is called “Shannon-weaver” index of diversity, which combines the number of species present and evenness into a single index. The formula is given as: D = -Σ 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 transverse /examined by two observers, separately. Birds were searched on each side of the strip for 150m so that each study strip was 300m wide. Use of binoculars and telescopes was made to identify bird species, count or assess bird numbers, particularly in case of water-birds.

2.4.2 Evaluation of water bird numbers

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

a) Counting individuals birds within an area

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

b) Estimating the numbers of birds within an area

- Large numbers of birds present i.e. >1,000.
- Birds continually in flight i.e. moving along the coast to a roost site in large flocks.
- A lot of disturbance forcing birds to be unsettled and continually take flight, making prolonged observation on the ground difficult.
- A closely-packed flock of birds, where due to the "tightness" of the flock counting individual birds is difficult i.e. at a large roost.
- Due to poor light conditions i.e. viewing into the sun or over a great distance, identification of particular species is not possible.

2.4.3 Methods of accurate count

- Close viewing of individuals with binoculars or a telescope. Counting 1, 2,3,4,5,6,7…… etc.
- Distant viewing of an evenly distributed flock. Counting 1,2,3,4,5,6,7……..etc.
- Visually dividing birds into small groups and counting each group individually, i.e.) when there is an uneven distribution of numbers. Totals for each group are then added to form the final total.
- Counting flocks in multiples i.e. 3,6,9,12,15…….. Etc or 2,4,6,8,10……etc. This method can be used for either evenly or unevenly distribution of water-birds. (Howes, J. and Backwell, D. 1989).

2.5 Marine fisheries

2.5.1 Methodology

The fish production data used in the present studies is taken from the works published from 1965 to date. Tuna catches data was collected on Chinese Commercial vessel operated beyond the 35 nautical miles and in the EZZ area during 2005 – 2006 by Mr. Warayni, Marine Fisheries Department. (Hussain *et al.,* 2007). Data on Keti Bunder comes from the two weeks field collections on boat (using Gill nets) and from shore with the help of staff of WWF Pakistan/Indus for All Programme. Important sites that were surveyed are Chann Creek, Hajamaro Creek, Turshain Creek and Kaharo Creek. Although sampling was done along the three creeks two stations at Hajmora Creeks Lat. N. 24^0 $07^{'}$.3 79 Long E. 67^0.$24^{'}$.666 and Lat. N. 24^0 $07^{'}$. 42 2 and Long. E 67^0 $23^{'}$ .632 and 3 stations at Kharo Chann Creek Lat. N 24^0 $04^{'}$.574 and long. E 67^0 $34^{'}$.2 11, Long N. 24^0 $04^{'}$.678 Long. E 67^0 $34^{'}$.5 72 and Lat. N 24^0 $13^{'}$.633 and Long. E $67^0$$19^{'}$.753. Some basic hydrographical data was also collected and presented. The study on *T. ilishia* is based on the information obtained from literature together with observation made at various localities at Keti Bunder.

Fisheries Statistical data from 1995 – 2003 has been taken Hand Book of Fisheries statistics of Pakistan (2006 b) and Agriculture Statistics of Pakistan (2006 a). SSPS and Excel programmes were used to analyze the data.

2.6 Phytoplankton

2.6.1 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).

2.7 Zooplankton

2.7.1 Collection protocols and standardizing procedures

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

2.7.2 Aquatic invertebrate fauna - plankton net and drag nets

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

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

2.7.3 Random sampling

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

sampling. Each individual is chosen entirely by chance and the likelihood of a biased data collection is thus reduced.

2.7.4 Precautions in field

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

2.7.5 Precautions in taxonomic investigation

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

2.7.6 Hand picking and use of forceps

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

2.7.7 Preservation and storage of the specimens

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

2.7.8 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 pre monsoon (July 2007) and post monsoon (October 2007) period. The samples were collected in clean acid rinsed bottles for the general water quality parameters such as pH, temperature, conductivity TDS, Total Hardness, Chlorides, Phenol, Sulphates, turbidity, ions and four heavy elements. The BOD and COD water samples were collected in separate coloured water bottles and kept in ice box for preservation. All samples were properly sealed under specific codes/labels and dispatched to the water quality laboratory the day after the collection with proper custody protocol.

The sampling strategy was designed according to the site conditions and in consultation with the WWF team deployed at the study area. The sampling scenario was designed to cover some town area and creeks that should highlight the environmental effects on livelihoods. The location points and their significance are highlighted in **Table 2**. Water samples were drawn considering full depth of standing water or flowing water. The sample location points were marked on GPS maps GPS which will be used as reference points for future studies. The technique and methodology used for analyzing the samples are given in the annex document.

Table 2 – Significance of sample location points

S.no	Sample No	Location	Waypoints	Significance
1	KB-1	Surface Drain at Haji Halim Sholani Village	N 2408316 E 6732929	Agriculture Drainage water effluent discharging in to Hajamro Creek
2	KB-2	Waste water of Town	N 2408552 E 6727127	Keti Bunder Town waste water being thrown in to Hajamro creek
3	KB-3	Bhoori Village Hand Pump, Creek area	N 2403548 E 6728712	Drinking water source of the creek village
5	KB-4	Center of Kharo Chann creek	N 2402015 E 6728262	This creek receives fresh water from Indus river which supports to Palla Fish culture, which is reportedly under threat
6	KB-5	Phulwani creek area having Mangrove	N 2402750 E 6726166	This creek area receives fresh water from Indus river which supports mangrove forest, which is reportedly under threat

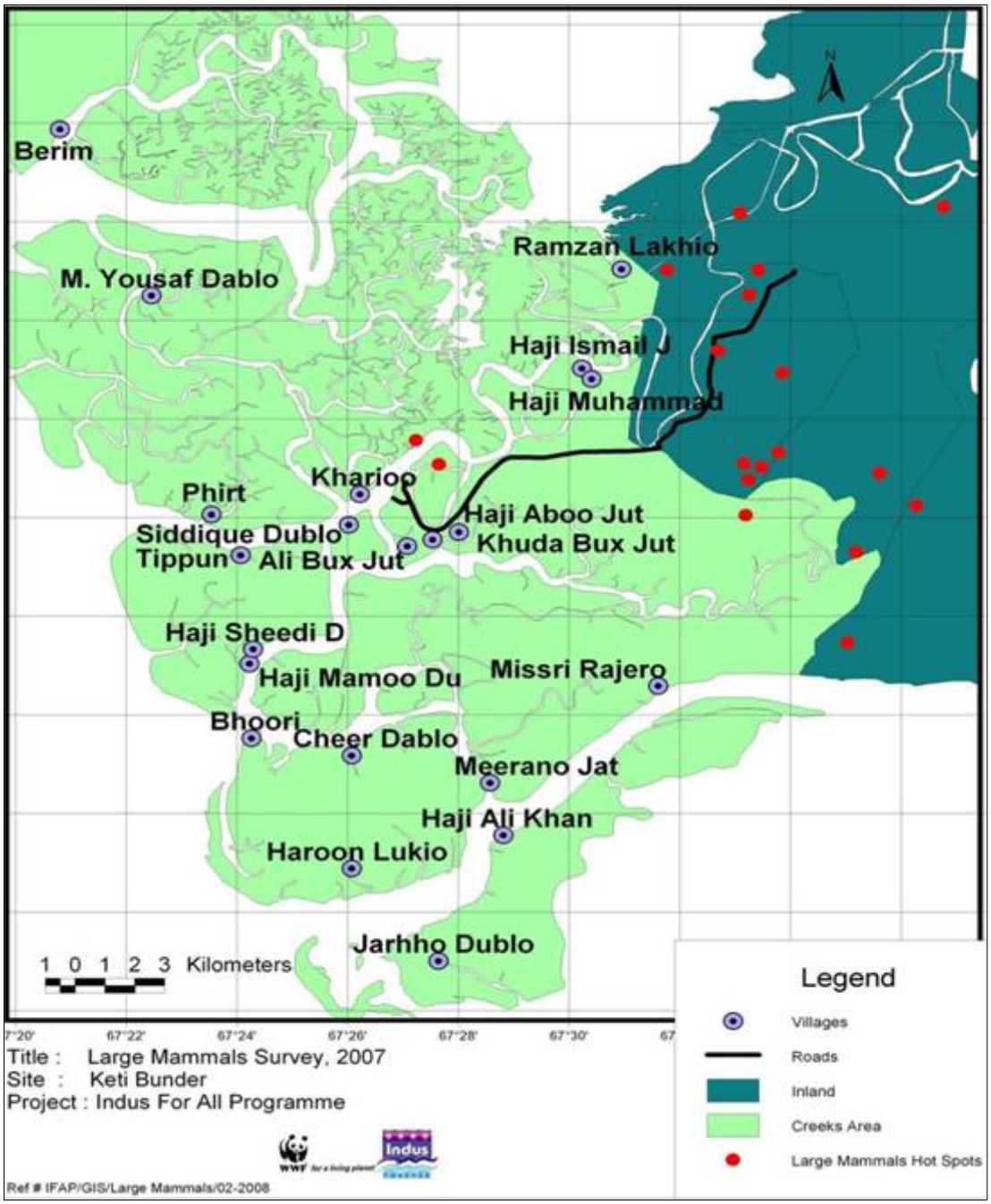
Chapter 3: Findings and discussion

3.1 Large Mammals

3.1.1 Sampling locations

Almost all the potential sites around Keti Bunder were searched to locate the existing large mammals and the GPS coordinates at different locations were noted. Different sampling sites around Keti Bunder during summer and winter surveys are given in **Maps 2** and **3**. GPS coordinates taken during summer and winter surveys are given in the annex document

Map 2 – Sampling sites of large mammals at Keti Bunder during summer



Map 3 – Sampling sites of large mammals at Keti Bunder during winter

3.1.2 Species identified

Spending eight days in the field (four days during summer survey and four days during winter survey) and applying all the possible direct and indirect observation methods, a total of 83 animals of 14 mammal species, belonging to four orders (Carnivora, Artiodactyla, Cetacea and Pholidota) were recorded from Keti Bunder (**Table 3**).

Table 3 – Mammal species recorded from Keti Bunder

S.no	Common Name	Zoological Name	Order	Animals Observed
1	Asiatic jackal	*Canis aureus*	Carnivora	3
2	Jungle cat	*Felis chaus*	Carnivora	2
3	Fishing cat	*Prionailurus viverrinus*	Carnivora	-
4	Indian desert cat	*Felis sylvestris ornata*	Carnivora	-
5	Bengal fox	*Vulpes bengalensis*	Carnivora	-

6	Desert fox	*Vulpes vulpes pusilla*	Carnivora	1
7	Small Indian mongoose	*Herpestes javanicus*	Carnivora	7
8	Grey mongoose	*Herpestes edwardsi*	Carnivora	2
9	Small Indian civet	*Viverricula indica*	Carnivora	1
10	Indian wild boar	*Sus scrofa*	Artiodactyla	-
11	Bottle-nosed dolphin	*Tursiops truncatus*	Cetacea	2
12	Hump-backed dolphin	*Sousa chinensis*	Cetacea	62
13	Finless porpoise	*Neophocaena hocaenoides*	Cetacea	2
14	Indian pangolin	*Manis crassicaudata*	Pholidota	1

3.1.3 Observation records

Out of 14 recorded species of large mammals, 10 were observed directly while the remaining four were recorded on the basis of indirect evidences like tracks and interviews of locals and wildlife watchers from Sindh Wildlife Department (**Table 4**).

Table 4 – Observation records of different mammal species at Keti Bunder

S.no	Species	Direct Observations	Indirect Observations		
			foot prints	fecal material	Interviews with locals
1	Asiatic jackal	✓	-	-	✓
2	Jungle cat	✓	-	-	✓
3	Fishing cat	-	-	-	✓
4	Indian desert cat	-	-	-	✓
5	Bengal fox	-	-	-	✓
6	Desert fox	✓	-	-	✓
7	Small Indian mongoose	✓	-	-	✓
8	Grey mongoose	✓	-	-	✓
9	Small Indian civet	✓	-	-	✓
10	Indian wild boar	-	✓	-	✓
11	Bottle-nosed dolphin	✓	-	-	✓
12	Hump-backed dolphin	✓	-	-	-
13	Finless porpoise	✓	-	-	-
14	Indian pangolin	✓	-	-	-

3.1.4 Conservation status of mammal species

Out of the 14 recorded species, one is Vulnerable (VU), five Near Threatened (NT), four Least Concern (LC) and four Data Deficient (DD) 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), Fishing cat as Vulnerable (VU) and Finless porpoise as Data Deficient (DD) in IUCN International Red List 2006. Jungle cat, fishing cat, Indian desert cat and Small Indian civet are protected in Sindh under Sindh Wildlife Protection Ordinance 1972. Jungle cat, Fishing cat and Indian desert cat are included in Appendix II while Bottle-nosed dolphin, Hump-backed dolphin and Finless porpoise are included in Appendix I of the CITES Category 2007. The conservation status of the mammalian species found at Keti Bunder is given in the **Table 5** below.

Table 5 – Conservation status of mammal species found at Keti Bunder

S.no	Mammalian Species Recorded from Keti Bunder	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	Fishing cat	VU	NT	P	Appendix II
4	Indian desert cat	-	DD	P	Appendix II

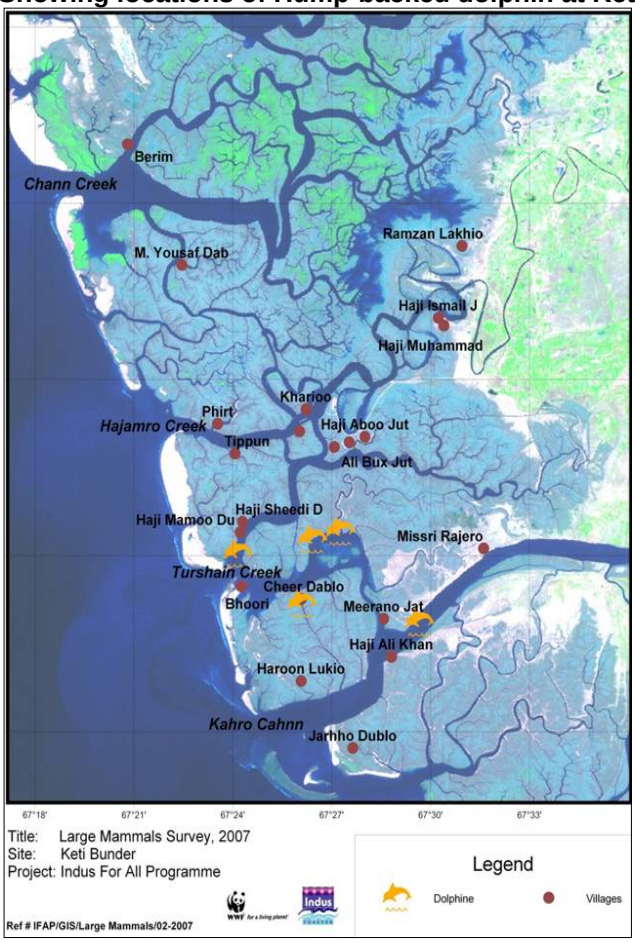
5	Bengal fox	-	NT	-	-
6	Desert fox	-	NT	-	-
7	Small Indian mongoose	LC	LC	-	-
8	Grey mongoose	-	LC	-	-
9	Small Indian civet	LC	NT	P	-
10	Indian wild boar	-	LC	-	-
11	Bottle-nosed dolphin	-	DD	-	Appendix I
12	Hump-backed dolphin	-	DD	-	Appendix I
13	Finless porpoise	DD	DD	-	Appendix I
14	Indian pangolin	-	VU	P	-
Legend: VU = Vulnerable, NT = Near Threatened, LC = Least Concern, DD = Data Deficient, P = Protected					

3.1.5 Population estimations

3.1.5.1 Population of Hump-backed Dolphin

Population of Hump-backed dolphin was estimated at Keti Bunder. The estimation was based on direct observations in different creeks. The estimated population was 62 animals. The distribution of hump-backed dolphins in different creeks at Keti Bunder is shown in the Map 4 below.

Map 4 – Showing locations of Hump-backed dolphin at Keti Bunder



3.1.6 Threats and recommendations

3.1.6.1 Threats

- **Persecuted wildlife:** Species such as jackal and jungle cats predate on poultry and therefore locals shoot or trap these species whenever they get the chance to;

- **Food competition:** Hundreds of feral dogs in the study area are not only a problem for the local residents but also for the wild animals. These are the major food competitors for most of the carnivore species in the area. Wild animals like jungle cat, fishing cat, jackal etc. are facing threats from the locals as they consider these as problem species. Feral dogs on the contrary, having been sheltered by man, face no problems at all and thus offer a real food competition for wild animals near human habitations as well as away from them;

- **Lack of awareness:** Usually the general public is not familiar with the wildlife, its positive role and ecological importance. Killing, hunting and trapping of wild animals is the result of such unawareness and a hurdle in wildlife conservation. Indian pangolin is a harmless animal but it is considered a fearful animal and killed whenever encountered;

- **Pollution:** Excessive pollution in the creek system is resulting in the unavailability of food for marine life as well as habitat degradation. The creek system receives untreated upland runoff, coastal dumps and domestic sewage which drain into creeks. Marine pollution mostly consists of synthetic materials resistant to degradation in marine environment. The oil and oil dispersants from the boats are also source of water pollution, all of which affect the marine ecosystem;

- **Entanglement of cetaceans in fishing gears:** Dolphins and porpoises are injured or killed when entangled in fishing gear. The fishermen don't try to rescue the dolphins when found entangled in their fishing nets and often let them die. They are often struck down by the motor boats, causing injury to the animal.

3.1.6.2 Recommendations

- **Control on Feral dog population:** Feral dog population at almost all the sites of *Indus for All Programme* is dominating the wildlife species. At Keti Bunder their population is almost double the population of livestock and thus a permanent threat for wildlife as well as for man. There have been few incidents of human deaths in the past due to dog bites (rabies) in Keti Bunder. People usually keep the dogs for security reasons as well as hunting purposes. But in Keti Bunder, most of the people do not need dogs. Thus there should be a check on population of feral dogs in the area.

- **Awareness raising campaign:** General public is not much familiar with the wildlife and its ecological role. Therefore, there is a need for raising awareness among the general public about the importance of wildlife and its role in the ecosystem.

- **Capacity building of fishermen:** Capacity building and orientation of local fishermen in Keti Bunder regarding cetacean identification, conservation and management is also needed.

- **Information about Pelagic ecosystem:** There is a need to collect information on the pelagic ecosystem around Keti Bunder and its effects on cetacean population.

- **Regular surveys for Cetaceans:** Regular surveys of small cetaceans (dolphins and porpoises) in the creeks should be conducted at least for a period of two years with the major objectives of recording their abundance, seasonal distribution pattern and habitat use.

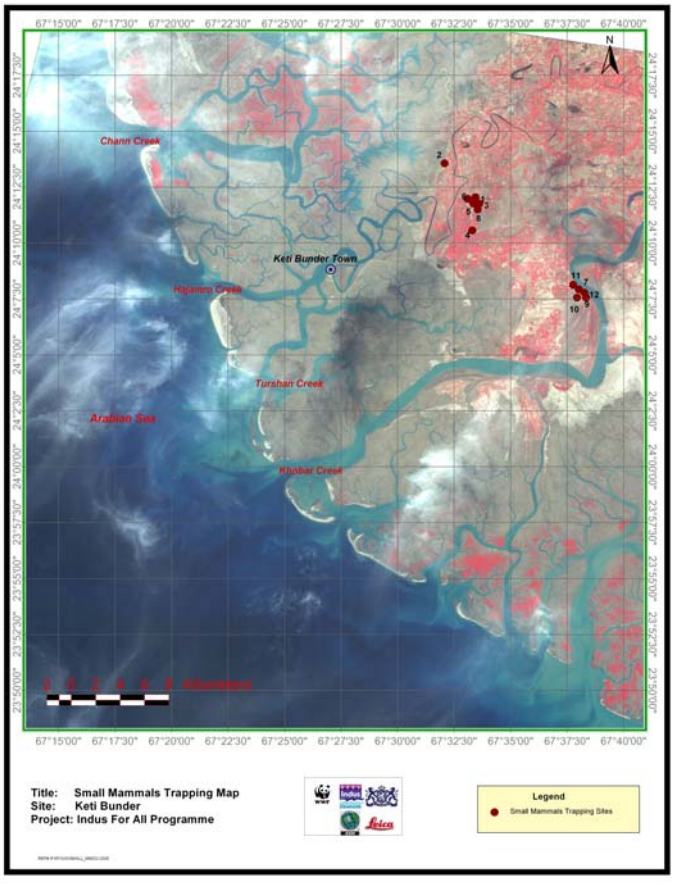
- **Dolphin Watch Programme:** *Dolphins watch programme* can also be initiated with the involvement of local community after their orientation and training in organizing dolphins watch. This could be an incentive for the local community regarding income generating activities. This could help protect the species as well as habitat and resulting in community based conservation.

3.2 Small Mammals

3.2.1 Sample locations

Map 5 shows the sampling locations of small mammal survey at Keti Bunder. Further details of the sampling points can be found in the annexure document.

Map 5 – Details of trapping locations for small mammals at Keti Bunder



3.2.2 Species account

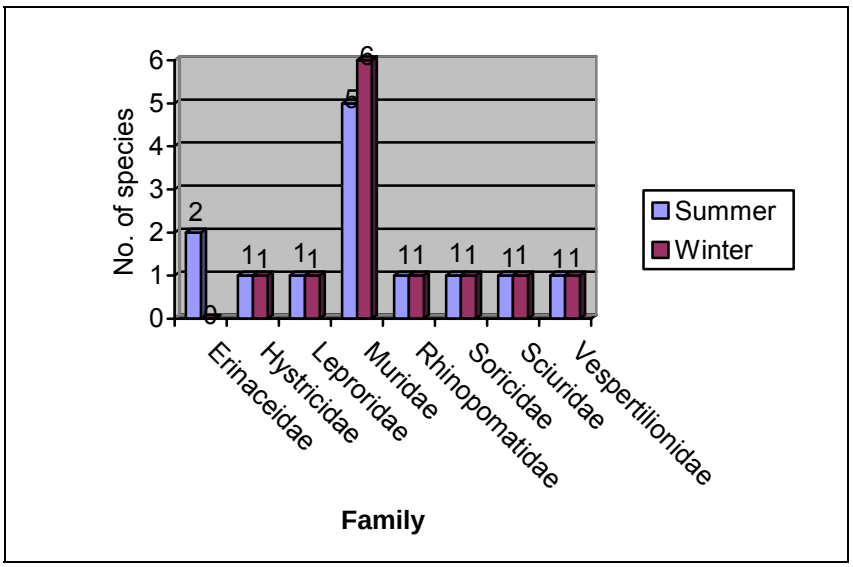
A total of 15 small mammal species were found in Keti Bunder out of which 13 species were recorded in summer and 12 in winter. These species belong to 4 orders (*Rodentia, Insectivora, Lagamorpha and Chiroptera*) and eight families. **Table 6** gives an account of the species recorded at Keti Bunder along with their conservation status, feeding habits and activity habits.

Table 6 – Total species recorded at Keti Bunder along with conservation status, feeding habits and activity habits

S. No	Scientific Name	English Name	Feeding Habit	Behaviour	Status	Summer	Winter
1	*Acomys cahirnus*	Cairo spiny mouse	GRN	NC	LC	-	+
2	*Bandicota bengalensis*	Sindh Rice Rat	GRN	NC	C	+	+
3	*Funambulus pennantii*	Palm Squirrel	GRN	DR	C	+	+
4	*Golunda ellioti*	Indian bush rat	GRN	NC	LC	+	+
5	*Hemiechinus collaris*	Long-eared Hedgehog	OMV	NC	LC	+	-
6	*Hystrix indica*	Indian crested porcupine	HRB	NC	C	+	+
7	*Lepus nigricolis*	Desert hare	HRB	NC	C	+	+
8	*Millardia gleadwi*	Sand colored 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	*Rhinopoma microphyllum*	Large mouse tailed bat	INS	NC	LC	+	+
14	*Suncus murinus*	House shrew	INS	NC	C	+	+
15	*Tatera indica*	Indian Gerbil	GRN	NC	C	+	+

Figure 1 below shows the number of species recorded from each family. As can be seen most of the species belong to the *Muridae* family (38% in summer and 50% in winter respectively). There was no major change in distribution of families during winter and summer, suggesting that there is little migration of animals over the seasons. Since there are no population figures available, it is hard to predict whether any of the small mammal populations increased or decreased over the study period.

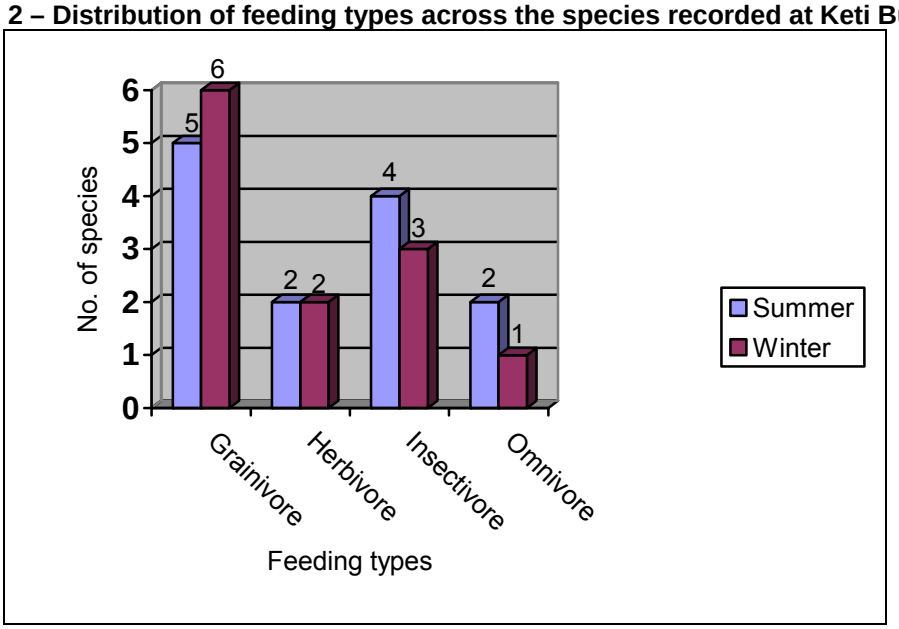
Figure 1 – Family representation of recorded small mammals at Keti Bunder



3.2.3 Feeding habits

Most of the species recorded from Keti Bunder were granivore in nature (five in summer and six in winter followed by insectivores (four in summer and three in winter) and then herbivores and omnivores (ranging from one to two species over both seasons). **Figure 2** gives a graphical portrayal of the number of species over feeding habits.

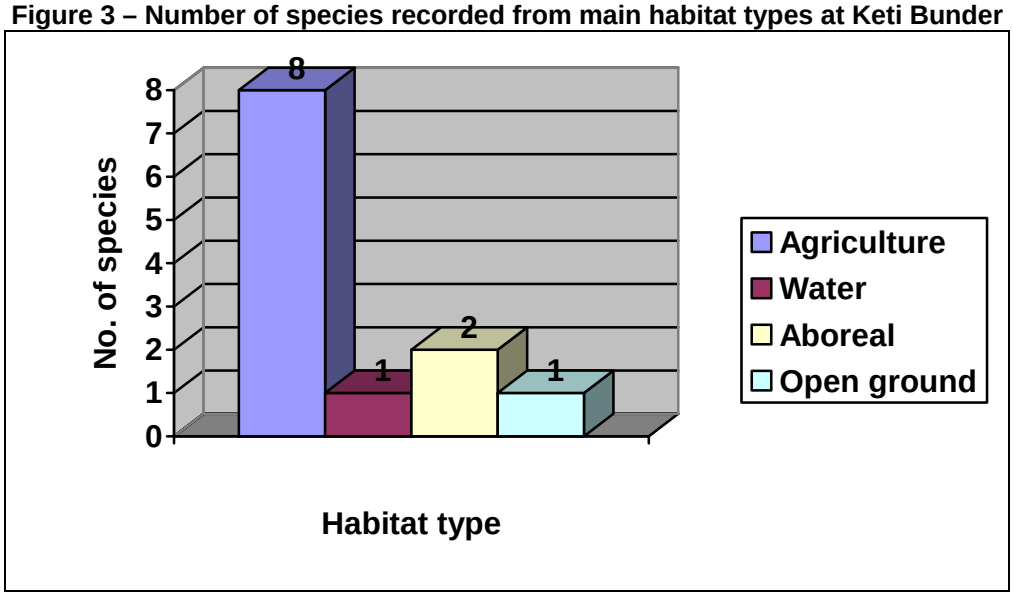
Figure 2 – Distribution of feeding types across the species recorded at Keti Bunder



3.2.4 Habitat and occurrence

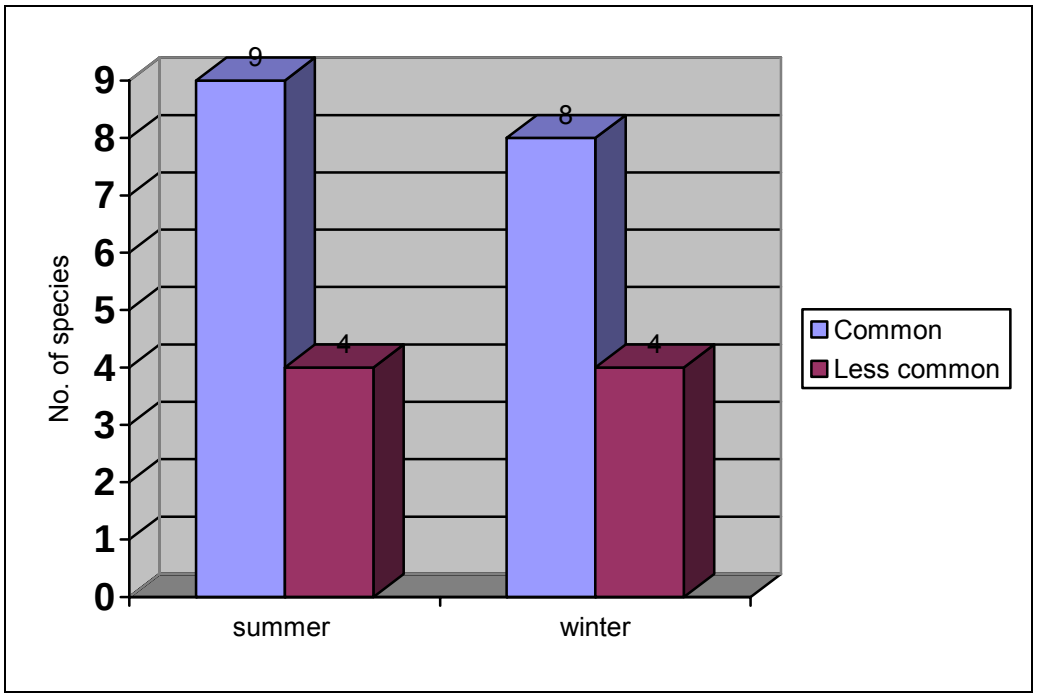
The majority of the species were recorded from agriculture land (shown by **Figure 3**) followed by trees (arboreal roosting sites of bat species) and then equally water and open land habitats. Any similarities between the results of feeding habits and habitat occupancy are probably auto-correlated.

Figure 3 – Number of species recorded from main habitat types at Keti Bunder



Out of the total species recorded from Keti Bunder more that 60% were common over both summer and winter. These figures however do not reflect the status of each species at site level which requires longer term studies.

Figure 4 – Distribution of small mammal status over the species and season at Keti Bunder



3.2.5 Threats and recommendations

3.2.5.1 Threats

- 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;

- The presence of a substantial feral dog population (unknown figure) in the area is probably may be having a detrimental affect on the local small mammal species. The dogs probably are additional predators to small mammals and themselves have no main predators;

- Hunting of Desert Hare and to some extent Indian Porcupine is common at Keti Bunder as it is throughout the region. The pressure on Desert Hare is present throughout the year and has probably caused the decline of the species in the Sindh Province.

3.2.5.2 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;

- Some attempts should be made to control the feral dog population in and around Keti Bunder. This would not only remove some of the pressure on small mammal populations but would bring benefit to a lot of the wildlife in the region;

- Public awareness about the need to control certain mammal populations that are known carriers of disease e.g. the Black Rat;

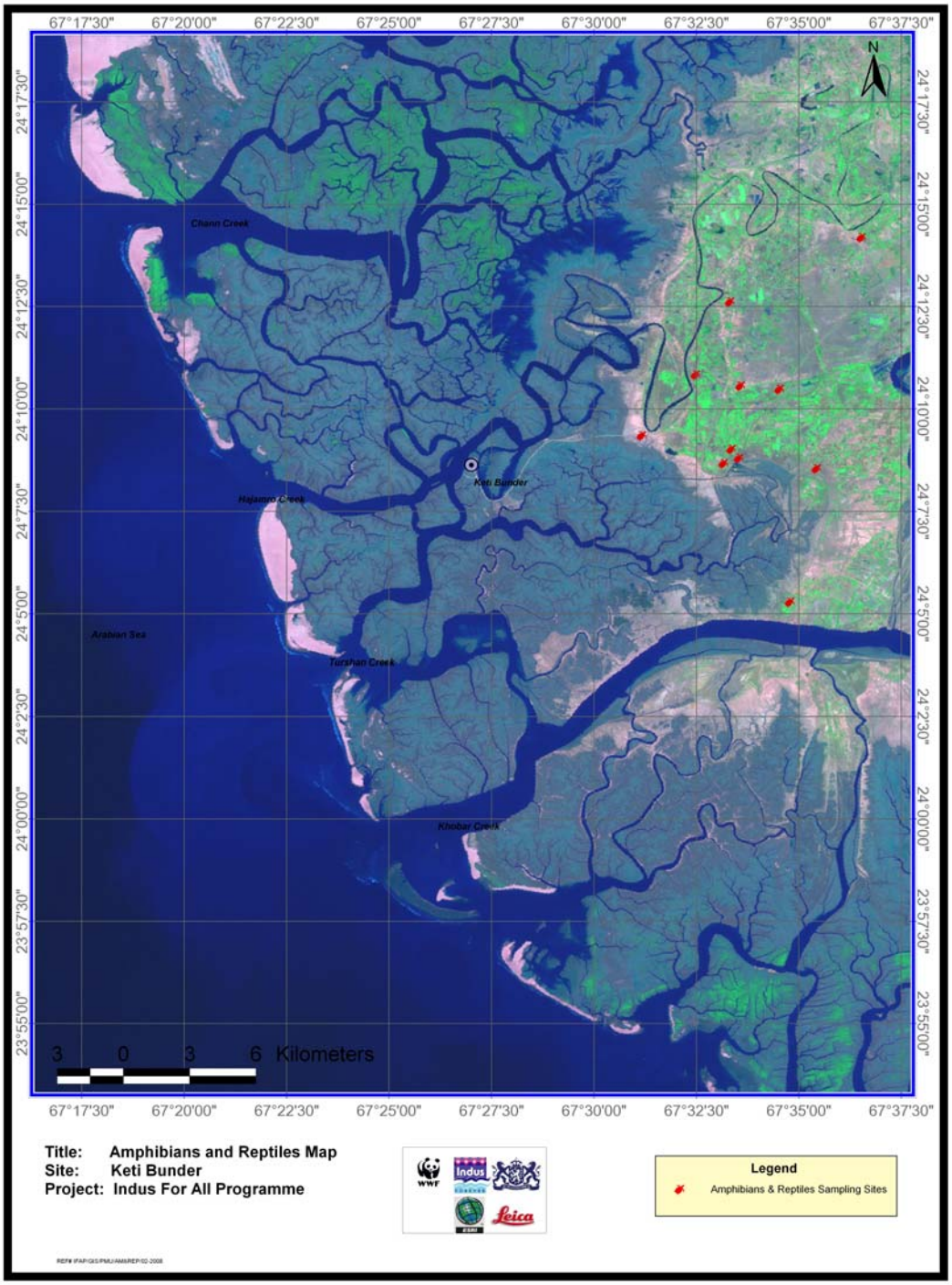
- Mark and recapture studies should be part of the Indus for All team at Keti Bunder. This assignment can be given to the Natural Resource Management Officer who can monitor the local population of selected small mammal as an indicator of the ecosystem.

3.3 Reptiles and amphibians

3.3.1 Sample locations

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

Map 6 - shows the sampling/trapping locations for reptiles and amphibians at Keti Bunder



3.3.2 Summary

Keti Bunder, Taluka (Tehsil) of Thatta District is situated at a distance of about 200 km SE of Karachi. It is located in Indus Delta and represents a diverse habitat complex supporting amphibians and reptiles. The area is very wide and consists of several Dehs (clusters of villages). There are four major creeks in the area viz. Chann, Hajamro, Khobar and Kangri branching into innumerable small creeks.

Image 3 – Mangrove habitat at Keti Bunder

Image 4 – Mudflat habitat at Keti Bunder

Out of 45 amphibian and reptilian species, possibly occurring in the area, 27 species were observed or collected by the author. The remaining species have been recorded through secondary data obtained through discussions with the local inhabitants and WWF members and consulting the previous literature citations. The amphibians are represented by three species belonging to three genera and two families. Among the reptiles, chelonians are represented by four species belonging to four genera and two families. Lizards are the second dominant group of herpetiles, represented by 18 species belonging to 12 genera and six families. Snakes outnumber all the groups of reptiles in the study area and are represented by 20 species belonging to 17 genera and seven families. A comprehensive list of species collected both in summer and winter in the annex document.

Keeping in view the diverse habitats, the Keti Bunder area is also interesting in the sense that three out of five species of sea turtles of Pakistan i.e. *Chelonia mydas* (Green turtle), *Lepidochelys olivacea* (Olive Ridley) and *Dermochelys coriacea* (Leather-back) may also visit and nest along the mangrove coastal strip, as reported earlier (Minton, 1966; Khan, 2006). Besides, there are 14 species of sea snakes occurring in Pakistan, the majority of which inhabit the mangrove swamps and the mouth of Indus.

The number of amphibian and reptilian species is seemingly less than what will be the actual occurrence in the area but was not unexpected due to several limitations mentioned earlier. In summer studies, the author observed or collected 20 species of amphibians and reptiles from all the study sites, adding 07 more species as a result of winter studies including *Hemidactylus brookii, Acanthodactylus cantoris, Ophisops jerdonii, Bungarus c. caeruleus, Daboia russelii, Hydrophis caerulescens* and *Praescutata viperina*.

Overall, the summer season is well represented by the higher richness, Shannon index and Margalef index of 20, 2.382, and 2.885 respectively. This highlights that the summer season, which is the active period of all of the herpetiles, is more

rich and diverse as compared to the beginning of winter season, when most of the herpetiles start hibernation.

Table 7 – Comparison of amphibian and reptilian diversity during summer and winter studies at Keti Bunder

S. No	Species Name	Total	Summer	Winter
1	*Bufo stomaticus*	117	117	0
2	*Euphlyctis c. cyanophlyctis*	39	25	14
3	*Hoplobatrachus tigerinus*	31	24	07
4	*Lissemys punctata andersoni*	14	14	0
5	*Calotes v. versicolor*	170	140	30
6	*Uromastyx hardwickii*	18	18	0
7	*Cyrtopodion scaber*	25	25	0
8	*Hemidactylus brookii*	14	0	14
9	*Hemidactylus flaviviridis*	158	135	23
10	*Acanthodactylus cantoris*	06	0	06
11	*Ophisops jerdonii*	04	0	04
12	*Eutropis dissimilis*	41	35	06
13	*Varanus bengalensis*	73	55	18
14	*Eryx johnii*	08	08	0
15	*Lycodon s. striatus*	03	03	0
16	*Oligodon a. arnensis*	01	01	0
17	*Platyceps v. ventromaculatus*	10	10	0
18	*Psamophis l. leithii*	03	03	0
19	*Ptyas m. mucosus*	09	07	02
20	*Spalerosophis atriceps*	04	04	0
21	*Xenochrophis p. piscator*	06	06	0
22	*Naja n. naja*	16	16	0
23	*Bungarus c. caeruleus*	01	0	01
24	*Daboia r. russelii*	07	0	07
25	*Echis carinatus sochureki*	116	78	38
26	*Hydrophis caerulescens*	03	0	03
27	*Praescutata viperina*	02	0	02
	Total number of individuals collected	899	724	175

3.3.3 Species richness

Table 8 gives four indexes of richness starting with the number of species (graphically shown in Figure 5). Evenness and two biodiversity indexes are also given in the table, namely Shannon's and Margalef

Table 8 – Diversity indexes for reptiles and amphibians recorded from Keti Bunder

S. no	Index type	Summer	Winter
1	Richness (number of species)	20	15
2	Evenness	0.5415	0.6752
3	Shannon Index	2.382	2.315
4	Margalef Index	2.885	2.771

Figure 5 – Number of reptile and amphibian species recorded during summer and winter from Keti Bunder

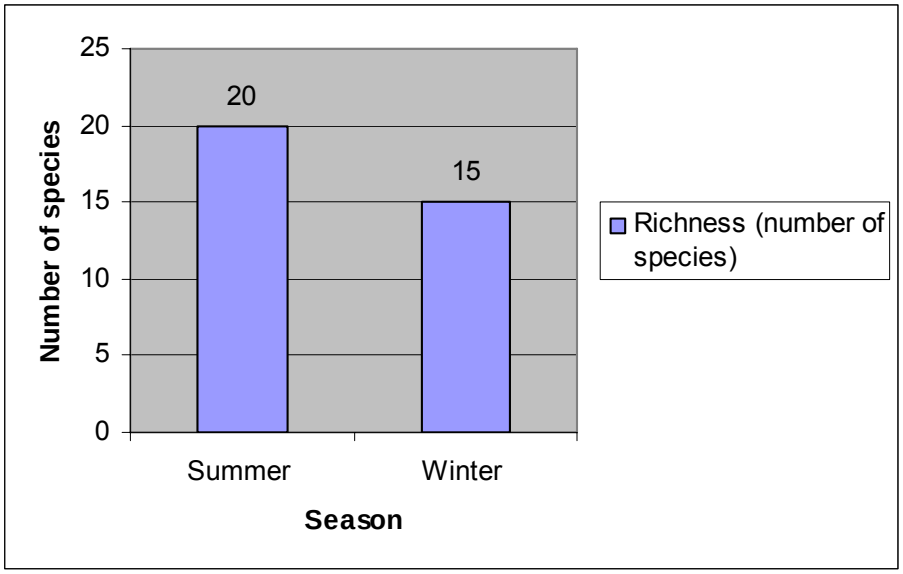


Figure 6 – Evenness of species recorded over summer and winter from Keti Bunder

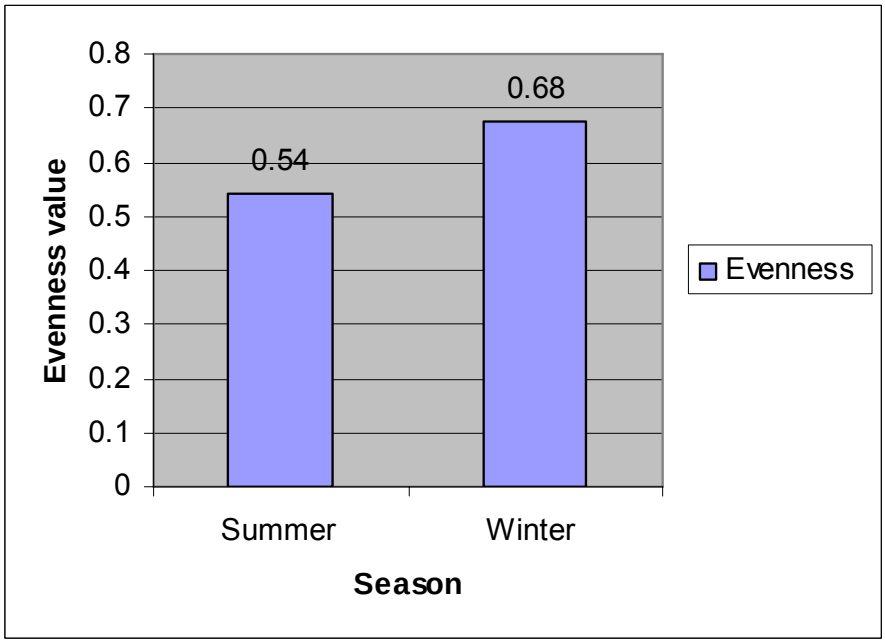
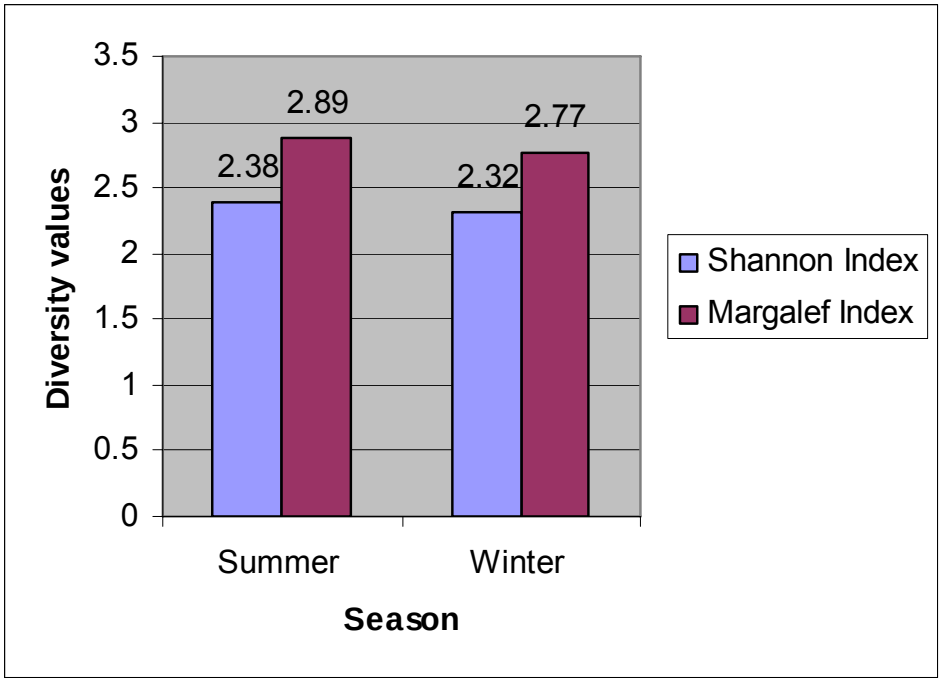


Figure 7 – Shannon and Margalef indexes for summer and winter at Keti Bunder



3.3.4 Discussion

More species of reptiles and amphibians were recoded during summer that in winter at Keti Bunder. Given the hibernating nature of reptiles and amphibians, thus is not an unusual phenomenon. The evenness of species was greater in winter than summer presumably because in summer there is more variation in the available species population

3.3.5 Threats and recommendations

3.3.5.1 Threats

- The increased demand of seafood for export has led to the mechanization of fishing crafts, which is not only responsible for over-exploitation of fishery resources but also causing threats to un-targeted vulnerable and endangered sea turtle species through their entanglement in fishing gears or accidental capture;
- Due to lack of proper sewage water and solid waste disposal systems, Keti Bunder area is heavily polluted. Extensive farmland and agricultural activities are causing pesticides contamination in the sea and ground water, keeping the fauna of the sea, as well the population of Keti Bunder, at stake;
- All the lizards and snakes are regarded as poisonous by the locals and thus are killed on sight, without considering its impacts, ultimately decreasing the herpetile population;
- Some of the reptilian species, which are protected under IUCN categories, are killed on roads. The road-kills of *Varanus* species (Monitor lizards) are self-evident and are increasing at a rapid scale due to infrastructure and road construction.

3.3.5.2 Recommendations

- Public awareness regarding the natural resources of the area, their current status and sustainable utilization should be highlighted through workshops, seminars, posters, pamphlets and brochures. Efforts should be made to make possible the community and game watchers' participation in such activities;

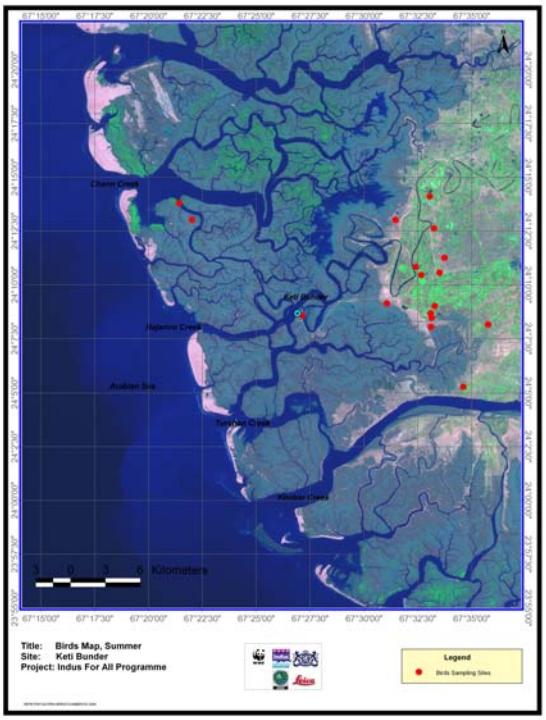
- A comprehensive and regular survey for at least a period of two years of sea turtles landing on different creeks and sea snakes population dynamics is of prime importance as the earlier literature is out-dated and needs to be refined;
- Establishment of small research grants to the young researchers and university students for different herpetological surveys of economically important species of this area and involving the locals through capacity building will also help in their livelihood improvement;
- To protect and conserve the vital species of amphibians and reptiles, there should always be the signboards on the roads, depicting the importance of nearby heavily populated amphibian or reptile species and the speed of vehicles must remain within limits accordingly.

3.4 Birds

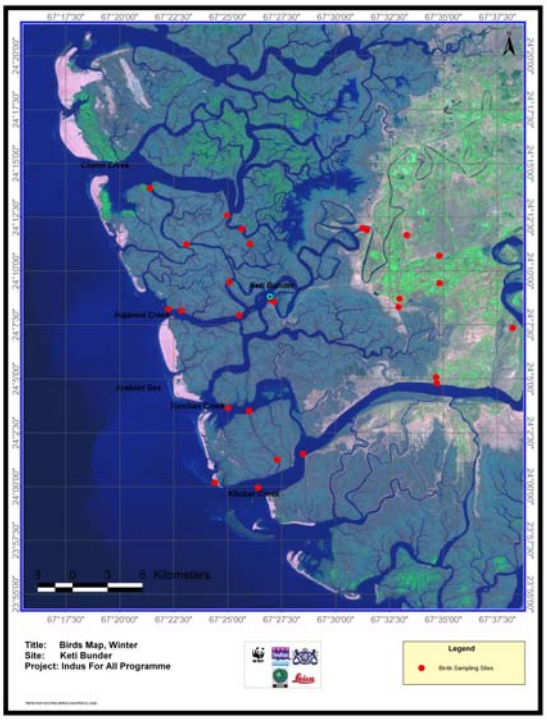
3.4.1 Sampling locations

Map 6 and **7** show the observation points of bird surveys at Keti Bunder over summer and winter. Details of the sampling points can be found in the annexure document.

Map 6 – Sampling locations for birds at Keti Bunder in summer



Map 7 – Sampling locations for birds at Keti Bunder in winter



The locations visited were during the surveys were agriculture and fruit areas, inland coastal belt and creek areas. The main bird habitats are coastal areas, agricultural fields, small forest areas having Mesquite, Salvadora, Capparis, Typha and Phragmites spp., fruit farms, marshes and the creek area. The main creek area comprises of Hajamro, Chann, Khobar and Bhoori creeks. The main habitat here is the mangrove forest. 68 species of birds were recorded in the summer surveys while 91 species were recorded in the winter surveys.

3.4.2 Species account

Out of 68 species recorded in the summer surveys, 22 species were of water-birds, 6 birds of prey and 25 passerines along with Pigeons, Doves, Pygmies, Kingfishers, Parakeets, Cuckoos, Bee-eaters and woodpeckers. Blue Rock Pigeon, Common Myna and Common Babbler were quite common; 3 over summering birds' viz. Curlew, Redshank and Osprey were also recorded. Pied Crested Cuckoo was the summer breeding visitor.36 species were common, 6 less common, and 25 scarce and 1 abundant. A total of 91species of birds were recorded in the winter surveys out of these, 49 species were resident, 31 species were winter visitors, 8 were irregular year-round visitors and 3 were passage migrants. Out of the total 48 species were common, 36 less common, 5 scarce and 2 rare birds were recorded. The important species recorded were: Painted Stork, Black-headed Ibis, Common Quail, Black-bellied Tern, Rufus-fronted Prinia, Paradise Flycatcher and Rosy Pastor.

3.4.2.1 Summer

Table 9 shows the list of bird species recorded from Keti Bunder during summer. A total of 68 species were recorded.

Table 9 – List of bird species recorded from Keti Bunder during summer

S. no	English name	Scientific name	Status	Occurrence	Birds recorded
1	Little Cormorant	*Phalacrocorax niger*	Common	Resident	7
2	Black Bittern	*Ixobrychus flavicollis*	Scarce	Resident	2
3	Little Green Heron	*Butorides striatus*	Scarce	Resident	3
4	Indian Pond Heron	*Ardeola grayii*	Common	Resident	54
5	Cattle Egret	*Bubulcus ibis*	Common	Resident	58
6	Western Reef Heron	*Egretta gularis*	Common	Resident	16
7	Little Egret	*Egretta garzetta*	Common	Resident	12
8	Grey Heron	*Ardea cinerea*	Scarce	Resident	2
9	Black/Pariah Kite	*Milvus migrans*	Scarce	Resident	4
10	Brahminy Kite	*Haliater indus*	Common	Resident	38
11	Shikra	*Accipiter badius*	Scarce	Resident	1
12	White-eyed Buzzard	*Butastur teesa*	Scarce	Resident	1
13	Osprey	*Pandion haliaetus*	Scarce	Winter visitor	1
14	Black Partridge	*Francolinus francolinus*	Scarce	Resident	6
15	Indian Grey Partridge	*Francolinus pondicerianus*	Scarce	Resident	1
16	Black-breasted Quail	*Coturnix coromandelica*	Scarce	Summer visitor	1

17	Pheasant tailed Jacana	*Hydrophasianus chirurgus*	Scarce	Resident	2
18	Black-winged Stilt	*Himantopus himantopus*	Common	Resident	4
19	Kentish Plover	*Charadrius alexandrinus*	Common	Resident	29
20	Lesser Sand Plover	*Charadrius mongolus*	Common	Winter &Summer visitor	7
21	Red-wattled Lapwing	*Hoplopterus indicus*	Abundant	Resident	53
22	Eurasian Curlew	*Numenius arquata*	Common	Winter visitor	7
23	Common Red Shank	*Tringa totanus*	Common	Winter visitor	58
24	Gull-billed Tern	*Gelochelidon nilotica*	Common	Winter visitor	20
25	Caspian Tern	*Sterna caspia*	Scarce	Passage migrant	1
26	Lesser Crested Tern	*Sterna benghalensis*	Scarce	Irr-year round visitor	6
27	Indian River Tern	*Sterna aurantia*	Scarce	Winter visitor	3
28	White-cheeked Tern	*Sterna repressa*	Scarce	Summer visitor	4
29	Little Tern	*Sterna albifrons*	Common	Winter visitor	12
30	Whiskered Tern	*Chlidonias hybridus*	Scarce	Irr-year round visitor	3
31	Blue Rock Pigeon	*Columba livia*	Common	Resident	98
32	Collared Dove	*Streptopelia decaocto*	Common	Resident	17
33	Little Brown Dove	*Streptopelia senegalensis*	Common	Resident	26
34	Rose-ringed Parakeet	*Psittacula krameri*	Common	Resident	11
35	Pied Crested Cuckoo	*Clamator jacobinus*	Scarce	Summer breeder	1
36	Common Koel	*Eudynamys scolopacea*	Common	Resident	16
37	Common Crow Pheasant	*Centropus sinensis*	Scarce	Resident	3
38	White-breasted King fisher	*Halcyon smyrnensis*	Scarce	Resident	11
39	Common Kingfisher	*Alcedo atthis*	Common	Resident	1
40	Pied Kingfisher	*Ceryle rudis*	Common	Resident	25
41	Little Green Bee-eater	*Merops orientalis*	Common	Resident	26
42	Lesser Golden-backed Woodpecker	*Dinopium benghalensis*	Scarce	Resident	2
43	Singing Bush Lark	*Mirafra cantillans*	Scarce	Resident	4
44	Crested Lark	*Galerida cristata*	Common	Resident	7

45	Small Sky Lark	*Alauda gulgula*	Common	Resident	17
46	Common/Barn Swallow	*Hirundo rustica*	Common	Winter visitor	4
47	Wire-tailed Swallow	*Hirundo smithi*	Common	Resident	14
48	Paddy-field Pipit	*Anthus rufulus*	Common	Resident	11
49	Common Wood Shrike	*Tephrodornis pondicerianus*	Scarce	Resident	4
50	White cheeked Bulbul	*Pycnonotus leucogenys*	Common	Resident	63
51	Red-vented Bulbul	*Pycnonotus cafer*	Common	Resident	5
52	Pied Bush Chat	*Saxicola caprata*	Common	Resident	10
53	Streaked/Graceful Prinia	*Prinia gracilis*	Scarce	Resident	2
54	Rufous fronted Prinia	*Prinia buchanani*	Common	Resident	8
55	Plain Prinia	*Prinia inornata*	Scarce	Resident	2
56	Common Babbler	*Turdoides caudatus*	Common	Resident	98
57	Striated Babbler	*Turdoides earlei*	Scarce	Resident	2
58	Jungle Babbler	*Turdoides striatus*	Common	Resident	36
59	Purple Sun Bird	*Nectarinia asiatica*	Common	Resident	44
60	Black Drongo	*Dicrurus macrocercus*	Common	Resident	10
61	Indian Tree-Pie	*Dendrocitta vagabunda*	Common	Resident	6
62	Indian House Crow	*Corvus splendens*	Common	Resident	145
63	Common Myna	*Acridotheres tristis*	Common	Resident	89
64	Bank Myna	*Acridotheres ginginianus*	Common	Resident	17
65	Indian House Sparrow	*Passer domesticus*	Common	Resident	62
66	Tailor Bird	*Orthotomus sutorius*	Common	Resident	12
67	Black-shouldered Kite	*Elanus caeruleus*	Scarce	Resident	1
68	Streaked Weaver	*Ploceus manyar*	Common	Resident	42
	Total				1366

3.4.2.2 Winter

Table 10 shows the list of bird species recorded from Keti Bunder during winter. A total of 91 species were recorded.

Table 10 – list of bird species recorded from Keti Bunder during winter

Sr. No.	Common Name	Scientific Name	Status	Occurrence	Obser. No.
1	Great Cormorant	*Phalacrocorax carbo*	Common	Winter Visitor	20
2	Indian Pond Heron	*Ardeola grayii*	Common	Resident	19
3	Cattle Egret	*Bubulcus ibis*	Common	Resident	12
4	Western Reef Egret	*Egretta gularis*	Common	Resident	28
5	Little Egret	*Egretta garzetta*	Common	Resident	09
6	Great White Egret	*Casmerodius albus*	Common	Resident	47

7	Gray Heron	*Ardea cinerea*	Common	Resident	147
8	Painted Stork	*Mycteria leococphala*	Rare	Resident	02
9	Black-Headed Ibis	*Threskornis melanocephalus*	Rare	Year-round visitor	01
10	White Spoonbill	*Platalea leucorodia*	Scarce	Year-round visitor	05
11	Greater Flamingo	*Phoenicopterus ruber*	Less Common	Year-round visitor	03
12	Eurasian Widgeon	*Anas penelope*	Common	Winter Visitor	38
13	Common Teal	*Anas crecca*	Common	Winter Visitor	155
14	Northern Pintail	*Anas acuta*	Common	Winter Visitor	31
15	Crested Honey Buzzard	*Pernis ptilorhynchus*	Scarce	Year-round visitor	01
16	Black-shouldered Kite	*Elanus caeruleus*	Less Common	Resident	02
17	Black Kite	*Milvus migrans*	Common	Resident	25
18	Brahminy Kite	*Haliastur Indus*	Less Common	Resident	40
19	Marsh Harrier	*Circus aeruginosus*	Less Common	Winter Visitor	03
20	Shikra	*Accipiter badius*	Less Common	Resident	03
21	White eyed Buzzard	*Butaster teesa*	Less Common	Resident	02
22	Long Legged Buzzard	*Buteo rufinus*	Less Common	Winter Visitor	02
23	Osprey	*Pandian haliaetus*	Less common	Less common	05
24	Black partridge	*Francolinus francolinus*	Less common	Resident	02
25	Indian gray Partridge	*Francolinus pondicerianus*	Less common	Resident	06
26	Common Quail	*Coturnix coturnix*	Common	Double passage migrant	02
27	White breasted water hen	*Amaurornis phoenicurus*	Common	Resident	07
28	Common Coot	*Fulica atra*	Common	Winter visitor	32
29	Eurasian oystercatcher	*Haematopus ostralegus*	Common	Resident	35
30	Great Stone Curlew	*Eracus recurvirostris*	Scarce	Winter visitor	02
31	Kentish or Snowy Plover	*Charadrius mongolus*	Common	Winter visitor	14

32	Lesser Sand Plover	*Charadrius leschenaulti*	Common	Resident	101
33	Greater Sand Plover	*Charadrius leschenaultia*	Common	Winter Visitor	140
34	Red Wattled Lapwing	*Hoplopterus indicus*	Common	Winter visitor	58
35	Little stint	*Calidris minuta*	Less common	Winter visitor	74
36	Whimbrel	*Numenius phaeopus*	Common	Winter visitor Winter visitor	05
37	Eurasian curlew	*Numenius arquata*	Common	Winter visitor	242
38	Red shank	*Tringa tetanus*	Common	Winter visitor	72
39	Green Shank	*Tringa nebularia*	Common	Winter visitor	30
40	Great Black Headed Gull	*Larus ichthyaetus*	Less common	Winter visitor	134
41	Brown headed gull	*Larus brunnicephalus*	Common	Resident	18
42	Slender billed gull	*Larus genei*	Common	Winter visitor	164
43	Herring gull	*Larus argentatus*	Common	Winter visitor	398
44	Heuglins gull	*Larus heuglini*	Common	Winter visitor	154
45	Slack headed gull	*Larus ridibundus*	Common	Winter visitor	650
46	Gull billed tern	*Gelochelidon nilotica*	Common	Winter visitor	97
47	Caspian tern	*Sterna caspia*	Common	Irregular year round visitor	28
48	Great crested tern	*Sterna bergii*	Less common	Irregular year round visitor	04
49	Lesser crested tern	*Sterna bengalensis*	Less common	Irregular year round visitor	03
50	Indian river tern	*Sterna aurentia*	Common	Winter Visitor	39
51	Black billed tern	*Sterna acuticauda*	Scarce	Winter Visitor	04
52	Little tern	*Sterna albifrons*	Common	Resident	82
53	Whiskered Tern	*Chlidonias hybridus*	Common	Year-round visitor	117
54	Blue rock pigeon	*Columba livia*	Common	Resident	27
55	Indian collard Dove	*Streptopelia decaocto*	Common	Resident	22
56	Litter Brown Dove	*Streptopelia senegalensis*	Common	Resident	21
57	Rose ringed parakeet	*Psittacula krameri*	Common	Resident	24
58	Koel	*Eudynamys scolopaeea*	Less Common	Resident	05
59	Crow pheasant	*Centropus sinensis*	Less Common	Resident	04
60	Short eared owl	*Asio flammeus*	Scarce	Winter Visitor	01

61	Sykes's or Sindh night jar	*Caprimulgus mahrattensis*	Less Common	Resident	03
62	White throated kingfisher	*Halcyon smyrnensis*	Common	Resident	12
63	Common Kingfisher	*Alcedo atthis*	Less Common	Resident	1
64	Small Pied kingfisher	*Ceryle radis*	Less Common	Resident	08
65	Little green bee-eater	*Merops orientalis*	Less Common	Resident	06
66	Indian roller or blue jay	*Coracias benghalense*	Less Common	Resident	05
67	Lesser golden backed wood pecker	*Dinopium benghalense*	Less Common	Resident	02
68	Crested lark	*Galerida cristata*	Less Common	Resident	03
69	Small Indian skylark	*Alanda gulgula*	Common	Resident	18
70	Yellow wagtail	*Motacilla flava*	Less Common	Winter Visitor	03
71	White wagtail	*Motacilla alba*	Less Common	Winter Visitor	07
72	White cheeked bulbul	*Pycnonotus leucogenys*	Less Common	Resident	02
73	Red-vented Bulbul	*Pycnonotus cafer*	Common	Resident	21
74	Blue throat	*Luscinia svecica*	Less Common	Winter Visitor	03
75	Pied bush chat	*Saxicola caprata*	Less Common	Resident	05
76	Rufous fronted wren warbler /prinia	*Prinia buchanani*	Less Common	Resident	03
77	Tailor Bird	*Orthotomus sutorius*	Less Common	Winter Visitor	02
78	Lesser Whitethroat	*Sylvia curruca*	Common	Winter Visitor	18
79	Eurasian Chiffchaff	*Phylloscopus collybita*	Less Common	Resident	05
80	White-Browed fan tail fly catcher	*Thipdura aurela*	Less Common	Double Passage Migrant	02
81	Asian Paradise Flycatcher	*Terpsiphone paradise*	Common	Resident	02
82	Common Babbler	*Turdoides caudatus*	Common	Resident	69
83	Jangle Babbler	*Turdoides striatus*	Less Common	Resident	66
84	Purple sunbird	*Nectarinia asiatica*	Less Common	Resident	04
85	Oriental White-eye	*Zosterops palpabrosa*	Less Common	Resident	15
86	Indian Tree-pie	*Deridrocitta vagabunda*	Common	Resident	15
87	Indian House Crow	*Corvus splendens*	Common	Resident	47
88	Rosy Pastor	*Sturnus roseus*	Common	Double Passage Migrant	62
89	Common Myna	*Acridotheres tristis*	Common	Resident	16
90	Bank Myna	*Acridotheres ginginianus*	Common	Resident	21
91	Indian House Sparrow	*Passer domesticus*	Common	Resident	215

3.4.3 Summer and winter

The results also show that the number of species found in the winter survey was greater than the results of the summer survey. A total of 91 species were found in winter whereas 68 species of birds were found in the summer. A major reason for this could be the presence of migratory birds in the winter.

Figure 8 – Number of species, families and orders observed during the summer and winter season

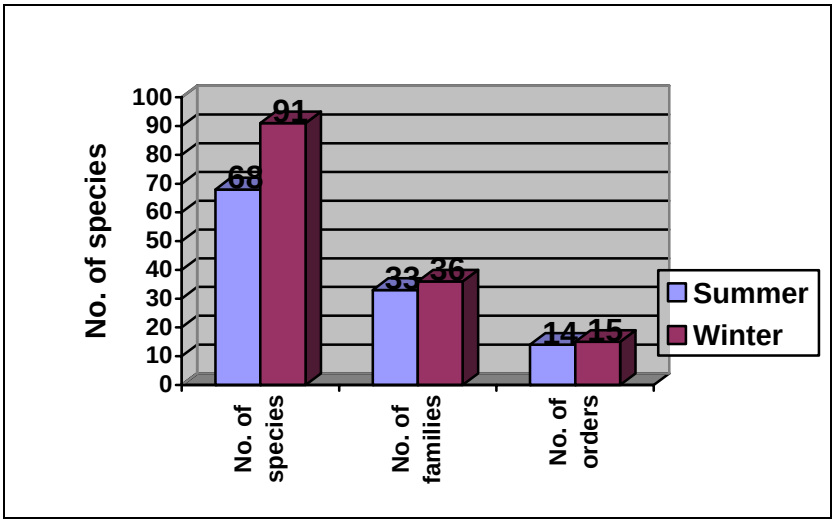


Figure 9 – The abundance of the number of species during the summer and winter season

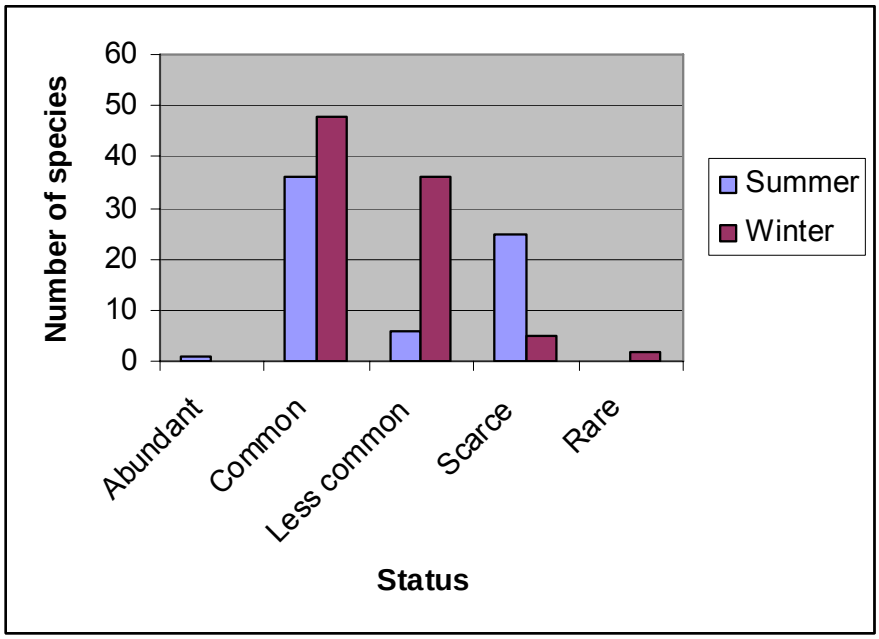


Figure 10 – Representation of birds found during the two seasons

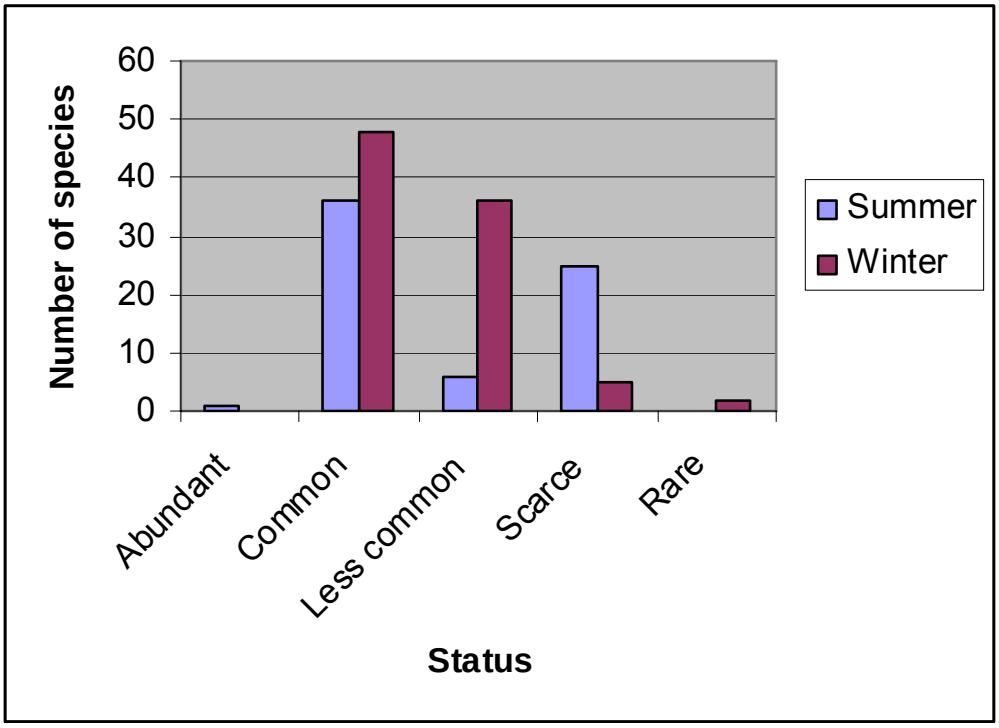
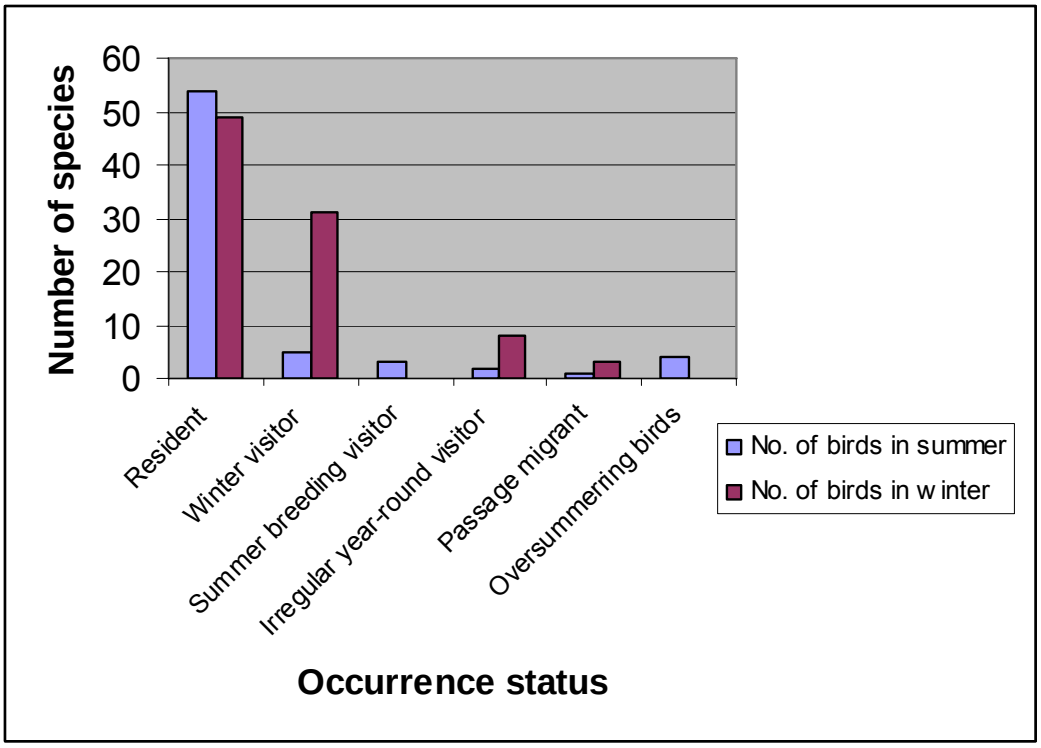


Figure 11 – Number of bird species recorded from Keti Bunder against season and occurrence



3.4.4 Threats and recommendations

3.4.3.1 Threats

- Hunting and poaching of birds is a major threat in the area despite the area being declared a wildlife sanctuary;

- Removal of habitat, primarily mangroves has deprived many species of breeding and feeding grounds. Very few birds are unable to breed in the creeks due to lack of forest cover;

- The presence of feral dogs inland and in nearly every creek is probably having an effect on the local bird population, especially terrestrial nesting birds. There is also numerable feral cats that are probably exuberating the threat of un-natural predators.

3.4.3.2 Recommendations

- The entire aquatic and terrestrial biodiversity need to be conserved particularly the mammals, water-birds and the mangroves. Protecting the existing mangroves should also be a priority;

- There is a need to prepare Management Plan for the Keti Bunder North and Keti Bunder South Wildlife Sanctuary outlining conservation initiatives such as community;

- An attempt should be made to control the feral dog (and cat) population in and around Keti Bunder. This will not only help conserve the bird population but will help wildlife in general.

Image 5 – Oriental white eye at Keti Bunder

Image 6 – Reef Egret at Keti Bunder

Image 7 – Common redshank at Keti Bunder

Image 8 – Jungle babbler at Keti Bunder

3.5 Marine fisheries

3.5.1 Sampling locations

Map 8 shows the sampling locations for marine fisheries at Keti Bunder

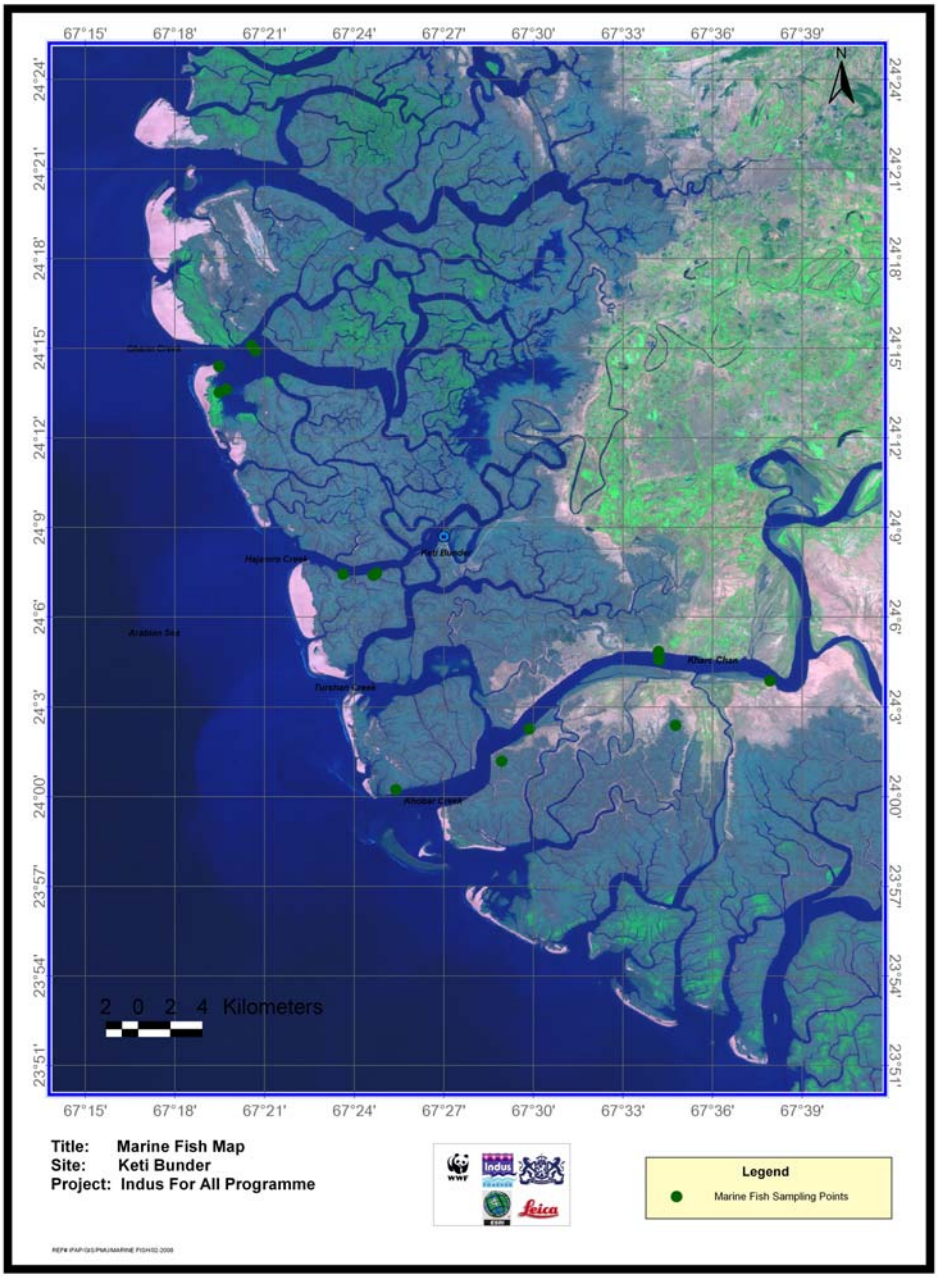


Table 11 shows the sampling locations covered in the winter survey. The table also shows some water qualities that were recorded during the survey as well as some of the abundant species collected.

Table 11 – Stationed sampled during the study

Date	Locality	Latitude	Longitude	Salinity	DO	Temp. ^{0}C	Net Operated	Abundant species
8-9-07	Left bank of Hajamro Creek	24^{0}07'379 N	67^{0}24'666 E	20 ppt	5 mg/l	25	Beach Seine net	Juveniles
8-9-07	Tippan village (Left bank of Hajamro Creek)	24^{0}07'422 N	67^{0}23'632 E	20 ppt	5 mg/l	24	-do-	Goboid fishes
9-9-07	Kharo Chann Creek	24^{0}04'574 N	67^{0}34'211 E	1 ppt	less than 5 mg/l	23	-do-/ Gill net	Mullets/ Palla
10-9-07	Chann Creek	24^{0}13'633 N - 24^{0}14'389 N	67^{0}19'753 E 67^{0}19'478E	30 ppt	5 mg/l	20	Gill net	Palla
23.09.07	G.M. Barrage			5 ppt	5 mg/l	21	Gill net	Palla
11-11-07	Chann\ Creek	24^{0}14'909 N 24^{0}15'016 N	67^{0}20'699 E 67^{0}20'625 E	41 ppt	-do-	22	Bulla Gujjo	Shrimps
12-11-07	Kharo Chann Creek	24^{0}04'835 N	67^{0}34'191 E	24 ppt	6mg/l	20	Bulla Gujjo	Varity of small fish and shrimp juveniles
12-11-07	Khobar Creek	24^{0}00'230 N	67^{0}25'399 E	40 ppt	7 mg/l	23	Bulla Gujjo	Juvenile fishes
12-11-07	Near mouth of river Indus, at Kharo Chann Creek	24^{0}02'265 N	67^{0}29'867 E	23 ppt	5mg/l	21	Ruch	Palla juveniles
12-11-07	At the mouth of river Indus, near Kharo Chann Creek	24^{0}03'877 N	67^{0}37'927 E	19 ppt	6 mg/l	23	Bulla Gujjo	Palla juveniles and other small fishes
5-2-08	Hajamro Creek	24^{0}07'386N	67^{0}24'645 E	40 ppt	7mg/l	16	Ruch	Lady fish, Mullets, Albula, Engraulids
5-2-08	Chann Creek	24^{0}13'617 N	67^{0}19'724 E	40 ppt		14	Ruch	Lady fish, Mullets, Albula, Engraulids
6-2-08	Khobar Creek	24^{0}00'70.9 N	67^{0}28'56.5 E	40 ppt		13		Dolphins, Scombrids, Sparids, Pomfrets, Lobsters
6-2-08	Kharo-Chann Creek	24^{0}02'23.3 N	67^{0}34'45.7 E	38 ppt		13	Ruch	Scats, Harpodon, Sciaenids, Sparids, Pomfrets

3.5.2 Summary

Compared to inland where number of fishermen engaged is higher than those exploiting marine resources but the marine fish catches are overwhelmingly higher than inland fish catches. During the year 1995 – 2003 the higher catches were recorded from 1997 – 2000 with highest of 474456 metric tons in 1999 (Anon, 2006 b). Further separation of the data between cartilaginous and bony fishes indicates higher catch of sharks and rays than that of bony fishes.

Elasmobranches are quite diverse and abundant there are number of pelagic and demersal species that often are caught and sometime form abundant part of the commercial catches. Saw sharks (Pristophoridae) are rare and often caught in deeper parts of Arabian Sea. Hammer headed sharks (*Sphyrna sp*) once very common are rare in catches. Saw-fish (Pristidae) are seen in trawl catches. Several species of Rajidae occur through out the Arabian Sea, Rhinobatidae, Torpedinae, Rajinae and Dasyatinae commonly occur in estuaries and shallow open seas. There is no specific fishery but these species are often caught in trawl net and because of low fecundity are especially sensitive to fishing pressure (Anon, 2006 b). Since the study of Qureshi, 1972 no other studies have appeared in the literature. There are some published lists of Elasmobranches species given as check list of Marine fishes of West Pakistan (Jaleel and Khalil Uddin, 1972).

Dominant pelagic communities are the fishes of Clupeiformes. These are not only in pelagic ecosystem but also in the benthic-demersal ecosystem. Several species dominant in occurrence in the region belong to genera *Ilisha, Pellona, Pellonula, Opisthonema, Opisthopterus* and *Sardinella* (Qureshi, 1955). All Clupeiformes fishes are separated as *Clupeoides*, Shads, *Sardinella Thryssa*, *Chirocentru*s and *Megalops*. The abundant species is *Sardinella longiceps* its catches have declined from 45 thousand metric tons in 1995 to 21,000 metric tons in 2003. The other abundant species is *Thryssa* sp its catches were 17,000 metric tons in 1995 and have declined to 10,000 metric tons. Other species caught show low catches but the decline in their catches from 1995 to 2003 is very distinct (Anon, 2006 b). Mostly these species constitute major part of trash fisheries that is used for poultry feed or in fertilizers industry.

Among the marine catfishes Ariidae, Tachysuridae occur inshore and in estuarine areas. *Arius, Bagre* and *Trachysurus* dominate this group (Qureshi, 1955). Some larges Size of catfish Ariidae were observed during November surveys in catch from Keti Bunder. Among the fishes of Scorpaeniformes Trigla, Lepidotrigla, Prionotus and Platycephalus are found abundant in the coastal areas, estuaries and along the continental shelf.. (Qureshi, 1955; 1970). Three families Synodontidae, Harpodontidae and Chlorophthalmidae of Myctophiformes are abundant along the continental shelf areas (Qureshi, 1955; 1970). Perciformes is the largest group of fishes that dominate the demersal fish fauna of coast, estuaries, mangrove swamps and continental shelf of the tropical sea. Along the coast of Pakistan three groups of the Perciformes can be separated into species associated with inshore muddy areas, of sandy bottoms like that of continental shelf and those that inhabit rocky areas.
Drums and croakers (Sciaenids, Pseudotolithus) dominate demersal fish fauna. On muddy grounds and in the creeks (Hussain, 1973). In associations with Sciaenids are the threadfin fishes Polynemidae, Mugillidae and Ehippidae (Spade fishes) (Qureshi, 1960a. and b. 1969; Husain, 1973). Wide variety of Perciform families occur on sandy grounds are Sparidae, Nemptridae, Pomadasyidae, Mullidae, Gerridae and Leiognathids. *Epinephelus, Serranus*, *Lutjanus, Lethrinus* etc are the dwellers of rocky grounds in estuaries and offshore waters (Hussain, 1973). Generally Groupers and snappers dominate in trawl catches and long line fishing operations (Qureshi, 1955; Hassan, and Qureshi, 1969). The other important commercial group of fishes belongs to Perciformes which is represented by more than 100 species in catches. Species of *Epinephelus, Pomadsys, Lutjanus,*

Lethrinus, Pampus, Carangoides, and species of *Sciaenidae, Protonibes diacanthus, Nemipterus japonicus and* species of Trichiuridae are of common abundance from both Sindh and Balochistan regions. Species which are only represented in higher number from Sindh *Epinephelus, Lutjanus*, *Sillagnids*, *Acanthopagrus, Parastromateus niger* and species of Trichiuridae. Species more common from Balochistan are *Epinephelus,* species of Sciaenidae*, Pomadsys, Rachycentron canadium, Pampus argenteus,* Species of Carangoides*, Coryhaena hippurus.* Most of the species had peak some time in 1995 or in 2000 after that decline in their catch is observed (Anon, 2003). Except few species all observed species are over fished. The reduction of catch is due to the modern mechanized fishing techniques and greater investment input, which results in the addition of higher number of unplanned efforts (Anon, 2006b). Somewhat common in occurrence throughout the coastal areas are the two groups of flounders *Psettodes* and *Cynoglossus.* The other groups that belong to continental fauna are the fishes of families Balistidae, Tetrodontidae, Ostraciontidae and Zaidae which sometimes constitute the major portion of trawl catches (Hussain and Ali-Khan, 1980, 1982 a & b; Khaliluddin, 1975). The detail fish production during 1989 – 2006 from the coast of Pakistan is given in table.1.

3.5.3 Species account

Table 12 and **13** give the details of fish species recorded from Keti Bunder during summer and winter surveys.

3.5.4 Environmental features of Indus delta close to Keti Bunder:

Indus delta all along its creeks is shallow of about 2.5 m with some scour holes of 4 m depth in average. The information provided by the fishermen and available data the greatest depth of 9 m has been reported at some areas along the Indus delta. Width of the delta range from 750 m – 1050 m Average tidal level may be 0.27 – 1.95 m. Tides in the delta are mixed and characterized by progressive wave extending to 175 km upstream. The average tide levels are 1.678 m and in neap tide 0.88 m.

Salinity in most of the creeks during the period of September was noted as 20‰. The salinity is subject to change at places where seawater intrusion is expected during southwest monsoon. It may even reduce during rain and in NE monsoon period. Highest temperature at the surface is reported as 28^0 C. Temperature in the estuary follow seasonal changes minimum temperature reported as 13^0 C as observed in the month of February.

3.5.5 Current velocities as reported to be bi-directional simultaneous currents

Dissolved oxygen at the surface was recorded as 5mg/l in Kharo Chann Creek and 3.5 mg/l at Chann Creek. Kharo Chann is main hub of the delta that connects the river to sea. Till September the salinity in the area is low about 1ppt in November sea water intrudes the delta and the salinity increases resulting the destruction of major agriculture and Fisheries resources.

Table 12 – List of marine fish species recorded from Keti Bunder

	Species	Family	English name	Local name	Max size (cm)	Weight (gm)	Commercial value	Depth (m)	Habitat	Feeding habits
1	Arius dussumieri	Ariidae	Sea cat fish		60	1400	Average	20-50	Found along the coast. Enters the lower parts of rivers.	Feeds on invertebrates and small fishes
2	Arius maculatus	Ariidae	Spotted catfish	Khagga	40	50	Low	2-10	Inshore and estuarine water	Invertebrate and small fishes
3	Osteogeneiosus militaris	Ariidae	Soldier cat fish		35		Medium	10-90	Marine, coastal waters, as well as in estuaries and river mouths.	Polychaetes, small crustaceans, small fishes
4	Mystus gulio	Bagridae	Long whisker catfish		45		Medium	0-10	Brackish water fish that enters in fresh water	Aquatic insects and worms
5	Strongylura strongylura	Belonidae	Spottail needlefish		40		High	10-13	Coastal areas and mangrove-lined lagoons, also enters freshwater	Small fishes, especially clupeoids
6	Strongylura leiura	Belonidae	Banded needlefish	Kangho	100	200	Average	1-2 (pelagic)	Coastal waters, estuaries as well as freshwaters	Small fishes
7	Pseudorhombus arsius	Bothidae	Largetoothed flounder	Kuker-jeeb	35	1000	high	1-100	Esturine Continental shelf	Bottom living animals
8	Alepes djedaba	Carangidae	Shrimp scad	Seem, Bangra	40	90	Average	3-10	Coastal water and reef areas (Amphidromous)	Crustacean and copepods
9	Carangoides chrysophrys	Carangidae	Longnose trevally	Seem, Bangra	72	500	Average	30 - 60	Open waters of coastal reefs	Crustacean, copepods
10	Caranx para	Carangidae	Banded scad	Bangra, Kakkar	20	500	low	2-10	Inshore coastal	zooplankton
11	Scomberoides commersonnia nus	Carangidae	Blacktip leatherskin	Aal, Saram	120	16,000	high	10-200	Coastal waters	Fish, crustacean
12	Trachinotus blochii	Carangidae	Snubnose Pompano	Sonab	110	3,400	high	0-7	Juveniles in shallow sandy or muddy bays near river mouths	Molluscs and crabs
13	Chirocentrus dorab	Chirocentridae	Dorab wolf herring	Kerli, gairi	100	500	Average	0-120	Pelagic, inshore	Small fishes and crustaceans
14	Nematolosa nasus	Clupeidaae	Long-ray bony bream	Daddi-palli	22	200	Average	0-30	Pelagic, coastal waters, entering estuaries, creeks	Detritus, phyto and zooplankton

15	Anodontostoma chacunda	Clupeidae	Shortnose Gizzard Shad	Daddi-palli	17	150	low	0-50	Pelagic, in inshore waters	Detritus, phyto and zooplankton
16	Escualosa thoracata	Clupeidae	White sardine	Mithoo	10	15	low	0-50	Pelagic in coastal waters	Phytoplamkton and Zooplankton(copepods, crabs, bivalve larvae, fish eggs
17	Ilisha megaloptera	Clupeidae	Bigeye ilisha	Palli	28	200	low	0-50	Pelagic in coastal waters	Fish and crustacean
18	Ilisha melastoma	Clupeidae	Indian ilisha	Palli	12	70	low	0-50	Pelagic in coastal waters	Mollusc
19	Opisthopterus tardoore	Clupeidae	Tardoore		20	90	low	35-40	pelagic; amphidromous	Small crustacean and zooplankton
20	Tenualosa ilisha	Clupeidae	Hilsa shad	Palla	60	2,490g	high	0-200	pelagic; anadromous	plankton, mainly by filtering, but apparently also by grubbing on muddy bottom
21	Cynoglossus bilineatus	Cynoglossidae	Tonguesoles	sole	44	225	high	10 - 400	Coastal areas and estuaries. May ascend into the freshwater	bottom-living invertebrates
22	Cynoglossus dubius	Cynoglossidae	Tonguesoles	sole	50	300	high	10	Continental shelf	Bottom-living invertebrates
	Cynoglossus arel	Cynoglossidae	Tonguesoles	Sole	40	220	Average	10-125	Inhabits muddy and sandy bottoms of the continental shelf	Bottom-living invertebrates
23	Himmantura walga	Dasyatidae	Dwarf whipray		45			20-30	Inshore waters	
24	Elops machnata	Elopidae	Tenpounder	Kinarhal	90	10,000	Average	0-50	Inhabits shallow coastal waters, estuaries and bays	Small fishes, mollusks, shrimps, crabs
25	Coilia dussumieri	Engraulidae	Anchovy	Patia	20	15	low	0 - 50	Pelagic; Amphidromous	copepods, prawn and fish larvae
26	Thryssa hamiltonii	Engraulidae	Thryssa	Phyasa	20	40	low	10-13	Pelagic in coastal waters, estuaries	mainly on crustaceans (zoea larvae, amphipods, Acetes)
27	Thryssa setirostris	Engraulidae	Thryssa	Phyasa	15	40	low	1-20	Pelagic in coastal waters, estuaries	mainly on crustaceans (zoea larvae, amphipods, Acetes)
28	Gerres filamentosus	Gerreidae	Long-rayed silver- biddy	Jerkari	25	125	low	1-50	Shallow coastal waters	crustaceans, polychaetes and forams on sand or muddy-sand

										bottoms
29	Gerres oyena	Gerreidae	Lined silver-biddy	Jerkari	30.	125	low	0-20	coast, saltwater lagoons, and estuaries	crustaceans, polychaetes and forams on sand or muddy-sand bottoms
30	Glossogobius giuris	Gobiidae				40	low	1-10		small insects, crustaceans and small fish
31	Periophthalmus koelreuteri	Gobiidae	Mud skipper		10	40	low	0.5	Coastal areas	small fish,crabs and other arthropods
32	Periophthalmus weberi	Gobiidae	Weber's mudskipper		10		Low		Inhabits brackish mangroves	
33	Psammogobius biocellatus	Gobiidae	Sleepy gobby		12	35	Low	1-10	Intertidal areas, estuaries, lagoons and coastal rivers Common in mangroves, occasionally penetrates the lower reaches of freshwater streams	Small crustaceans and Zooplanktons
34	Pomadasys kaakan	Haemulidae	Grunter	Dhother	80	35000	high	1-60	Coastal waters	benthic invertebrates and small fishes
35	Pomadasys stridens	Haemulidae	striped grunter	Bukra	20	15000	high	65 - 68	coastal waters	benthic invertebrates and small fishes
36	Hyporamphus dussumieri	Hemiramphidae	Dussumier's halfbeak		40		Medium	2-15	Most common around islands and coral reefs	Aquatic insects
37	Hyporamphus (Hyporamphus) limbatus	Hemiramphidae	Congaturi halfbeak	Thute	22	40	Average	1-2	Marine and brackish water	omnivorous
38	Lates calcarifer	Latidae	Baramundi	Dangri	200	60,000	high	10 -40	demersal; catadromous	crustaceans, molluscs, and smaller fishes
39	Leiognathus balochi	Leiognathidae	Twoblotch pony fish		10		Medium	0-40	Found on shallow waters near the bottom.	Small crustaceans, foraminiferans and nematodes
40	Leiognathus equalus	Leiognathidae	Common ponyfish		28		Minor	10-70	Coastal inhabitant, ascends into freshwater	Polychaetes, small crustaceans, small fishes
41	Leiognathus daura	Leiognathidae	GoldstripePony fish	Kaanteri	14	30	low	0-40	Shallow waters	polychaetes, bivalves, small

										crustaceans and sponges
42	Leiognathus splendens	Leiognathidae	Splendid ponyfish	Kaanteri	17	40	low	10 - 100 m	coastal waters	fish , crustaceans , foraminiferans , and bivalves
43	Secutor insidiator	Leiognathidae		Kaanteri	11.3	25	low	10 - 150	shallow waters	zooplankton including copepods, mysids, and larval fishes and crustaceans
44	Lutjanus johnii	Lutjanidae	One spot golden snapper	Hira	35	40000	high	5-80	Shallow coastal waters mainly around mangroves	fishes and benthic invertebrates including shrimps, crabs and cephalopods
45	Liza carinata	Mugilidae	Keeled mullet	Boi, Mori	25	40	Average	1-10	Marine coastal waters	small benthic invertebrates, planktonic organism alga and detritus
46	Liza melinoptera	Mugilidae	Large scale gery Mullet	Boi, Mori	22	30	low	1-15	Coastal waters, Estuaries	Feeds on plant detritus, microalgae, minute benthic organisms, and organic matter in sand and mud
47	Liza parsia	Mugilidae	Gold spot mullet	Boi, Parsi	16	30	low	10-30	Shallow coastal waters	small benthic invertebrates, planktonic organism alga and detritus
48	Liza subviridis	Mugilidae	Green back mullet	Chhodi	30	500	high	0.5-1	Coastal waters, estuaries	small algae, diatoms and benthic detrital material taken in with sand and mud
49	Mugil cephalus	Mugilidae	Large scale mullet	Pharra, Boi	60	12,000	high	0 - 120	Coastal areas ,enters estuaries and rivers	Omnivorous zooplankton, benthic organisms and

										detritus
50	Valamugil cunnesius	Mugilidae	Long arm mullet	Pharra, Boi	50	1000	high	0-10	Coastal waters, estuaries, enters rivers	organic matter contained in sand and mud
51	Upeneus vittatus	Mullidae	Yellow-striped goatfish	Manori	28	300	Average	1-100	Turbid waters	small crustaceans
52	Congresox talabonoides	Muraenesocidae	Pike congers	Bam	250	50000	Average	10-100	Continental shelf	Feeds at night, on bottom fishes and crustaceans
53	Pisodonophis canarivorous	Ophichthidae	Long fin snake eel		110		Minor	1-50	Tidal channels and estuaries	Small fish and crustaceans
54	Grammoplites suppositus	Platycephalidae	Softfiin flathead	Kuker	25	300	Average	1-75	Rocky shores	crustaceans and small fish
55	Platycephalus indicus	Platycephalidae	Bartail flathead	Kuker	100	3000	High	20-200		crustaceans and small fish
56	Eleutheronema tetradactylum	Polynemidae	Four finger threadfin	Seeri, Ranwas	200	80000	High	0-25	Shallow coastal waters entering river mouths	prawns and fish
57	Polynemus indicus	Polynemidae	Indian threadfin	Seeri, Ranwas	200	80000	High	55-100	Shallow coastal waters	omnivorous and feeds on diatoms, copepoda, crustaceans and smaller fish
58	Scatophagus argus	Scatophagidae	Spoted scat	Korgi	38	2000	Average	1 - 4	Inhabit brackish estuaries and the lower reaches of freshwater	worms, crustaceans, insects and plant matter
59	Johnius belangerii	Sciaenidae	Croaker		30		Minor	0-40	Inhabits coastal waters and estuaries	Invertebrates, particularly worms.
60	Johnius dussumieri	Sciaenidae	Silver Jewfish	Mushka	30	40	Average	1-40	coastal waters. Enters estuaries	invertebrates and small fishes
61	Otolithes ruber	Sciaenidae	Rosy jewfish	Mushka	90	7,000	High	10 - 40	Coastal waters	fishes , prawns and other invertebrates
62	Protonibea diacanthus	Sciaenidae	Jewfish	Sua	120	60000	High	0-60	Coastal waters	crustaceans and small demersal fishes
63	Rastrelliger chrysozonus	Scombridae	Indian mackerel	Bangra	35	120	high	2-10	Coastal water	Fish and shrimp larvae

64	Rastrelliger kanagurta	Scombridae	Indian mackerel		35		Highly commercial	20-90	Occurs in coastal bays, harbors and deep lagoons	Phytoplank and zooplankton
65	Scomberromorus guttatus	Scombridae	Indo-Pacific king mackerel	Kalgund	76	800	high	8-200	Coastal to deeper water	Fishes and cephalopods
66	Promicrops lanceolatus	Serranidae	Grouper	Gisser	270	400,000	High	1 -300		fishes, large crustaceans and ... Chelonia mydas
67	Sillago sihama	Sillaginidae	Silver whiting	Bhamboore	25	40	High	0-60	Shores, Bays, Creeks, estuaries	mainly on polychaetes and other benthic organisms
68	Solea elongate	Soleidaae	Solea	Phani	30	30	low	10-30	Shallow coastal waters	benthic invertebrates, especially small crustaceans
69	Acanthopagrus berda	Sparidae	Black Bream	Dandya	50	1,500	High	1-50	Muddy grounds in estuarine areas	invertebrates, including worms, mollusks, crustaceans and echinoderms
70	Acanthopagrus latus	Sparidae			50	1,500	High	0-50	coastal waters, estuaries, river mouth	echinoderms, worms, crustaceans and mollusks.

71	Sparidentex hasta	Sparidae	Sobaity seabream		50		Minor	1-2	Shallow coastal waters to moderate depths	Carnivore eating crustaceans, worms, insects
72	Sphyraena putnamiae	Sphyraenidae	Barracuda	Kund	90	40000	High	1-100	inshore-pelagic	fishes and large invertebrates
73	Pampus argenteus	Stromateidae	Silver pomfret	Achopito, Sufaid poplet	60	30000	High	5 - 110	Inshore species	ctenophores, salps, medusae, and other zooplankton groups
74	Pseudosynanceia melanostigma	Synanceiidae	Blackfin stone fish		12	30-60	None	1-30	Brackish and marine waters in coastal areas	
75	Terapon jerboa	Teraponidae	Jerbua terapon	Ginghra	36	10000	Average	20 -290	Vicinity of river mouths, Estuarine, demersal; catadromous	Omnivorous, feeds upon fishes, insects, benthic invertebrates, and algae
76	Terapon puta	Teraponidae	Smallscale terapon	Ginghra	15	25	low	0-30	Inhabits coastal waters, entering brackish estuaries and mangrove areas Also in fresh waters	small fishes and invertebrates
77	Tetrodon lunaris	Tetraodontidae	Filefish		45	30	Low	15-80	Mainly marine, occasionally enters estuaries	Small invertebrates
78	Lepturacanthus savala	Trichiuridae	Hairtail	Talwar	120	3000	high	1-100	Benthopelagic	variety of small fishes and crustaceans

Table 13 – List of marine fish species recorded from Keti Bunder during winter

	Scientific Name	Family	Common Name	Local Name	Migratory	Resident	Abundant	Less Common	Rare
1	*Scolidon laticaudus*	Carcharhinidae	Spade-nose shark						
2	*Sardinella sindensis*	Clupeidae	Sind sardinella		+			+	
3	*Sardinella gibbosa*	Clupeidae	Goldstripe sardinella		+		+		
4	*Sardinella albella*	Clupeidae	White Sardinella	Tarli, Luar Tarli, Luar	+				
5	*Escualosa thoracata*	Clupeidae	White sardine	Mithoo	+			+	
6	*Hilsa kelee*	Clupeidae	Kelee shad	Palli	+			+	
7	*Tenualosa toli*	Clupeidae	Toli shad	Nur-palla	+				+
8	*Nematalosa nasus*	Clupeidae	Bloch's gizzard shad	Daddi-palli	+				
9	*Anodontostoma chacunda*	Clupeidae	Chacunda gizzard-shad	Daddi-palli	+				
10	*Dussumieria acuta Valenciennes*	Clupeidae	Rainbow sardine	Tel-tampri	+				
11	*Pellona ditchela Valenciennes,*	Clupeidae	Indian pellona	Palli		+			
12	*Opisthopterus tardoore*	Clupeidae	Tardoore	Koor, Palli		+			+
13	*Thryssa dussumieri*	Engraulidae	Gold-spotted grenadier anchovy	Paddan		+	+		
14	*Thryssa hamiltonii*	Engraulidae	Hamilton's thryssa	Paddan			+		
15	*Thryssa mystax*	Engraulidae	Moustached thryssa	Paddan	+			+	
16	*Thryssa vitrirostris*	Engraulidae	Orange-mouth anchovy	Paddan	+				+
17	*Thrysa setirostris*	Engraulidae	Longjaw Thryssa	Paddan	+				
18	*Muraenesox cinereus*	Angullidae	Dagger-tooth pike conger		+			+	
19	*Arius arius*	Ariidae	Thread-fin sea catfish	Khagga, Singhara	+		+		
20	*Arius maculatus*	Ariidae	Spotted catfish	Khagga, Singhara	+			+	
21	*Arius teniuspinis*	Ariidae	Thin-spine sea catfish	Khagga, Singhara	+				+
22	*Arius thalassinus*	Ariidae	Giant catfish	Khagga, Singhara	+				+
23	*Arius crossocheilus*	Ariidae	Roughback sea catfish	Khagga,	+				
24	*Arius caelatus*	Ariidae	Engraved catfish	Khagga,	+				
25	*Hemiramphus far*	Hemiramphidae	black-barred halfbeak	Thute	+				+
26	*Strongylura leiura*		Banded needlefish	Kango, Kungi	+				+
27	*Platycephalus indicus*	Platycephalidae	Bartail flathead	Khuker		+		+	
28	*Terapon jarbua*	Teraponidae	Jarbua terapon	Ginghra	+				
29	*Sillago sihama*	Sillaginidae	Silver sillago	Bhambor	+		+		
30	*Lactarius lactarius*	Lactaridae	White fish	Bukko	+			+	
31	*Alepes djedaba*	Carangidae	Shrimp scad	Bangra, Seem		+			+
32	*Carangoides malabaricus*	Carangidae	Malabar trevally	Bangra, Kakkar		+			+
33	*Decapterus macrosoma*	Carangidae	Shortfin scad	Seem		+		+	
34	*Scomberoides commersonnianus*	Carangidae	Talang queenfish	Aal, Saram		+	+		
35	*Trachinotus mookalee*	Carangidae	Indian pampano	Sonaf		+	+		
36	*Megalaspis cordyla*	Carangidae	Torpedo scad	Bangra					
37	*Leiognathus blochi*	Leiognathidae	Two-blotch ponyfish	Kaanteri		+	+		
38	*Leiognathus brevirostris*		Shortnose ponyfish	Kaanteri	+				
39	*Leiognathus equulus*		Common ponyfish	Kaanteri		+	+		
40	*Harpodon nehereus*	Harpodontidae	Bombay-duck						

41	*Lutjanus johni*	Lutjanidae	John's snapper	Hira	+		+		
42	*Gerres filamentosus*	Gerreidae	Whip-fin silver-biddy	Jerki	+			+	
43	*Gerres lucidus*		Saddleback silver-biddy	Jerki	+			+	
44	*Pomadasys kaakan*	Haemulidae	Javelin grunter	Dhother	+		+		
45	*Pomadasys maculates*		Saddle grunt	Dhother	+				
46	*Acanthopagrus latus*	Sparidae	Yellowfin seabream	Dandya, Daleri	+			+	
47	*Otolithes ruber*	Sciaenidae	Tigertooth croaker	Mushka	+			+	
48	*Johnius dussumieri*	Sciaenidae	Bearded croaker	Mushka, Chan	+			+	
49	*Johnieops sina*	Sciaenidae	Sin croaker	Sua	+			+	
50	*Johnius osseus*	Sciaenidae	Croaker	Sua	+				+
51	*Drepane punctata*	Ephippidae	Spotted sicklefish	Rupichand	+			+	
52	*Liza carinata*	Mugilidae	Keeled mullet	Boi, Mori		+	+		
53	*Liza subviridis*	Mugilidae	Greenback mullet	Boi, Chhodi		+	+		
54	*Mugil cephalus*	Mugilidae	Flathead mullet	Boi, Meengh		+	+		
55	*Eleutheronema tetradactylum*	Mugilidae	Four finger threadfin	Seeri, Ranwas	+			+	
56	*Polynemus sextarius*	Polynemidae	Blackspot threadfin	Seeri					
57	*Polynemus heptadactylus*	Polynemidae	Sevenfinger threadfin	Seeri					
58	*Polynemus sexfilis*	Polynemidae	Six-finger threadfin	Seeri	+		+		
59	*Glossogobius biocellatus*	Polynemidae	Gobies	Sleepy goby	+	+	+		
60	*Gobius ocellatus*	Polynemidae	Gobies		+	+	+		
61	*Boleopthalmus tenius*	Gobiidae	Mud-skippers		+	+	+		
62	*Boleopthalmus dussumieri*	Gobiidae	Mud-skippers		+	+	+		
63	*Periopthalmus koelreuteri*	Gobiidae	Mud-skippers		+				
64	*Trichiurus lepturus*	Trichiuridae	Largehead hairtail	Chund	+		+		
65	*Pampus argenteus*	Stromateidae	Silver pomfret	Sufaid-poplet		+	+		
66	*Echeneis naucrates*	Echeneidae	Live sharksucker						
67	*Antennarius cryptacanthus*	Scorponidae	Cryptic anglerfish						
68	*Pseudorhombus arsius*	Scorponidae	Largetooth flounder		+				
69	*Synaptura orientalis*	Bothidae	Oriental sole		+				
70	*Solea ovata*	Soleidae	Fourlined tongue-sole		+				
71	*Cynoglossus macrostomus*	Cynoglossidae	Malabar tonguesole						
72	*Cynoglossus puncticeps*	Cynoglossidae	Speckled tongue-sole						
73	*Cynoglossus bilineatus*	Cynoglossidae	Carrot tongue-sole		+				
74	*Cynoglossus dubius*	Cynoglossidae	Tonguesole		+				

Table 14 – list of marine fish species recorded from Keti Bunder over summer and winter

S.no	Scientific Name	Winter	Summer
1	Acanthopagrus berda	+	-
2	Acanthopagrus latus	+	+
3	Alepes djedaba	+	+
4	Anodontostoma chacunda	+	+
5	Antennarius cryptacanthus	-	+
6	Arius arius	-	+
7	Arius caelatus	-	+

8	Arius crossocheilus	-	+
9	Arius dussumieri	+	-
10	Arius maculatus	+	+
11	Arius teniuspinis	-	+
12	Arius thalassinus	-	+
13	Boleopthalmus dussumieri	-	+
14	Boleopthalmus tenius	-	+
15	Carangoides malabaricus	-	+
16	Carangoides chrysophrys	+	-
17	Caranx para	+	-
18	Chirocentrus dorab	+	-
19	Coilia dussumieri	+	-
20	Congresox talabonoides	+	-
21	Cynoglossus macrostomus	-	+
22	Cynoglossus puncticeps	-	+
23	Cynoglossus bilineatus	+	+
24	Cynoglossus dubius	+	+
25	Cynoglossus arel	+	-
26	Decapterus macrosoma	-	+
27	Drepane punctata	-	+
28	Dussumieria acuta Valenciennes	-	+
29	Echeneis naucrates	-	+
30	Eleutheronema tetradactylum	+	+
31	Elops machnata	+	-
32	Escualosa thoracata	+	-
33	Gerres filamentosus	+	-
34	Gerres lucidus	-	+
35	Gerres oyena	+	-
36	Glossogobius biocellatus	-	+
37	Glossogobius giuris	+	-
38	Gobius ocellatus		+
39	Grammoplites suppositus	+	-
40	Harpodon nehereus	-	+
41	Hemiramphus far	-	+
42	Hilsa kelee	-	+
43	Himmantura walga	+	-
44	Hyporamphus (Hyporamphus) limbatus	+	-
45	Hyporamphus dussumieri	+	-
46	Ilisha megaloptera	+	-
47	Ilisha melastoma	+	-
48	Johnieops sina	-	+
49	Johnius osseus	-	+
50	Johnius belangerii	+	-
51	Johnius dussumieri	+	-
52	Lactarius lactarius	-	+
53	Lates calcarifer	+	-
54	Leiognathus balochi	+	+
55	Leiognathus brevirostris	-	+
56	Leiognathus equalus	+	+
57	Leiognathus daura	+	-
58	Leiognathus splendens	+	-

59	Lepturacanthus savala	+	-
60	Liza carinata	+	+
61	Liza melinoptera	+	-
62	Liza parsia	+	-
63	Liza subviridis	+	+
64	Lutjanus johnii	+	+
65	Megalaspis cordyla	-	+
66	Mugil cephalus	+	+
67	Muraenesox cinereus	-	+
68	Mystus gulio	+	-
69	Nematolosa nasus	+	+
70	Opisthopterus tardoore	+	+
71	Osteogeneiosus militaris	+	-
72	Otolithes ruber	+	+
73	Pampus argenteus	+	+
74	Pellona ditchela	-	+
75	Periophthalmus koelreuteri	+	+
76	Periophthalmus weberi	+	-
77	Pisodonophis canarivorous	+	-
78	Platycephalus indicus	+	+
79	Polynemus heptadactylus	-	+
80	Polynemus indicus	+	-
81	Polynemus sexfilis	-	+
82	Polynemus sextarius	-	+
83	Pomadasys kaakan	+	+
84	Pomadasys maculates	-	+
85	Pomadasys stridens	+	-
86	Promicrops lanceolatus	+	-
87	Protonibea diacanthus	+	-
88	Psammogobius biocellatus	+	-
89	Pseudorhombus arsius	+	-
90	Pseudorhombus arsius	-	+
91	Pseudosynanceia melanostigma	+	-
92	Rastrelliger chrysozonus	+	-
93	Rastrelliger kanagurta	+	-
94	Sardinella albella	-	+
95	Sardinella gibbosa	-	+
96	Sardinella sindensis	-	+
97	Scatophagus argus	+	-
98	Scolidon laticaudus	-	+
99	Scomberoides commersonnianus	+	+
100	Scomberromorus guttatus	+	-
101	Secutor insidiator	+	-
102	Sillago sihama	+	+
103	Solea elongate	+	-
104	Solea ovata	-	+
105	Sparidentex hasta	+	-
106	Sphyraena putnamiae	+	-
107	Strongylura leiura	-	+
108	Strongylura strongylura	+	-
109	Strongylura leiura	+	-
110	Synaptura orientalis	-	+

111	Tenualosa ilisha	+	-
112	Tenualosa toli	-	+
113	Terapon jerboa	+	+
114	Terapon puta	+	-
115	Tetrodon lunaris	+	-
116	Thryssa dussumieri	-	+
117	Thryssa hamiltonii	+	+
118	Thryssa mystax	-	+
119	Thryssa setirostris	+	+
120	Thryssa vitrirostris	-	+
121	Trachinotus mookalee	-	+
122	Trachinotus blochii	+	-
123	Trichiurus lepturus	-	+
124	Upeneus vittatus	+	-
125	Valamugil cunnesius	+	-

3.5.6 Occurrence and conservation status of fish species recorded in winter

Figures 12 and **13** shows the occurrence of fish species recorded at Keti Bunder. As can be seen most of the species were migratory (45+) followed by resident species and the remaining have not been given a status. Most of the species recorded at Keti Bunder were abundant though there were a similar number of species that had no status given. Fifteen of the species recorded were categorized as rare and twenty-nine as less common.

Figure 12 – number of species in each occurrence category

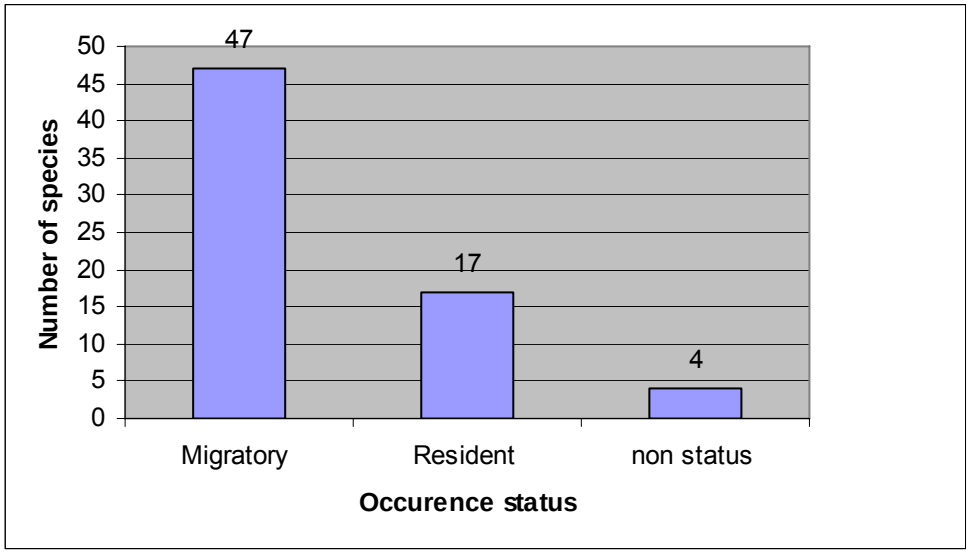
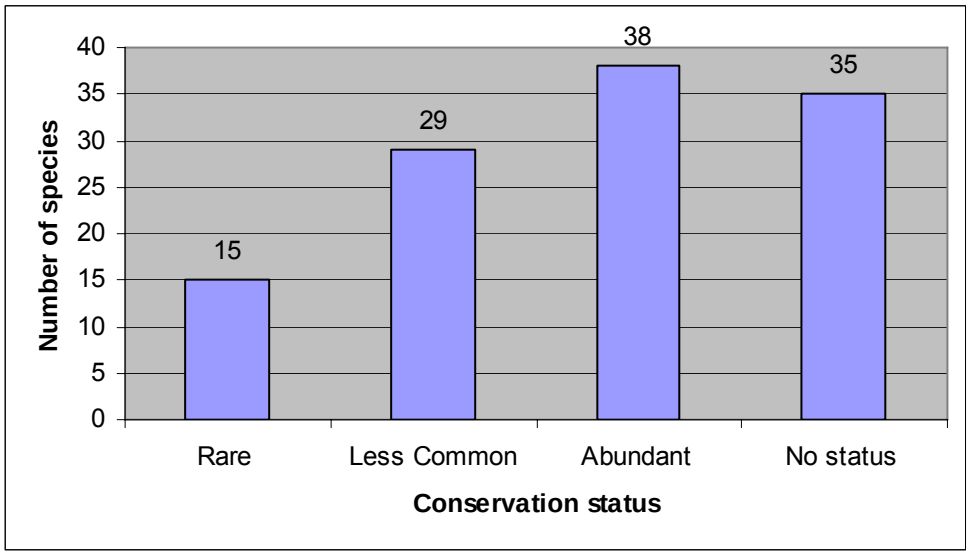


Figure 13 – Number of species in each conservation status category



3.5.7 Threats and recommendations

3.5.7.1 Threats

- **Reduced inflow of River Indus**: Fresh water flow of Indus River has been reduced from 150 million acre feet (MAF) a year some 60 years ago to 0.72 MAF last year (2006). For some years, there is virtually no fresh water flow to the sea. This has compounded the pace of the devastation effects on the overall environment of the coastal areas. Under the provisions of the Water Accord, 1991 a quantity of 10 MAF has been earmarked for outflow to sea. However, there are doubts that 10 MAF is sufficient and the IUCN has calculated that the annual requirements for environmental sustenance are 27 MAF. Influx of freshwater from the River Indus is known to be a major contributor towards the productivity of estuarine areas of Sindh, as well as in offshore waters. It also has multiple impacts some of which are as below:

    a) Overall reduction in the flow of the River Indus over recent decades has negatively affected fisheries in estuarine areas of Pakistan. The production of commercially important species such as river shad Palla', barramundi 'dangri' and Indian threadfin 'rawans' has decreased substantially in the past four decades. The famous Palla fish has become nearly extinct. The annual production has reduced from 5000 tons in 1951 to just 500 tons, besides marked reduction in its size. It has resulted in socio-economic hardships in coastal communities;

    b) There has been a progressive reduction in the volume of silt from 200 million tons/ year in 1947 to 36 million tons per year in 1991. This has resulted in the erosion and degradation of the Delta and consequent seawater intrusion besides the harmful effects on fisheries, specially shrimp and mangrove forests due to loss of nutrients;

    c) The mangrove forest area has reduced from 263,000 hectares in 1977 to 158,500 hectares in 1990 showing reduction of 38%. Even this remaining area is being progressively degraded. At least 10

thousand families (with at least 8 to 10 family members per house hold) have migrated due to increasing poverty and land degradation..

- **Over-exploitation of resources:** Mechanization of the fishing fleet and increased demand of seafood for export and domestic consumption have Led to increased fish production. However, inadequately managed, it has added a tremendous pressure on natural stocks. Some of the resources have been depleted; some are currently over-exploited while others are under threat of depletion. Shrimp stocks have been severely over-fished and a major decrease in landings of important shrimp species as well as a major reduction in the size of commercial species is now noticeable. Resources of lobsters have already been over-fished and annual landings have decreased from over 5,000 MT to about 800 MT. Resources of crabs, ivory shells and some fin-fishes have also shown signs of over-exploitation. No stock assessment survey has been carried out for the last 15 years, and the lack of information on the present status of various resources in shallow and offshore waters makes impossible the implementation of appropriate management measures. In the absence of regular monitoring of the resources, it is not possible to determine appropriate levels of exploitation of commercially important species.

- **Use of harmful fishing methods:** Use of some harmful exotic gears began in the 1970s in coastal areas of Sindh. Two types of these gears, i.e. encircling net 'katra' and estuarine set bag net 'bulo' are considered extremely harmful to juvenile populations of commercially important species which abound in creek systems. A trawl shrimp net 'gujja' is also used in creek areas. These illegal gears have devastating effects on the local fauna and populations of commercially important species. Ineffective legislation and a lack of monitoring and surveillance facilities have resulted in a failure to prevent the spread of some of these fishing gears to the coast of Pakistan.

- **Lack of skilled human resources:** Inadequate human resources and skills are found at two levels: within government structures, and (within fishing and fish farming communities. In most cases, fisheries institutions are inadequately staffed. Lack of trained manpower and suitable facilities in fisheries and aquaculture management organizations and research institutions are considered to be one of most important impediment to the development of both fisheries and aquaculture. This has consequences in terms of both the quality and the relevance of extension work carried out at the field level, with weak knowledge and experience is being passed on to fisher-folk and fish farmers.

- **Inadequacies in fisheries data**: Pakistan faces problems in of inadequacy, reliability and accuracy of Fisheries and aquaculture data. There are a lot of inadequacies in the data collection system linked to poor sampling methods along the coastal areas. In most cases, fisheries data from Sindh are merely estimates and prone to personal judgments resulting in unreliable conclusions. Inadequacies in the statistical fisheries and aquaculture data collection system make the management of aquaculture, and inland and marine fisheries resources very difficult.

- **Increase in pollution and environmental degradation**: Excessive pollution from Industries and agriculture is proving disastrous for the environmental life of this environmentally precious region. According to reports more than 2500 cusecs of left bank out fall drain (LBOD) effluent comprising poisonous pesticides residues are thrown in the Indus delta daily. Besides about 300 million gallons, urban sewerage from urban areas and about 37,000 tons of industrial waste are drained into coastal waters. This pollution is affecting marine life and ecosystem very badly. Fishing grounds coastal areas have been badly affected by industrial and urban pollution.

- **Lack of infrastructure:** Lack of suitable infrastructure one of the key constraints to the development of the fisheries and aquaculture sectors of the country. In the context of capture marine fisheries, no landing facilities are available at major fishing centers such Keti Bunder. Similarly, road linkages are insufficient and of poor quality. Other infrastructure facilities such as communication, educational and medical facilities still lack in Keti Bunder area. Problems faced for the transformation of products from aquaculture are similar. Lack of proper freezing facilities is another obstacle in increasing the shelf-life of fish.

- **Post harvest losses:** Post-harvest loss owing to poor handling practices, and a lack of preservation facilities on board fishing vessels and at landing centers, is some of the most important factors which result in the poor quality of raw material for processing and consumption. It is estimated that about 70 % of the harvested seafood becomes degraded or even putrefied before it reaches consumers or processing facilities. Opportunities to produce fish meal are missed as almost all by-catch from trawl fisheries is left to decompose. A similar situation prevails in the pre-processing industry where shrimps are peeled under extreme unhygienic conditions.

3.5.7.2 Recommendations

- **Mitigating reduced flow of Indus River:** which should ensure that aquaculture is closely linked to plans for investment in irrigation, irrigated agriculture and related infrastructures; establish a joint Committee composed of representatives of all Ministries dealing directly and indirectly with freshwater use, jointly engage in discussions and planning with other Ministries on priority uses, protection, sustainable development and increased productivity of freshwater resources, establish strong collaborative partnerships and processes to increase water flows in Indus River and tributaries and re-establish balanced water regimes/use, formulate policies concerning the reclamation and rehabilitation of areas affected by salinity, Monitor the impact of water diversions on habitats and livelihoods, and develop guidelines for the mitigation of negative impacts, support literacy, vocational training arid other educational programs in fishing communities; Support alternative and/or complementary livelihood activities in fishing communities through increasing access to credit and savings schemes and the provision of micro-finance initiatives. Activities should also ensure the participation of women and benefits from their involvement, in aquaculture, post-harvest and other livelihood activities, advocate for the allocation of marginal land for agricultural use to fishing communities who are affected by water diversion/limited release of water

in the River Indus and formulate and implement an integrated coastal zone management plan.

- **Mitigation for over-exploitation of resources:** which should establish guidelines and promote the use of environmentally responsible fishing practices (following internationally-established codes and standards), control fleet size and fishing capacity, create an exclusion zone for deep sea trawlers in coastal waters, introduce a seasonal ban on catching shrimp in coastal areas during the months of May, June and July, conduct resource surveys, species stock assessments in marine (coastal and off-shore) waters, determine and regulate optimal harvesting levels in marine waters, initiate a programme of awareness raising targeted at fishing communities and the general population about fish bio-diversity, natural fisheries environments, sustainable resource exploitation and conservation, establish a system of regular monitoring of various habitats along the coastline, including mangroves, marine turtles and other aquatic biodiversity.

- **Reduction in the use of harmful methods:** which would ensure the enforcement of fisheries laws and frame new set of fisheries laws ensuring sustainable fisheries in the coastal areas by formulating a committee among the local fishermen to check the boats for illegal fishing gears, imposing fines on the use of illegal fishing nets and confiscation of illegal fishing gears, establishing guidelines and promote the use of environmentally responsible fishing practices (following internationally-established codes and standards) and educating local fisheries community about the long term damage caused by the illegal fishing practices.

- **Mitigating the lack of skilled human resources: through** Reactivating the training program at Fisheries Training Centers, establishing a fisheries training centre at Keti Bunder and other areas, strengthening technical expertise of the staff of the fisheries departments through participation in regular skill development courses and training programs, starting university degree programs specific to fisheries sciences, fisheries management and aquaculture management, developing training modules for sustainable fisheries practices for building capacities and skills for sustainable management of ecosystem at all levels, broadening the range of topics covered in training programs to make them more relevant, effective and practical, establishing a system of certification of training courses and programs at national level to ensure that only certified staff be employed in the fisheries and aquaculture sectors, in particular in processing factories. In addition to this the following may also be adapted: ensuring that opportunities for study tours abroad are provided to trainees as part of training on fisheries and aquaculture, ensuring that fisheries and aquaculture-related subjects are included in primary and secondary curricula, preparing training materials and technical documentation for training at various levels in Urdu and other local languages, ensuring equal access and opportunities to men, women and minorities in accessing training, skill enhancement programs and extension activities, improving lodging and boarding facilities at training centers, improving, and where non-existent, establish mobile extension units at Tehsil/Taulka level, raise awareness among fishermen and fish farmers about conservation and sustainable management principles, broadening the

range and relevance of topics for extension to fish farmers and fishermen and educate and train fish traders on the use of improved fish transportation methods.

- **Mitigating the inadequacies in fisheries data**: by implementing a comprehensive and harmonized data collection system across provinces coordinated by Fisheries Departments at provincial level, with reporting to the Federal Bureau of Statistics, strengthening the capacity for collection in provincial fisheries departments and analysis of statistical data in the Federal Bureau of Statistics and adopting a comprehensive information system that allows evaluation and monitoring of progress towards the policy goals.

- **Mitigating the increasing in pollution and environmental degradation:** through conserving, replant and improve management of mangroves in coastal areas; contributing to the establishment of guidelines and processes for providing compensation to those affected by pollution based on the polluters pay principle, ensuring that industrial waste and domestic sewage is treated prior to release into marine environments, assessing, mitigating and controlling environmental degradation and pollution on coastal habitats and enforcing pollution control legislation in coastal areas.

- **Mitigating the lack of infrastructure:** by creating auction centers and markets marine fish products, at major fishing harbors, building landing facilities along the coast and construct landing jetties at major inland fish landing areas and at other major freshwater fish producing water bodies, improving existing harbor facilities, including regular dredging and expansion, establishing pre-processing industries (peeling sheds) in at the fishing centers, Improve transportation of aquatic products, constructing and improving road links from harbors and landing centers to the urban centers and improving access of aquatic products to international markets.

- **Mitigating post harvest loss**: through assisting in installation of quality ice making machines on board of fishing vessels and refrigeration systems on board of fishing boats involved in longer fishing operations; installing quality ice making plants and cold storage facilities at all major fish harbors, improving quality control in the landing centers, including promoting the use of fish crates and insulated boxes, attracting private investment in building and expansion of storage facilities at inland/coastal landing centers and near market centers; adding value transformation/processing) to aquatic products., improving by-catch utilization, promote the establishment of private value-adding processing facilities, establishing demonstration facilities for value addition and improved processing Improve transportation of aquatic products, promoting the use of insulated boxes and refrigerated carriers through provision of soft loans, improving hygiene conditions in all fish markets, updating fish quality control laws to ensure compliance with those of importing countries as well as ensure compliance of commodities with internationally recognized standards of food safety and trade and addressing comprehensively quality issues and establish quality assurance programmes.

3.5.8 Notes on the marine fishing policy

3.5.8.1 Deep sea Trawlers

In 1995 Govt. of Pakistan announced a deep sea fishing policy. Under this policy licenses for deep sea fishing are issued to deep sea trawlers of the international companies.

- The deep sea trawlers in the process of fishing catch a large number of unwanted fish and then throw it in the sea. This practice pollutes the sea water and the live fish leaves that area.
- These trawlers mostly use indiscriminate gear to have a maximum catch but only keeps that fish which generates lot of money. The official figure confirms that these trawlers discarded 332,000 m tons of fish during few years which resulted in a loss of 8 billion US$ to the country on one hand while on the other hand greatly polluted the water in the coastal areas.
- These trawlers are supposed to fish in EEZ some 32 km from the shore. They often violate the boundaries and practice fishing inside 35 km area and even close to creeks. Consequently, they not only deprive the fishermen from their livelihood but also damage their boats and nets.
- Being fully computerized and mechanized, these trawlers continue fishing un-abated and catch millions of tons of fish day and night. This over-fishing practice results in depletion of stocks of various fish species.

3.5.8.2 Exploitation of fishermen

There are many forms of exploitation of the fishermen. One way of wielding influence on the local fishermen is to trap them by providing them loans. Due to non-availability of formal credit systems, the fisherfolk communities rely only on non-institutional/informal credit system. The existing informal system of providing loans to fishermen is extremely exploitative. Details of these middlemen and the way they exploit the fisherfolk is as below.

3.5.8.3 Fishing boat owners

Boat owners own boats (usually trawlers) and operate them as a business, just as any other business. Trawlers usually target prawns, which is the main fisheries export commodity. The owners usually have other significant business interests outside the fishing industry. The skippers and crew of the vessels are hired persons.

3.5.8.4 Moles (Moleholders).

These are businessmen who lend money to private vessel owners and reclaim the debt from the proceeds of the sale of the catch. A fisherman wishing to go out to sea will seek an advance from a moleholder, who will provide what is required (but not in cash, the fisherman will usually receive a written chit to the fisherman who has to get his supplies from a supplier in league with or even owned by the moleholder). On return from fishing the catch is auctioned by the moles in Fish Market and from the proceeds is deducted commission 6.25% of the value which is split up 50/50 between the Fishermen Cooperative Society (FCS) and the Moles who get 50% auctioneers commission. From the proceeds of the auction after deduction of the 6.25% commission the moles deduct their pre trip advances, and the rest is split up amongst the crew (who divide it up amongst themselves on a separate share system) and the boat owner. If the boat owner is the mole himself then he takes the share destined for the boat owner. A powerful

mole may own several boats himself, and also have several other fishing directly to him, bonded by debt to allow him to do the auctioning, so that he can regain the debt owed.

There are various ways the moles can enrich themselves beyond that which is generally considered "fair". These include:

- Selling supplies to the vessel operators at inflated prices, or selling substandard supplies at normal prices, through their system of advancing loans in kind to finance trips;
- Their 50% share of the 6.25% auction fee;
- Under weighing the catch, because no trusted weighing system is currently enforced at the auction. Much fish is sold by heap or basket;
- Adjusting the auction price, since they do the auctioning. Either in collusion in the buyers, to obtain low prices at auction which are made up later out of sight of the public auction, or though condemning fish for fish meal which is subsequently sold for human consumption;
- Their portion of the catch that goes to pay back the loan of supplies, fuel and ice for the last trip – often valued at more than it cost with a percentage addition for interest;
- If they own the boat, through the proportion that goes to the owner;
- Personal loans to fishermen working on the boats (not related to the fishing operation).

Overall there is no realistic system to replace the moles. They provide an efficient loan service to fishermen, quickly, without lengthy paperwork, where no alternative exists. The situation is accepted by fishermen and administrators alike. The Karachi moles' pervasive influences control major commercial fishing in the Karachi area and their influence even extends to some areas of Badin and Thatta. No development affecting their interests is likely to succeed unless the senior moles approve of it. They must be consulted, and their support guaranteed, before inputs changing the structure of the fishery are applied. If they do not approve an intervention then so many impediments will be created that the intervention is likely to fail. They are powerful men. They are also politically active at high levels. Any suggested inputs by the SRCCDP will have to allow for this.

3.5.8.5 Middlemen

Other middle men called "bayparis" operate generally throughout the landing areas. They do not generally own boats in their own right. They lend money/materials to private vessel owners who are bound by the debt to land their fish to them. They also buy fish from independent operators. They operate throughout Badin & Thatta and in the lesser landing sites round Karachi.

Middlemen deliver ice, ice boxes, gear repair materials and fuel, as well as fresh water to some of the remoter areas. The cost of this is set against the catches of the vessels with which they are associated. Middlemen generally use (4 wheel drive) pick up trucks for valuable fish and prawns and hire in labor and 10 tonne trucks to load and carry bulky produce such as dried pelagics destined for fishmeal. Middlemen also provide loans for personal use, such as for weddings, funerals, large purchases, in times of hardship such as when the shrimp fishery is closed (two months of the year) and for a miscellany of other purposes. These

loans go to vessel owners, fishermen, laborers and others who become reliant on the middlemen and bound to them.

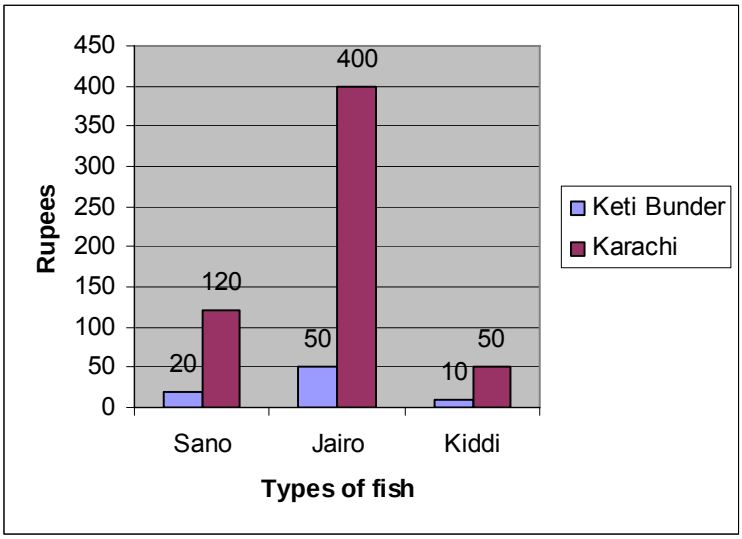
Some middlemen "own" or control landing areas, where fishermen landing at particular wharves are obliged to sell through a particular middleman. Some other middlemen have developed virtual control over fishing in particular creeks and areas, particularly in the Western area of the Delta, between the Indus and Karachi. They purchase the fish at highly decreased rates from the fishermen. A comparison of price in Karachi market and the price in Keti Bunder area is provided below:

Table 15 – Difference between prices of fish and shrimp in Keti Bunder and Karachi

S.no	Fish/Shrimp	Keti Bunder	Karachi
1.	Sano	Rs.20	Rs.120
2.	Jairo	Rs.50	Rs.400
3.	Kiddi	Rs.10	Rs.50

Source: Pakistan Fisherfolk study report

Figure 14 – Showing price disparity between fish/shrimp prices betweeb Keti Bunder and Karachi



Middlemen are often involved in local politics and seek to place their men in local and district councils. They often have other businesses associated with fishing such as gear stalls and ice factories.

3.5.8.6 Independent Vessel Owners (bonded)

Independent vessel owners (which are usually whole families) work their own boats and are theoretically free agents. They are not generally, however, free to sell their catch to anyone since they have become indebted to middlemen, both for the construction/purchase of the boat and for running costs and living expenses incurred day to day.

In addition the boats may be, particularly if large, be "owned" by a group of investors, who also receive a portion of the catch. One may own the hull, another

engine, and yet another net. The division of the proceeds of the catch after repayments is in Keti Bandar) reported to be:-

- Net – 6 shares ("patti" or "pati")
- Boat – 2 shares
- Engine – 6 shares
- Owner – 1 share
- Khalasi – 1 share (crew/labor)

Similarly, and illustrating the variety of systems, the shares after an 8 day trip are also described as being fivefold with two shares to the boat owner, and 3 to the crew, the catch being owned by the middleman. Another variation, reported by Sindh Forest and Wildlife Department 30 in 1999 for large gill-netters and trawlers of 9 to 15 m length with 6 to 15 crew was:-

- Engine owner – 2 patis
- Net owner – 2 patis
- Boat owner – 1 patis
- Driver/captain – 1.5 patis
- Crew – patis divided equally

The same reference comments that on larger trawlers and gill-netters there is a system of at least 60 pattis (shares) with 50% to the owner, 6 patis to the captain and his assistants and the rest divided equally among the crew.

In short the system of dividing up the catch proceeds amongst the crew is varied. Fishermen report being harassed by customs officials, the coastguard, the navy, American Naval boats undertaking anti terrorist operations and the Karachi Port Trust. These organizations merely add to their problems.

3.5.8.7 The contract system

The contract system was introduced in Badin District on the inland sea in 1977 and was intended to cover the areas close to the Indian Border. It expanded until it covered large tracts of land and many water bodies, some in Thatta. Under the contract system the fishermen were obliged to sell their catch to powerful men who had bought contracts from the Rangers. The Rangers were meant to pay for their rights to the Sindh Fisheries Department, but apparently did not. Contractors paid as little as 7% of the retail value of the product (usually small shrimp). The Rangers enforced the system. This system was seen a very unjust and following agitation by the Pakistan Fisherfolk Forum the system was abolished in 2005. It has been replaced by a license system, and it remains to be seen how many of the existing fishermen will obtain licenses, and to what degree their situation will be alleviated.

3.5.8.8 Tuna fisheries

Along the coast of Pakistan a very specific established commercial Tuna fishery exists the species belong to genus *Thunnus* of the family Scombridae. Tuna are great in demand in the world markets. Tuna fishery is exploited both from coastal waters and from off shore waters. In the coastal waters local boats operate with long lines and off shore fishing is mainly permitted to Chinese and Vietnamese factory ships. Locally caught species are *Thunnus tonggoi*, *Tuna nei* and *Scomberomorues sp*. Associated with the tuna species the local fishermen catch a small number of Sailfish *Istiophorous platypterus* and Black marlin *Makaira indica* Hussain *et al,* 2007.

The Chinese and Vietnamese factory fishing vessels operate with long lines off shore beyond 35 nautical miles from the coast with depth exceeding 500 meters the gear depth is normally 100 meters. The catches showed the distribution of Tuna from 22^0 47' N 63000' E .to 24^0 37 N 66 ^{0} 56 'E higher catches were mostly from 24 ^{0} 30 ' N 65^0 42' E. during November 2005. (Hussain *et al.,* 2007)

Yellow fin Tuna was abundant during NE monsoon (November – March) while no catches were observed during the first and second transitional periods (April and October) (Ali-khan, 1972 /1977). During the SW monsoon May – September the tuna catches were low. A similar picture is apparent from the catch and number composition of Sharks, Marlin, Sail fish and Dolphin Sharks. The highest catches in number are during the NE monsoon while are very low number in the other seasons. Dolphins are however only caught in the SW monsoon. The occurrence of tuna and other species from the catch analysis (Hussain *et al.,* 2007) shows that highest number and highest biomass of sharks (number 27 & 56 biomass kg1350 - 1456) were caught in areas where depth ranged from 825 – 1630 meters. Marlins were caught (no. 20 and 13 and biomass kg 1495 – 1204) at depth 100 – 475 meters and 1980 – 2355 meters. Sail fish 12 in number with biomass 220 kg were caught in areas at depths of 1228 – 1803 meters. Only 7 Dolphins were caught from 100 -475 meter depths. Highest number of Tuna (no. 2265) with biomass 79840 Kg was caught from areas where depth was 100- 476 meters. In areas where depth exceeded from 475 meters tuna were caught in less number Hussain *et al*., 2007.

3.5.8.9 Fishing fleet

Sharp increase of fishing efforts is shown in the **Table 16**. Specially sail boats in the marine sector the sailboats have seen slight increase from more than five thousand six hundred in 1993 to six thousand eight hundred in Sindh 2003 and decrease is noted from 144 to only 25 in operation in Balochistan. Table 2 gives number of sail boats from 1999 – 2006 in Sindh and Balochistan. Their number was 6358 in 1999 which increased to 6809 in 2006 in Sindh.

The number of Mechanized cum sail driven boats during the year 1993 – 2003 has increased both in Sindh and Balochistan and like wise their number has increased among inland fishing fleet .These fishing boats usually carry long line for fishing in high seas. **Table 16** gives detail number of mechanized boats in Sindh and in Balochistan.

The number of gill-netters has increased from 1993 – 2003 in both the provinces. A very significant increase of about 500 has been observed total number of trawlers from 1993 – 2003.

Table 16 - Fishing crafts

Year/Province	Sail Boats	Trawlers	Gill Netters	Mech. Sail Boats
Year 1999				
Sindh	6358	2564	2305	3755
Baluchistan	25	-	1295	4279
Year 2000				
Sindh	6504	2570	2317	3923
Baluchistan	29	-	1320	4314
Year 2001				
Sindh	6509	2578	2327	3928

Baluchistan	34	-	1335	4326
Year 2002				
Sindh	6555	2599	2398	3966
Baluchistan	36	-	1384	4377
Year 2003				
Sindh	6809	2702	2510	4388
Baluchistan	25	-	1508	4465
Year 2004				
Sindh	6200	2800	2550	4400
Baluchistan	20	-	1600	4560
Year 2005				
Sindh	6210	2815	2555	4430
Baluchistan	25	-	1620	4580
Year 2006				
Sindh	6240	2830	2560	4440
Baluchistan	30	-	1645	4590

3.5.8.10 Fishermen engaged:

The number of fishermen engaged in Marine and inland sector during 1993 – 2003 were 281443 – 416495 (Anon, 2006 b). The majority of these fishermen engaged are exploiting fresh water resources as their livelihood and their figures range from minimum in 2002 as 281443 the rest are operating in marine sector.

3.5.9 Palla – Tenualosa ilisha

3.5.9.1 Scientific classification

***Tenualosa ilisha* (Hamilton, 1822)**

Shad (Local name: Palla)

Synonyms:

Clupandon ilisha Hamilton, 1822
Clupea ilisha (Hamilton, 1822)
Clupea palasah Cuvier, 1820
Hilsa ilisha (Hamilton, 1822)
Macrura ilisha (Hamilton, 1822)
Tenualosa ilisha (Hamilton, 1822)

Class	Actinopterygii (Rayfin fish)
Order	Clupeiformes (Shads, Sardines, Herrings)
Length Range	Juveniles (unsexed): 101-151 mm (From literature) Male: 247-393 mm (from literature); 270-360 mm (Present observation) Female: 250-450 mm (from literature); 300-370 mm (Present observation) Weight Range: Juveniles: 45 g; Male & Female: 534-1970 g (From literature) Juveniles: 200 g; Male & Female: 600-800 g (Present observation)

3.5.9.2 Introduction

Tenualosa ilisha was first described by Russel (1803) from waters of Vizagapatan and named it “Palash”. Hamilton 1822 studied systematic status and described it

under the name of *Clupondon ilisha*; Cuvier 1829, named it *Clupea palasah*; Regan (1917) created a new genus Hilsa and included Hilsa like clupeoids of the Indo-Pacific as *Hilsa ilisha* with other species *Hilsa toli*, *Hilsa kanagurta*; later Fowler 1941 and Munro 1955 gave *Hilsa* as a different genus *Alosa* (Fowler, 1941).

T. ilisha (Palla) is one of the prominent commercial species of Pakistan and has a wide distribution, India, Bangladesh, Iran, Burma, Thailand, Malaysia, Iraq and in the Gulf area. This species is considered a delicacy and has a traditional food value cooked in various preparations in Sindh. It is sold at high price of 200-500/- Rupees a piece (one kg). The seasonal 'Palla' is liked because of the fatty contents in their muscles and viscera.

Information on Hilsa started from beginning of 1800 when Russel, 1803 was first to describe it as "Palla". Hilsa fisheries started sometimes in 1907 (Qureshi, 1968) by Department of Fisheries, Madras and Department of Fisheries, Bengal, Bihar, Orrisa and Bangladesh (formerly East Pakistan). Aitkin 1907 gave an count on *Hilsa* sp. from Sindh, later Jonkins 1910 discussed the spawning of *Hilsa* from River Indus. Simultaneously Devanesan 1942, Chacko & Gonapati 1949, Chacko *et al*., 1948 worked on biology, age and growth of *Hilsa ilisha* from Madras; Kulkarni (1950) studied population biology, spawning, migration of *T. ilisha* in Narbado River; Chacko and Krishnamurthy 1950, Jones & Menon 1951, Jones 1952, Raj 1951, Pillay 1957 & 1958, Nair 1958, Swarup 1959, Ahmad 1960 studied *Hilsa ilisha* from India and Bangladesh (East Pakistan). There after Qureshi 1968, Bhuiyan 1960 and Pillay & Rosa 1963 worked on *Hilsa* from River Indus. In seventies some of the works that appeared were of Rajyalakshmi 1973, Nurul Islam 1974 on biology, length weight studies. Al-Nasiri and Al-Mukhtar in 1988 worked on food and feeding habits and reproduction of *Hilsa*. Recent works on this species are by Al-Hassan 1993 and Narejo *et al*., 1998, 1999 and Panhwar 2006. Al-Hassan 1993 reviewed various studies of *Hilsa* (*Tenualosa ilisha*) including that of Pillay & Rosa 1963; Narejo *et al*., 1999 focused on growth, condition factor and length-weight relationship of *Tenualosa ilisha* from River Indus; Panhwar 2006 gave some data on *T.ilisha* and *Hilsa kelee*.

Studies on the biology of *T. ilisha* are Dutt, 1966, described as for Prashad, 1919 that *H.ilisha* (Ham.) was considered as a fluvial anadromous fish with feeding grounds in the sea and spawning in freshwater rivers; Further Dutt, 1966 mentioned that Prashad, 1919 and Hora, 1938 did not consider it as true anadromous fish and that the young ones spend time before maturation along the deeper parts of the estuaries. There have been reviews of literature that argued the possibility of *Hilsa* traveling in sea but presence of their stocks in the foreshore and shore waters suggest that the stocks are confined to coastal waters. Pillay 1961 reported spent fish *Hilsa* from sea 9-12 miles off Veraval (in Saurashtran, Gujrat state suggesting spawning in sea); *T. ilisha* is known as migratory fish ascends River Indus during pre-monsoon and has been observed till September and some times it has been reported in November also. No detailed studies have been carried out on this species from River Indus

3.5.9.3 Morphological and anatomical features

Image 9 – The Palla fish caught at Keti Bunder

Ventral Fin: 7, Gill rakers 60 – 100, Scutes: 32-33, Scales in lateral series: 37 - 47 Current studies indicate no special mucous glands in buccal cavity. Swarup (1959) reported mucosal epithelium, which is considered as remains of primitive taste buds. *T. ilishia* is a plankton feeder. Gill rakers are special hairy structures present on the gills; during migrating journey water enters through mouth passes gills and while gill covers remains open to expel the water out. All particles present in the water are swallowed.

3.5.9.4 Feeding habits

Food of fishes is mainly detritus, plankton (phytoplankton and zooplankton). Table 17 gives the brief feeding habits of *T.ilisha* in different regions and at length groups given by various workers. During migration these species are found starving while their young ones show plenty of sand grains and detritus in their stomach.

Table 17 – Feeding habits of *T. ilisha*

S.No.	Researchers author(s)	Locality	Major types of feed	Abundant by occurrence in guts
1	Hora, 1938	Pulta, Barrackpore, India.	Diatoms, Copepods, Daphnia, Ostracods & smaller Crustaceans	Diatoms, Copepods
2	Hora & Nair, 1940	East Bengal Rivers	Filamentous algae, sand grains, diatoms & copepods	Filamentous algae & diatoms
3	Jones & Menon, 1951		Diatoms, Copepods, sand grains & other Planktonic Organisms	Diatoms & Copepods
4	Pillay and Rosa, 1963	India	Diatoms	*Melosira* sp.
5	Qureshi, 1968 a	Bangladesh (East Pakistan)	Green & blue algae, Diatoms, mud and sand grains, the fish uses its fat during it's ascend in the river and stops feeding.	Green and blue algae, diatoms, copepods, sand grains.

6	Qureshi, 1968 b	Indus River	No clear information is given from fish collected from Indus River similar as observed from fishes of bangladesh (East Pakistan).	
7	Ramakrishnaiah, 1972 Seasonal study of stomach contents	Chilka Lake, India	Organic detritus, Algae, Diatoms, Copepods, Molluscan Larvae, Mysids (March, June, July 100% of diet)	Organic detritus & Copepods
8	Rajyalakshmi (1973)	Godavari River	Juveniles with guts full of Diatoms, *Spirogyra*, *Rotifers*, Copepods, Calanoid	Copepods 50%, algal filaments 35%
9	Nurul Islam, 1974	Allah abad, India.	Diatoms, Zooplankton Two period of feeding juveniles are voracious feeders	*Synedra ulna* and *Daphnia* sp., detritus & small sand particles
10	Al-Nasiri and Al-Mukhtar, 1988	Shatt al-Arab River, Iraq	Filter from gill rakers mosly herbivorous, Zooplankton feeder Dinoflagellates, Diatoms and zooplankton	Phytoplankton, Dinoflagellates, Diatoms, Copepods *Cyclotella*, *Planktosphera*
11	Al-Hassan, 1993	Chilka Lake, India	Diatoms, Detritus & Copepods	Detritus 48%, Copepods 25.8%
12	Present observation	Kharo-Chan, (Keti Bunder) & G.M. Barrage	Diatoms, Detritus and zooplankton Sand particals	Copepodes

3.5.9.5 Reproductive biology

Information of reproductive biology of *T.ilishia* from Indus is very rare. After the study of Qureshi, 1968 a & b) no comprehensive study appeared most of the data available is from Indian water. Recent studies that are of Narejo (199) and Panhwar (2006) give some data on the fecundity and reproduction but these studies are quite inconclusive. A detail account of studied carried out are given in the **Table 18.**

Image 10 – Ripe female gonads *T. ilisha*

Image 11 – Male gonads of *T. ilisha*

Table 18 – accounts of reproductive biology of *T. ilisha*

S. No.	Author(s)/ Locality	Spawning grounds	Spawning season	Length range/ age	Size of ova	fecundity
1	Pillay (1958)	Hooghly River	Spawn several times during breeding season	169 mm male; 199 mm female	NA	NA
2	Talbot, 1959	Indus River	NA	NA	NA	755,000-2,917000
3	Swarup (1961)		Seasonal fishes in breeding season			289,000 – 1,168672
4	Pillay & Rao, 1962	Godavari River		355 mm		
5	Pillay and Rosa, 1963	Hooghly River	Monsoon	NA	Small transparent size 370 um	Not clear
6	Mathur, 1964	Ganga River, India	Spawn several times during breeding season	350 mm	Not available	Not available
7	Qureshi, 1968 a	Hooghly River, Bangladesh (East Pakistan)	Two strains, 1). Start with monsoon (May-Nov.) 2). Jan.-Feb.- sometimes to March	19-20 cm	Not available	Not available
8	Qureshi, 1968 b Indus river	476 miles from mouth of Indus river (before G.M. Barrage) reduced to 190 miles after construct G.M. Barrage	March - September	24.7-39.3 cm males; 26.5-43.6 cm females	0.7 mm	2 million
9	Doha & Hye, 1970	Padma River, Bangladesh (East Pakistan)	Monsoon	273-420 mm Fork length	430-729 um	348,318000-1,465,969000
10	Ramakrishnaiah, 1972	Chilka Lake, India	July-August	172-187 mm (male); 186-515 mm (female)	Not available	390,379-1,120,304
11	De (1980)		September -October		Not available	373,0120-132,30500
12	Quddus *et al*., 1984			342-750 mm		660,000 – 1,547,000
13	Al-Nasiri and Al-	Shattul Arab River, Iraq		70-152 mm	Not available	

	Mukhtar, 1988					
14	Narejo, 1996	River Indus		331 mm	Egg size 0.32-0.44 mm (March); 0.72-0.84 mm (April); 0.92-1.04 mm (June); 1.12-1.24 mm Jul-Aug.)	351682
15	Saifullah *et al.*, 2004	Bay of Bengal, Bangladesh	June - August	39-51 cm	0.66-0.85 mm	10,30,951-19,40,620
16	Panhwar, 2006	River Indus	May-October	21.0-25.9 cm 31.0-35.9 cm	Not available	Average 1,3403 – 382105 up to 572709-619482
17	Present observation, 2007	Kharo-Chan (Keti Bunder)	June - October	247-393 mm male; 250-450 mm female	0.39 – 0.534 mm	232,1830 – 6588664

3.5.9.6 Migration patterns of *T. ilisha*

Migration of fishes can be categorized in four major types 1. Entering rivers from sea. 2, Descending River from sea. 3. Moving up and down the upper reaches and 4. Local migration in plain. *T.ilisha* (*Hilsa ilisha*) ascends rivers where ever the species is prevalent. This species is considered as fluvial anadromous with feeding grounds in the sea and spawning grounds in the middle reaches of rivers. Earlier workers like Mojumdar 1939, Chacko 1949, Jones and Menon 1951, Pillay 1958 etc. were reluctant to consider *T.ilisha* as anadromous fish. Dutt 1966 suggested Indian Shad (*H. ilisha*) the Surashtra stock of Hilsa breeds in sea in still waters but at the same time in Narbada River. Hilsa stocks ascend the river for breeding (Kulkarni, 1950 and Karamchandani, 1961). Raj (1917) observed in south India that *Hilsa* species spends first two years in estuaries and return to river in the third year. Prashad *et al*., (1940) and Jones and Menon (1951) suggested that in the Hooghly these species ascends in the sea during first year while juveniles occur in the rivers (Hora, 1938, Jones & Menon, 1951; Pillay 1949; Sujansingani, 1957; Bhimachar, 1962).

Al-Hassan 1993 in the light of observations of various authors discussed medium sized active fish restore to an inter-tidal habitat during its fluvial phase. The anadromous stocks of *T.ilisha* enter sea but the data on the sea movement is very rare based on individual observations. The present authors are also of the opinion that most of the landings from sea are toward the deeper regions of shore and on very few occasions the catch of *T. ilisha* is reported from sea. There are species like *Hilsa kelee* very much identical to *T. ilisha* often confuse with catch of *T. ilisha*.

Tenualosa ilisha from Indus is an important commercial species of Pakistan but very little data is available in the literature. Studies that been carried are very brief and inconclusive. The recent study of Panhwar (2006) presents brief information on fecundity and reproductive biology. No information is available on the

migration of this species in the sea after the spawning journey. Qureshi, 1968b studied migration of *T. ilisha* in the rivers of Bangladesh (East Pakistan)

It ascends rivers at all areas (India, Burma, Saim, Gulf and Island of Malaya Archipelago), it is known to have two rims 1) starting in May-September and the other 2) December to March. Qureshi (1968a) based on observations on the coast of Bengal and Orissa support the views of Prashad (1919); Hora and Nair (1940) and Hora (1938) to consider this species as not true anadromous as Hora used the word "wandering" instead of 'migration' and suggested that leaving the rivers the fish do not go far forward in the sea but stays in offshore waters. In India it has known to have two migrations toward sea first in May and again in January. Qureshi, 1968 reported such observation from East Pakistan. Two breeding periods once in monsoon and second in spring season have been reported from river Hooghly (Jones and Menon, 1951; Pillay 1958) and Gange (Mathur, 1964). Some authors like Ravischnadra (1962) reported single spawning River Hooghly. In 1959 the published reports indicate ascend of *T.ilishia* from February and peak is attained in July which gradually diminishes till September.

Present studies under the 'Indus For All Development Programme' conducted by WWF Pakistan in brief surveys found adult fishes from Kharo-Chan Creek where the salinity was low and oxygen was high indicating the 'Indus' a deltaic region during monsoon and during the months of October-November when young fish were mostly collected from the lower parts of the River Indus indicating juvenile migration to the sea. Palla landing at the harbors were not commonly observed which might perhaps prove the fish mostly stays in foreshore waters not traveling far towards deeper part of the sea. The analyses of mature gonads indicate the eggs in single mature stage no successive size of eggs was found which may lead to suggest that the spawning occurs once.

3.5.9.7 Construction of dams (G.M. Barrage)

Formerly *Tenualosa ilisha* was caught from Multan. Qureshi (1968) quoted the catch of oozing males and females from 2 miles down the Llyoyd's Barrage at Sukkur as reported by Lims in 1948-1950. Ghulam Mohd. Barrage was constructed in 1954 and migration of *T.ilisha* was reduced to 180 miles from 476 miles before the construction of G. M barrage.

Constructions of dams have been problem throughout the world where migratory fish/fisheries exist. However areas where necessary precautions have been taken before the construction of dams or similar structures, the migratory fish successfully migrated and ascend the higher reaches of rivers. Ghulam Mohd. Barrage constructed without taking in consideration the fisheries resources of the area. There are some so-called fish ways, which are not useful for *T. ilisha* to continue its upward migration causing depletion of this important resource. The fish however aggregates at the barrage and spawning is limited to the area. There have been similar reports discussing the fish ladders of G.M.Barrage by Sindh Fisheries Department (Anon. 1957-58; 1991-92 etc), notification of government of Sindh Livestock & Fisheries Department 2003. An ordinance describing the measures to give a sustainable level of *T. ilisha* fisheries in Sindh Indus River was issued in 1980.

To this date no action has been taken neither by the Government of Pakistan nor any other agency. During the present studies G.M. Barrage was visited and literature available has been reviewed. Several suggestions are highlighted by experts of Fisheries Department and by Talbot FAO expert. Talbot 1959 published a comprehensive report on the construction of G.M.Barrage and suggested some modifications. The author mentioned following obstacles with fish ladders of G.M. Barrage.

1. Fish ladders in the middle as in G.M. Barrage are not suitable for fish to enter as fish avoid main currents where velocity exceeds 50 cubic feet/second.
2. Present Fish ways are constructed as 10 feet wide in the lower section, which reduces to 5 feet in the upper section. Such structure is narrow for fish to enter.
3. The Fish ways of G.M. Barrage change shape or direction which causes hurdles to fish to ascend.
4. Overflow weirs of the fish ways are not needed

Image 12 – A view of G.M. Barrage.

Talbot 1959 suggested following alterations in the existing fish ways of G.M. Barrage.

1. The fish ways of G.M. Barrage should be replaced by modern fish ways
2. The best location of the fish ways is at the banks of river immediately below barrage.
3. The velocity of water should be controlled at the raceways to 5 cubic feet/second.

It is presumed that if these suggestions would have been carried out or experiments to see the effect of some changes in the fish ways were observed the *Hilsa* fisheries could be saved or at least its migration would have made possible beyond the G.M.Barrage.

3.5.9.7 Conclusions

Keti Bunder the delta of Indus River is known to be second largest delta in the World. It has historic background and source for the high production of the Arabian Sea due to discharge of sediments brought by river currents from Tibet, the ultimate origin of Indus. In the historical days the delta was a hub of fishing, navigation and other activities for major countries along the Arabian Gulf. With the establishment and modernization of Pakistan several dams appeared that considerably reduced the size of delta because of the low water and simultaneously low sediment discharge in the sea. As reported by NIO scientists zero discharged is observed during the most part of the year while from June – September fresh water reached deltaic region quite infrequently. The river thus contributing hardly into the delta and almost no sediments are brought to the sea and sea water ascends the vast area. The impact of such conditions (no freshwater and intrusion of sea) are understandable by the loss of ecological

features, loss of agriculture, loss of fisheries economic destruction resulting mass migration of population.

The matter is difficult to find solution however efforts should be focused towards efficient development of the water system so that proper fresh water flow is maintained. The biggest city close to the Keti Bunder is Karachi where growing population is causing extension and establishment of new ventures that hamper the environment and cause ecological disorder. Oil exploration in the mouth of Indus delta has been reported as news item of the "The News" of Friday, October 12, 2007 further with the increase of such establishments shipping activities are expected to enhance more loss to the ecosystem.

Environment impact assessment program should be developed by agencies that operate in the region with regular monitoring of the situation by the concern Government department. In order to protect the existing ecological features of the region any dredging for oil or construction of harbor close compliance with International Dredging Conservation to which Pakistan is signatory should be followed and the national agencies should monitor the impact of such operations.

Fishing is the major source from the region but has been under great fishing pressure which becomes more devastating by the use of illegal nets that render recruitment losses for fish population. These illegal nets are installed at fixed selected areas of the delta creating ecological imbalance eventually producing permanent loss of resources.

The present extent of over fishing requires effective implementation of fisheries rules and laws should be ensured with close surveillance and monitoring practices. The more effective means would be to develop close coordination among fishermen, their societies and fisheries managers. Use of illegal nets in any part of creek should be prohibited by developing strategies relating to awareness among stakeholders.
There exits scarcity of knowledge on the biological and ecological status of such significant ecosystem. Available data is either old or based on inadequate short term sampling efforts made by agencies. We are unaware of the extent of losses in progress given the variation of climatic and physical changes occurring by continuous and regular processes.

- Regular yearly data collection to observe the seasonal impact on the ecology and fish production is essential for management of the region. Palla fisheries once the wealth of the river needs to be monitored through out the year. Construction of Dams/Barrages if required has to be associated by modern fish ladders consultation of fishery biologists. Modifications of the existing structure of G.M. Barrage to save the depleting resource of Palla are essential.
- Socially the inhabitants of Keti Bunder are neglected and very pathetic state. The poor citizens have no houses, drinking water, medical facilities, bad family links resulting involvements in illegal, unsocial activities such as women and men relations, use of drugs at very young age, two years boy was made addict by his parents to "Gutkka" (recent observations), most of the fishermen are under the pressure of loans provided by few influential persons.
- The Government and other donor agencies should take a close look of the social status of population and establish priorities to undertake development programs.

The foreign investments and donations that come for the development of mangrove plants by establishment of nurseries etc need to focus aspects that are essential for the communities such as establishments of schools, hospitals, training centers for women and awareness among fishermen to preserve and protect the natural resources for future generations.

The local community in coordination with experts in various fields should be involved and all future efforts may be channeled through the community to achieve a permanent solution of the growing unfriendly and immoral activities among the society and towards natural resources should be checked.

Image 13 – Pampus argenteus

Image 14 – Platycephalus indicus

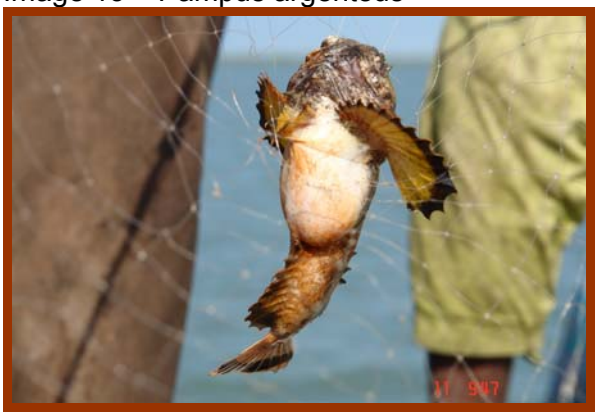


Image 15 – Antennarius sp.

Image 16 – Echeneis naucrates

Image 17 – Arius sp.

Image 18 – Acanthopagrus latus

3.6 Phytoplankton

3.6.1 Sampling locations of water quality

Map 9 shows the sampling points of water quality at Keti Bunder. Details of each sampling points can be found in the annexure document.

Map 9 – Showing sampling points of water quality from Keti Bunder

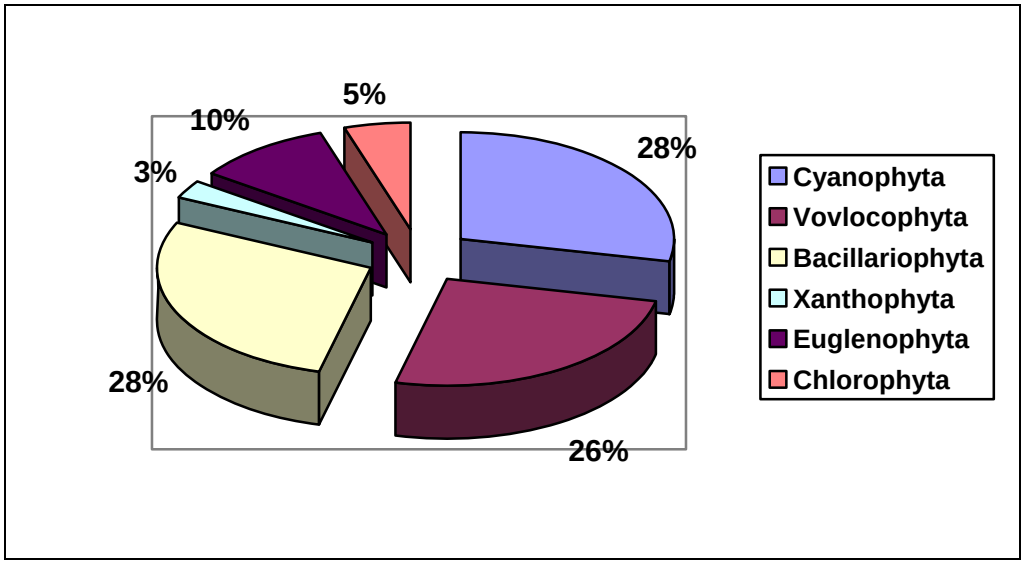
3.6.2 Summer

Table 19 and **Figure 15** show the distribution of species over genera, family, order and class recroded at Keti Bunder during summer.

Table 19 – Distribution of Phytoplankton/Algal species in Keti Bunder in June 2007 (summer)

Kingdom	Phylum	Class	Order	Family	Genera	Species
MONERA	Cyanophyta	2	2	2	8	11
PROTISTA	Volvocophyta	2	3	7	8	10
	Bacillariophyta	1	2	5	9	11
	Xanthophyta	1	1	1	1	1
	Euglenophyta	1	1	1	2	4
PROTOCTISTA	Chlorophyta	2	2	2	2	2
Total: 3	6	9	11	18	30	39

Figure 15 – Percentage of species against phylum recorded in Keti Bunder (summer)



Eleven species belonging to 8 genera of phyla Cyanophyta were recorded as shown in **Table 19.** One species from each of the following genus Aphanocapsa*, Aphanothece, Gloeothece, Gomphosphaeria, Phormidium and Trichodesmium* were recorded*.* Two species from the each genus *Lyngbya, Oscillatoria* were recorded. All the species are included in epilithic and planktonic group. They have much resistance power towards salinity.. A number of the species were found in marine and in fresh water, e.g. *Comsopogon coeruleus, Batrachospermum moniliforme* Roth*., Cyanidium, Audouinella hermanii* (Roth.) Duby and the fish Palla, Mori, Ghago, Dhahi are found both in marine and fresh water.

The above algal specimens original habitat is marine water but is also found in fresh water. The plant specimen through out the year were available in these localities e.g. Wah Garden Nullah, Kattas, Khwzakhella near Mangora. As a whole 39 species were recorded from different places of Keti Bunder and its adjacent areas (Shameel, 2001).

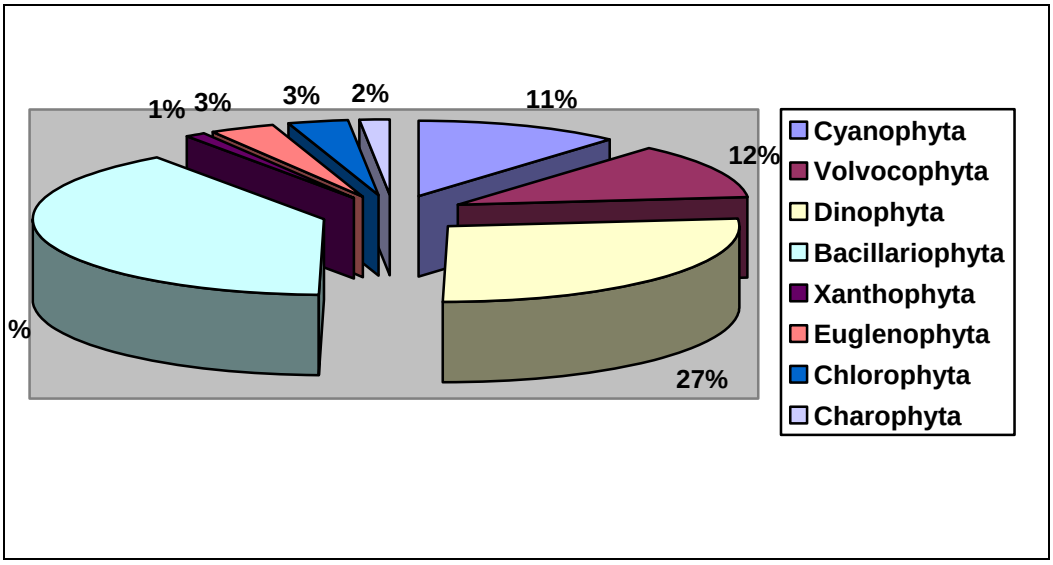
3.6.3 Winter

Table 20 and **Figure 16** show the distribution of species over genera, family, order and class recroded at Keti Bunder during winter.

Table 20 Distribution of phytoplankton/algal species in Keti Bunder in November 2007 (winter)

Kingdom	Phylum	Class	Order	Family	Genera	Species
MONERA	Cyanophyta	2	3	3	8	20
PROTISTA	Volvocophyta	2	3	7	9	21
	Dinophyta	1	0	0	9	47
	Bacillariophyta	1	0	0	30	70
	Xanthophyta	1	1	1	1	2
	Euglenophyta	1	1	1	2	6
PROTOCTISTA	Chlorophyta	2	3	3	3	6
	Charophyta	1	1	1	1	3
Total: 3	**8**	**11**	**12**	**16**	**63**	**175**

Figure 16 – Percentage of species against phylum recorded in Keti Bunder (winter)



During second survey in November, 50 algal samples were collected out of which 150 algal/phytoplankton species belonging to 65 genera of eight phyla namely Cyanophyta, Volvocophyta, Dinophyta, Bacillariophyta, Xanthophyta, Euglenophyta, Chlorophyta, Charophyta were observed in Keti Bunder and its adjacent area.

The original habitat of the above algal specimens is marine water but they are also found in fresh water. The plant specimen found through out the year were also recorded in other localities e.g. Wah Garden nullah (northern Punjab), Kattas (where the hell is this), Khwazakhella near Mingora, Swat (northern NWFP). As a whole 39 species were recorded from different places of Keti Bunder and its adjacent areas. In **Table 21** each species has been mentioned, along with habitat, current status, presence/absence at across the sampling points total and relative frequency relative density and classification (Shameel, 2001).

Fifty fish species were recoded due to rich flora of algal/phytoplankton species in the water body. During this season the light transparent in the water was more

than three meter deep, high ratio of dissolved oxygen and low ratio of turbidity were also found. All these factors are favourable for production of phytoplanktons; many kinds of birds were found in the area which is a good indicator of the good water quality which can sustain marine life. The findings of the winter survey prove to be better than the summer season results.

- **Blue green algae**: The samples were crushed and taken from rocks, boats, and from corner sides; marine water was also very turbid with silt particles. The algal species were disturbed temporarily but not destroyed due to high tides, turbidity and storm (what storm). The random method was used at the time of collection (this should be in methodology). Filamentous and multi-cellular algal species were directly picked with help of forceps and latest equipments when collection became difficult

- **Xanthophyta:** One species belongs to the genus *Ophiocytium* of the phyla Xanthophyta as recorded. All the species have flagella so they are included in Flagellales group. They move easily with the help of flagella in water body.

- **Grass green algae:** 6 species belonging to 3 genera of the phyla Chlorophyta, e.g. *Cladophora, Oedogonium, Spirogyra* etc. all the genera produce good food for aquatic life in which *Spirogyra* produce huge mates in large area even usually cover the small plants of mangrove forest, it is also found on epiphytic condition in marine water as small piece of wood, *Spirogyra* attached such piece of wood float freely in water body, with help of boat collect.

- **Charophyta:** Three species belongs to one genus *Chara* of the phyla Charophyta were recoded. The species of the genus *Chara* have capacity to produce excellent food for fishes, aquatic fauna etc.

3.6.4 Winter and summer

Table 21 and **Figure 17** show the number species in each class along with the proportion that they represented in the overall study.

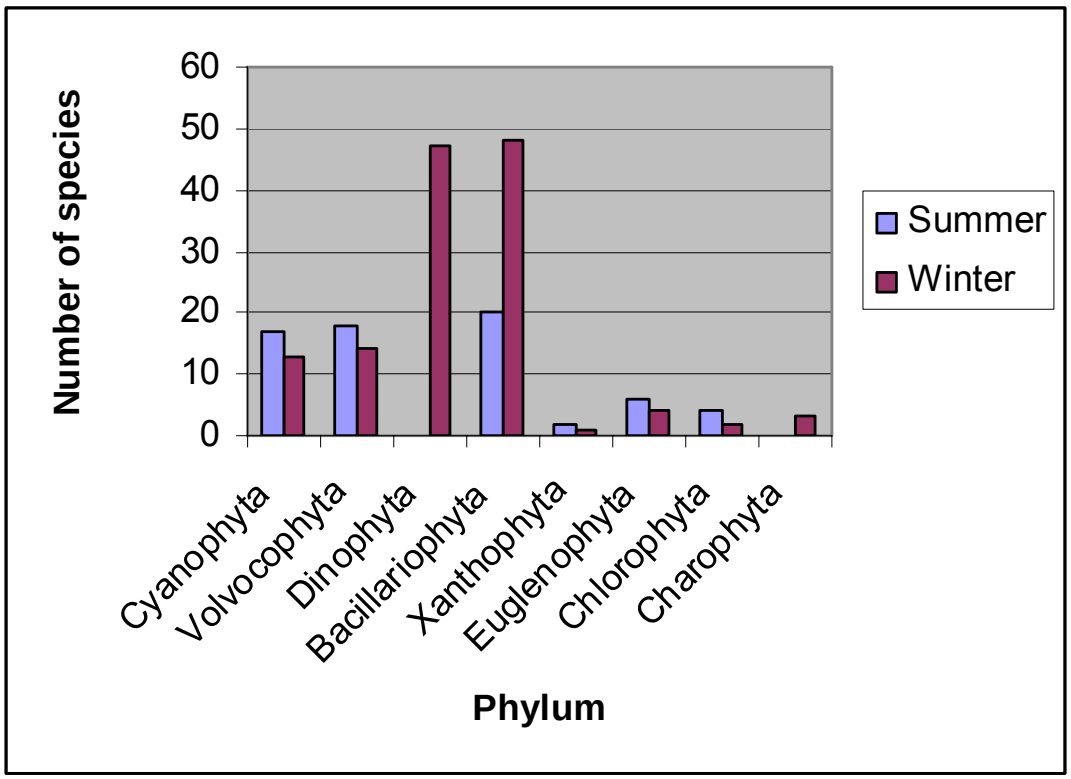
Table 21 – Genera and their species along with percentage at Keti Bunder and its adjacent areas (summer and winter)

Name of Genera	Summer		Winter	
	Number of species	Percentage %	Number of species	Percentage %
Kingdom: MONERA				
Phylum: Cyanophyta				
Class: Chroocophyceae				
Order: Chroococcales				
Family: Chroococcaceae				
1. *Aphanocapsa*	2	2	1	0.7
2. Aphanothece	2	2	1	0.7
3. Gloeothece	2	2	1	0.7
4. Gomphosphaeria	2	2	1	0.7
Class: Nostocophyceae				
Order: Oscillatoriales				
Family: Oscillatoriaceae				
1. *Lyngbya*	3	3	2	1.3
2. Oscillatoria	3	3	2	1.3

3. Phormidium	2	2	1	0.7
4. Trichodesmium	1	1	1	0.7
Order: Nostocales				
Family: Nastocaceae				
1. Anabaena	0		3	2
Kingdom: PROTISTA				
Phylum: Volvocophyta				
Class: Volvocophyceae				
Order: Chlorococcales				
Family: Oocystaceae				
1. *Oocystis*	2	2	1	0.7
2. *Tetraedron*	2	2	1	0.7
Family: Coelastraceae				
3. *Coelastrum*	3	3	2	1.3
Family: Dictyosphaeriaceae				
4. *Dictyospherium*	2	2	1	0.7
Family: Hydrodictyaceae				
1. *Pediastrum*	2	2	2	1.3
Family Scenedesmaceae				
1. *Scenedesmus*	3	3	2	1.3
Order: Volvocales				
Family: Chlamydomonadaceae				
1. *Chlamydomonas*	2	2	1	0.7
Class: Desmidiophyceae				
Order: Desmidiales				
Family: Desmidiaceae				
1. *Closterium*	2	2	1	0.7
2. *Cosmarium*	0	0	3	2
Phylum: Dinophyta				
Class: Dinophyceae				
1. *Amphisolenia*	0	0	1	0.7
2. Ceratium	0	0	27	18
3. Dinophysis	0	0	4	2.7
4. Gonyoulax	0	0	2	1.3
5. Nactiluca	0	0	2	1.3
6. Ornithocercus	0	0	1	0.7
7. Prorocentrum	0	0	4	2.7
8. Podalampas	0	0	1	0.7
9. Protoperidinium	0	0	5	3.3
Phylum: Bacillariophyta				
Class: Bacillariophyceae				
1. *Achnanthes*	2	2	1	0.7
2. *Bacillaria*	0	0	1	0.7
3. *Bacteriastrum*	0	0	3	2
4. *Chaetoceros*	0	0	16	10.7
5. *Climacodium*	0	0	1	0.7
6. *Cocconies*	2	2	1	0.7
7. *Corethron*	0	0	1	0.7
8. *Coscinodiscus*	2	2	1	0.7
9. *Diatoma*	2	2	2	1.3
10. *Doctyliosolen*	0	0	1	0.7
11. *Eucampia*	0	0	1	0.7
12. *Fragilaria*	2	2	2	1.3
13. *Gomphonema*	0	0	2	1.3
14. *Guinardia*	0	0	1	0.7
15. *Gyrosigma*	3	3	2	1.3

16. *Hemialus*	0	0	2	1.3
17. *Lyptocylindrus*	0	0	2	1.3
18. *Melosira*	2	2	1	0.7
19. *Navicula*	2	2	3	2
20. *Odontella*	0	0	3	2
21. *Planktoniella*	0	0	1	0.7
22. *Pleurosigma*	0	0	1	0.7
23. *Probostcia*	0	0	1	0.7
24. *Pseudo-nitzschia*	0	0	2	1.3
25. *Rhaphonies*	0	0	1	0.7
26. *Rhizosolenia*	0	0	6	4
27. *Schroderella*	0	0	1	0.7
28. *Skeletonema*	0	0	1	0.7
29. *Synedra*	3	3	3	1.3
30. *Thalassionema*	0	0	2	1.3
Phylum: Xanthophyta				
Class: Xanthophyceae				
Order: Mischococcales				
Family: Chlorobotrydaceae				
1. *Ophiocytium*	2	2	1	0.7
Phylum: Euglenophyta				
Class: Euglenophyceae				
Order: Euglenales				
Family: Euglenaceae				
1. Euglena	3	3	2	1.3
2. Phacus	3	3	2	1.3
Kingdom: PROTOCTISTA				
Phylum: Chlorophyta				
Class: Siphonocladophyceae				
Order: Cladophorales				
Family: Cladophoraceae				
1. Cladophora	2	2	1	0.7
Class: Zygnemophyceae				
Order: Oedogoniales				
Family: Oedogoniaceae				
1. Oedogonium	2	2	1	0.7
Order: Zygnematales				
Family: Zygnemataceae				
1. *Spirogyra*			1	0.7
Phylum: Charophyta				
Class: Charophyceae				
Order: Charales				
Family: Charicaceae				
1. *Chara*			2	1.3

Figure 17 – Number of species in each phylum during the summer and winter surveys



3.6.5 Discussion

During the two surveys carried out between 11 to 13 June 2007 and 8 - 11 November 2007, a total of 76 samples were collected. In 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). In the winter survey a total of 50 algal samples were collected; out of which 150 algal/phytoplankton species belonged to 65 genera of 8 phyla namely Cyanophyta, Volvocophyta, Dinophyta, Bacillariophyta, Xanthophyta, Euglenophyta, Chlorophyta and Charophyta. Overall the winter flora results proved to be more satisfactory compared with the summer flora results. In the winter months low tides and turbidity was observed. There was no evidence of floods or rain in the site area. Various birds and fish were present due to the presence of rich algal and phytoplankton flora. The physico – chemical factors were found to be favorable along with the climatic and environmental conditions for the growth of aquatic fauna and flora including fish species. However, the salinity in the area is on the rise due to lack of management and fresh water.

3.6.6 Threats and recommendations

No specific threats or recommendations were given by the consultant. However it was pointed out that the main factor affecting phytoplankton growth and production is salinity. Due to the lack of fresh water salinity in the surrounding areas has increased especially in the regions of Thatta and Badin. The rapid increase in salinity has caused a decrease in phytoplankton and algae production. Some other factors include high tides, turbidity, rain and floods causing a steep decline in vegetation growth. A major problem in the area is

pollution from agricultural and domestic waste. Oil spills from motorized boats directly affect the phytoplankton and algal vegetation.

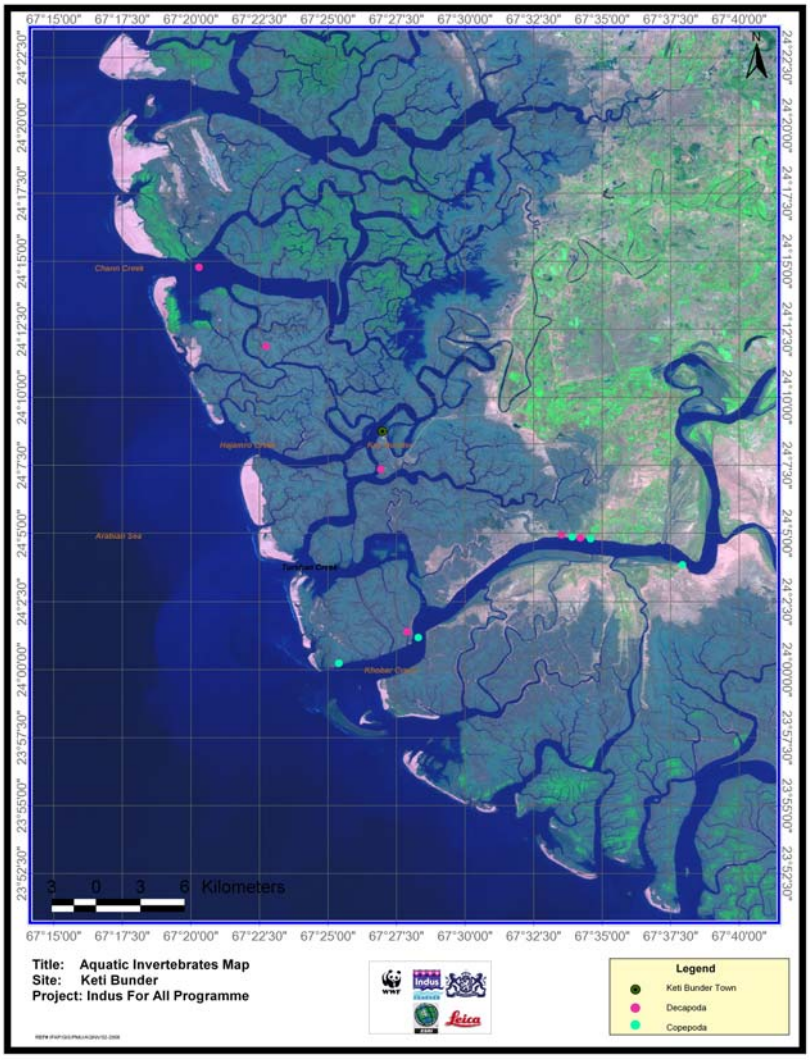
To further strengthen these findings further studies should be conducted to monitor the growth, production and degradation of phytoplankton and algal vegetation. The community must be educated about the importance of phytoplankton as an integral part of the food chain. Care must be taken during fishing season to maintain the flora and fauna of the sea.

3.7 Zooplankton

3.7.1 Sampling locations

Map 10 shows the sampling point for zooplankton collection from Keti Bunder. Details of the sampling points can be found in the annexure document.

Map 10 – showing the sampling points for zooplankton collection at Keti Bunder



3.7.2 Summary

The crustaceans captured from the Keti Bunder were catalogued and identified at the lowest taxonomic level, which in most of the cases was the species, and in some cases, genus for that species. As most of the prawns captured from the area

belong to the genus Macrobrachium it is therefore vital to briefly discuss this economically imperative decapod genus, which, owing to its high fecundity, appropriate size and adaptability in the cultural practices has been a distinct focus of the prawn farmers and fisheries activities globally since decades. Following is its taxonomic hierarchy.

Table 22 – Data of aquatic invertebrates collected from Keti Bunder during the summer and winter surveys

Aquatic invertebrate groups	Locality (Coordinates)		Season	Date
Decapoda	N 24 15' 016''	E0 67 20' 675''	Summer	12-06-07
	N 24 14' 776''	E 067 20' 298''	Summer	13-06-07
	N 24 07' 343''	E 067 26' 929''	Summer	13-06-07
	N 24 04 ' 823''	E 067 34' 202''	Winter	11-11-07
	N 24 04' 778''	E 067 34' 130''	Winter	12-11-07
	N 24 01' 390''	E 067 27' 891''	Winter	13-11-07
Copepoda	N 24 03' 857''	E 067 37' 927''	Summer	13-06-07
	N 24 04' 798''	E 067 34' 063''	Summer	12-04-07
	N 24 00' 230''	E067 25' 399''	Winter	11-11-07
	N 24 01' 180''	E 067 28' 296''	Winter	12-11-07
	N 24 04 ' 816''	E 067 34' 168''	Winter	13-11-07

3.7.3 Species account

Phylum: Arthropoda Latreille, 1829 - arthropods
Subphylum: Crustacea
Class: Malacostraca Latreille, 1802
Subclass: Eumalacostraca Grobben, 1892
Superorder: Eucarida Calman, 1904
Order: Decapoda Latreille, 1802
Suborder: Pleocyemata Burkenroad, 1963
Infraorder: Caridea Dana, 1852
Family: Palaemonidae
Subfamily Palaemoninae
Genus: Macrobrachium (De Man, 1879)

- ***Penaeus indicus***
  Phylum : Arthropoda
  Class : Crustacea
  Series : Eumalacostraca
  Superorder : Eucarida
  Order : Decapoda
  Suborder : Natantia
  Infraorder : Penaeidea
  Superfamily : Penaeoidea
  Family : Penaeidae
  Genus : Penaeus
  Subgenus: Fenneropenaeus
  Species : indicus

Image 19 – *Penaeus indicus*

Penaeus indicus is another important species found in the Keti Bunder area and is found and caught in reasonable abundance though like most of the other commercially important species of the area its frequency in the catch has also reduced than the normal over the last decades.

- ***Penaeus meruginus De Man, 1882***

Kingdom: Animalia
Phylum: Arthropoda
Subphylum: Crustacea
Class: Malacostraca'
Order: Decapoda
Suborder: Dendrobranchiata
Superfamily: Penaeoidea
Family: Penaeidae
Genus: Penaeus

Image 20 – *Penaeus meruginus*

This species is commonly called 'Jaira' or 'Jiaro' by the locals in Sindh. It is abundant in Keti Bunder area and many local fishermen depend solely on this species for their livelihood. This species is commercially important in the Persian Gulf and Pakistan. In India this species has often been confused with *Penaeus indicus* so that its present economic status is not accurately known but it certainly contributes to the commercial fishery in Sindh.
This widely distributed and important Indo-West Pacific species lives in shallow water between 10 and 45 meters on muddy bottoms. Juveniles are estuarine, while adults mostly marine. This species ranges from the Persian Gulf and Pakistan through the Malay Archipelago and South China Sea to Australia, where it is found from Western Australia all the way around the north coast to northern New South Wales.

- ***Parapenaeopsis stylifera***

Phylum: Arthropoda
Class: Crustacea
Series: Eumalacostraca
Superorder: Eucarida
Order: Decapoda
Suborder: Natantia
Infraorder : Penaeidea
Superfamily : Penaeoidea
Family: Penaeidae
Genus: Parapenaeopsis
Species: stylifera

Image 21 – *Parapenaeopsis stylifera*

Parapenaeopsis stylifera is another important crustacean found in the Gharo area and is caught in sufficient abundance. It is locally called 'Kiddi'

by the fishermen. It is a commercially important species of prawn in the Arabian Sea and it is found in estuarine areas and thus it seems to have developed some interesting environmental tolerance and physiological resistance to the estuarine conditions. Attempts have been made to rear this species in the laboratories in Karachi and successful rearing practices including the rearing of the eggs and larvae have also been executed recently near the sea shore of Karachi.

- ***Scylla serrata***

Phylum: Arthropoda
Subphylum: Crustacea
Class: Malacostraca
Order: Decapoda
Infraorder: Brachyura
Family: Portunidae
Genus: Scylla
Species: S. serrata

Image 22 – Scylla serrata

Commonly called Mangrove crab or mud crab, this species is found in huge abundance in Keti Bunder area. It is locally named as 'khakua' by the fishermen community at Keti Bunder and surrounding areas. This mud crab inhabits muddy bottoms in brackish water along the shoreline, mangrove areas, and river mouths; hence it is given the name mud crab or mangrove crab.

It has been reported that both, temperature and salinity can affect the nitrogen metabolism of mud crabs. At low salinity i.e. 10 ppt, there is catabolism of amino acid and formation of ammonia to reduce osmolarity. As regards the reproduction of this economically imperative crab, mating takes place as early as the first year of life after the female undergoes a pre-copulatory molt. As regards its feeding habits, 50% of the identifiable material in the foreguts is mollusks, 20-22% crustaceans, and the remaining 28-30% consisting of small amounts of plants and debris.

- ***Partunus pelagicus***

Phylum: Arthropoda
Class: Crustacea
Series: Eumalacostraca
Superorder: Eucarida
Order : Decapoda
Infraorder : Brachyura
Family :Portunidae
Genus : Portunus
Sub Genus : Portunus
Species : pelagicus
Authority : Linnaeus

Image 23 – *Partunus pelagicus*

Commonly called Blue crab, this species is undoubtedly the most abundant crab species of the Keti Bunder and suburbs. It prefers to live on sandy bottoms, in lagoon and bay. It hides in the sand when threatened. Large swimmer crabs, carapace with large lateral spines, a series of 8 small anterior spines (on each side of the eyes), spines along the claws. Blue color not always present on legs and claws tips. Carapace is usually 20 cm wide. A spine at distal end of posterior border of mercus of cheliped, front composed of four teeth.

3.7.3 Zooplankton at Keti Bunder

Zooplanktons captured during sampling from Keti Bunder were found to belong to the sub-class Copepoda of the class Crustacea. Acartia is the numerically dominant species in the early spring to early summer faunal assemblage in the Keti Bunder area.

Phylum Arthropoda
Class Crustacea
Subclass Copepoda
Order Calanoida
Family Acartiidae
Genus: Acartia Dana, 1846

- **Copepoda**
  Copepods, cladocerans and other larval crustaceans make up the micro-crustaceans. The free-living copepods, together with the parasitic copepods constitute the Order Copepoda of the Class Crustacea in the phylum Arthropoda. The copepods are the largest and most diversified group of crustaceans. At present they include over 14,000 species, a surely underestimated number, inhabiting marine and fresh waters, semi terrestrial habitats, or living in symbiotic relationships with other organisms. Copepods are an exceptionally important group of freshwater zooplankton. They utilize varieties of food items ranging from detritus; bacteria to a wide array of unicellular and multi-cellular phytoplankton and themselves serve as an excellent food for zooplanktivorous fish. Their nutritional value is higher as compared to that of Rotifera. These play vital role in energy transfer from primary producers to secondary consumers in aquatic ecosystem. Marine copepods are slightly larger than marine rotifers and smaller than newly hatched brine shrimp.

3.7.4 Impact on the ecosystem

The invasion of *Acartia tonsa* into the Arabian Sea has a positive impact regarding its position as a fish food item. On the other hand, increase in its abundance is responsible for the stock decline of *Calanipeda aquaedulcis*. Similarity of habitat requirements of these two species has strained their competition.

3.7.5 Discussion

It has been suggested that the zooplankton abundance allows for the enhanced survival and growth for fish larvae. The zooplankton biomass supports high ichthyoplankton concentrations. Many zooplanktons including the copepods are known to be the important component of the larval fish diets. Predaceous invertebrates preferably prey upon the smaller zooplankton. If the nutrient supply is not continued, the elevated predation by fish larvae also creates food limitation. The predation pressure therefore not only controls the abundance of the

zooplankton but can also change the composition and size spectrum of zooplankton community.

Zooplankton density and the gill infection of fish are inversely proportional to each other. At a low zooplankton density the fish fingerlings change their feeding behaviour and due to the insufficient zooplankton, they ingest a larger number of fish parasites from the detritus. It is possible that the lower intensity of gill infection at a high zooplankton density could also be explained by the more intensive fish parasite consumption by the copepods.

Dodson and Frey (1991) and Williamson (1991) also include keys to identification. The keys for the copepods and cladocerans go only as far as the genus level. Since taxonomy is a dynamic science, names of some groups have changed with time; thus professionals also use a widely scattered primary literature. In Pakistan, however, no profound work has been done regarding the identification and key-making of the zooplankton and there is dearth of literature which adds to the complications related to the identification of the rich and diverse zooplankton fauna of Pakistan up to the species and, in many cases, even up to the genus level.

Zooplanktons are common in the pelagic and littoral regions of ponds, lakes, large rivers, and oceans. In freshwater, these assemblages are dominated by the rotifers and two groups of micro-crustaceans—the four orders of cladocerans and the class Copepoda. The copepods are also dominant in marine environments. The littoral and benthic regions of freshwater and marine environments characteristically hold large numbers of the diverse and ancient micro crustacean class Ostracoda. Most species of these four groups make their living grazing algae from the water column or off surfaces and are, in turn, a vital link for passing energy up the food chain to fish.

Zooplanktons occupy an important position in the trophic structure and play a major role in the energy transfer of an aquatic ecosystem. An inadequate knowledge of the zooplankton and their dynamics is a major handicap for better understanding of life processes of fresh water bodies. Such studies have extreme significance and ecological value since eutrophication is bound with the components and production of zooplankton.

Among zooplankton, the relative abundance of copepods was dominant in the Keti Bunder. The abundance of crustaceans collected by the plankton net method was found healthier than their usual abundance in polluted areas of the oceans.

Detectable changes in the abundance or species composition of zooplankton may reflect fundamental changes in the aquatic environment affecting phytoplankton. In turn, because zooplankton are eaten by larger animals, some of which are of commercial importance, changes in zooplankton communities can provide early indications of forthcoming changes in the food conditions for fish, birds and mammals. As most of the zooplankton are relatively short-lived and have enormously high growth rates, they respond quickly to the environmental perturbations that influence diversity, such as any localized or broad-spectrum pollution, degradation and predation pressure. Crustacean zooplankton growth and development rates are well known to depend strongly on water temperature. The diversity in the stages of life history of the copepods may also be a sensitive early warning of temperature increases in the aquatic ecosystems in response to global atmospheric warming.

Planktonic nutrient regeneration is a fundamental process that maintains most of the primary productivity in freshwater environments, and the phosphorus supply for stream plankton comes primarily from within the plankton community, rather than from external loading or from larger organisms such as fish.

Even though the zooplankton may seem a minor link in the pathway of energy from algae to higher trophic, they are extremely important as food for young fish and for certain forage fish. The zooplankton graze on phytoplankton and are themselves the primary food source for many larval fish, some larger fish and most invertebrates found in the freshwaters (Darnell 1961). Planktivorous (plankton eating) fish regulate the abundance and size structure of zooplankton populations. Prey is targeted usually on an individual basis, although the gill rakers of certain fish collect some zooplankton as water passes through the mouth and across the gills. Planktivorous fish prefer larger zooplankton and can eliminate many important crustacean groups from the water body. Planktonic animals, especially rotifers, cladocerans, and copepods of the order Cyclopoida are the most important food items in freshwater aquaculture, and copepod nauplii are especially valuable for feeding fry.

The most important aquatic invertebrates in the Keti Bunder area are the shrimps, crabs and oysters. Shrimps form the backbone of marine fisheries industry of Pakistan and earn a large amount of foreign exchange. The management of responsible and sustainable fisheries in the coastal areas and Indus delta has direct impact on the economy of the country. Fishing activities should be streamlined so that the coastal populations inhabiting the area receive maximum benefits and their socio-economic conditions can be improved. These biological resources need protection against inappropriate uses and overexploitation. A large amount of data is available on shrimps. It has been estimated that annual average catch of shrimps associated with mangrove forest at Sindh coast surpasses thousands of tons. When expressed on the basis of per km coastline length, this production is estimated at around hundred tons per kilometer in Sindh as compared to one ton per kilometer in Balochistan. The underlying cause of this productivity in Sindh water is the wealth of extensive mangroves. To sustain the marine fishery the man-agreement and rehabilitation of the mangroves is imperative.
Finally it is imperative to note that the value assignments for direct and indirect uses of ecosystem goods and services can be very useful in order to establish the physical/ecological linkages that make such uses possible and also partially measure the derived economic benefits from these uses. Knowing these values, and by incorporating the benefits and costs of environmental effects into an analysis of development alternatives, we are better positioned to decide which alternative would provide the largest net benefit to society. Similar analyses are becoming widespread and many examples relevant for wetland services are available (Hamilton et al., 1989; Ruitenbeek, 1992; Barbier and Strand, 2000; Cesar et al., 1997; to name a few relevant to coastal areas).

Although there are few directly marketed products from mangroves of Keti Bunder, local coastal communities continue to depend on mangroves for a range of goods such as fuel, wood, shellfish and on ecosystem services such as maintenance of the productivity of important estuarine dependent fisheries, water quality regulation, flood reduction and shoreline stability just as in the other mangroves of the world. Communities further inland similarly depend on many of these same products, transported to markets as finished or primary products. These areas provide vital nurseries for fisheries that support global communities

and often shelter biodiversity of global importance by virtue of being, in general, relatively undisturbed ecosystems. The loss of these ecosystems would therefore suggest potential local, national and global welfare losses. Yet, quantifying those losses in as accurate a manner as possible, and actually using them to make more informed decisions about land use and land conversion, is a task of phenomenal proportions. Economic values associated with healthy mangrove ecosystems can however be generated through economic analysis that attempts to measure the use and non-use values of these ecosystems.

Coastal areas of Pakistan in common and Keti Bunder and its adjoining areas in particular are highly modified landscapes, supporting large, and of course, poor populations. These areas are under enormous pressures of all sorts not only because of the large numbers of inhabitants who depend on the resources from these areas, but more so because of indiscriminate conversion of these areas to other land uses.

3.7.6 Threats and recommendations

There were no specific threats or recommendations submitted in the report. However the following conclusion was made:

The most important aquatic invertebrates in the Keti Bunder area are the shrimps, crabs and oysters. Shrimps form the backbone of marine fisheries industry of Pakistan and earn a large amount of foreign exchange. The management of responsible and sustainable fisheries in the coastal areas and Indus delta has direct impact on the economy of the country. Fishing activities should be streamlined so that the coastal populations inhabiting the area receive maximum benefits and their socio-economic conditions can be improved. These biological resources need protection against inappropriate uses and overexploitation. A large amount of data is available on shrimps. It has been estimated that annual average catch of shrimps associated with mangrove forest at Sindh coast surpasses thousands of tons. When expressed on the basis of per km coastline length, this production is estimated at around hundred tons per kilometer in Sindh as compared to one ton per kilometer in Balochistan. The underlying cause of this productivity in Sindh water is the wealth of extensive mangroves. To sustain the marine fishery the man-agreement and rehabilitation of the mangroves is imperative.

Finally it is imperative to note that the value assignments for direct and indirect uses of ecosystem goods and services can be very useful in order to establish the physical/ecological linkages that make such uses possible and also partially measure the derived economic benefits from these uses. Knowing these values, and by incorporating the benefits and costs of environmental effects into an analysis of development alternatives, we are better positioned to decide which alternative would provide the largest net benefit to society. Similar analyses are becoming widespread and many examples relevant for wetland services are available (Hamilton et al., 1989; Ruitenbeek, 1992; Barbier and Strand, 2000; Cesar et al., 1997; to name a few relevant to coastal areas).

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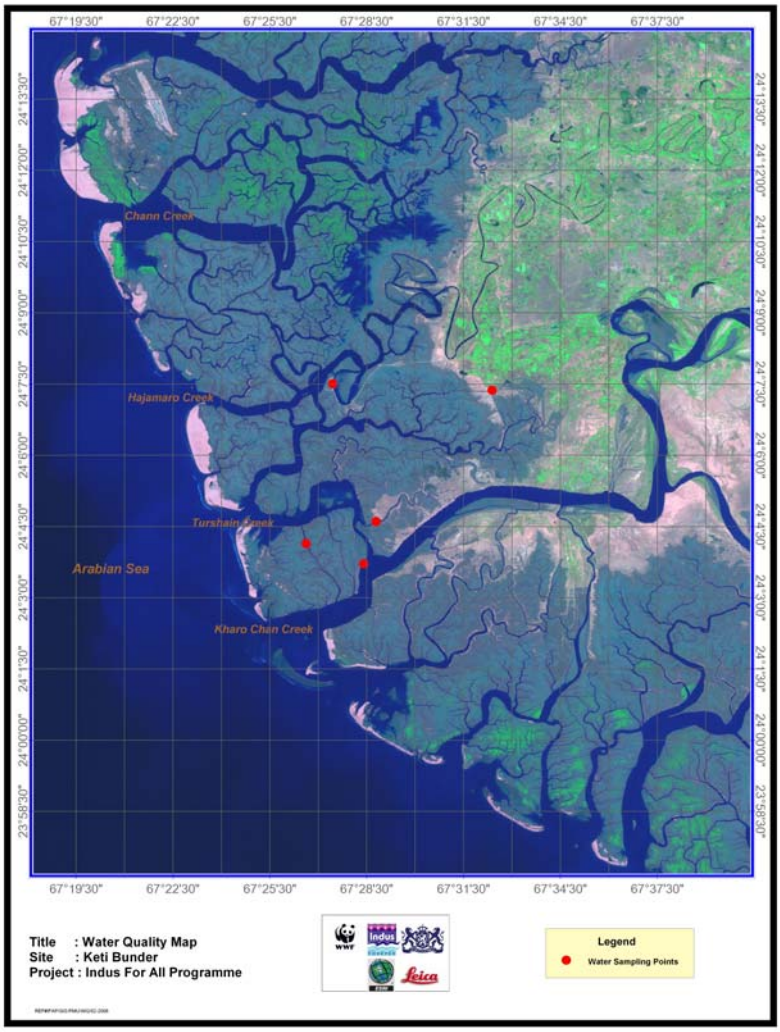
3.8 Physico-chemical properties of water

3.8.1 Sample locations

Map 11 shows the sampling locations of water quality for Keti Bunder. Details of sampling points can be found in the annexure document.

Map 11 – sampling locations for water quality sampling



3.8.2 Field observations during water sampling

Keti Bunder is connected with nearby cities by road. Keti Bunder study area can be divided in to two parts; (1) Keti Bunder Town area where people are living and (2) creeks area where livelihood is dependent. The town area gets drinking water from a distance of about 10 Km through hired water tankers. Town waste water is collected in to the cemented tank and pumped into Hajamro creek area. This creek also gets agriculture drainage from the adjacent irrigated area. People living in the surrounding areas of the creeks were found mostly engaged in fishing. The living conditions of people are very hard; health, education and drinking water are the core issues of the area.

During the pre monsoon visit, the high tide raised the water level in surface drains in the Keti Bunder town area. The over cutting of mangrove trees for fuel and fodder is widespread, as there is no other cheap and easily available source of food and energy for the community living in the creek area.

3.8.3 Results

The data set of Keti Bunder study area is presented in two parts. Set one represents Keti Bunder Town area and set two represents creeks containing fishery and mangrove forest. The water quality data obtained in the month of July-2007 (pre monsoon) and in October/November 2007 (post monsoon) is shown in the annexure document.

Table 23 – Water quality parameters found in Keti Bunder town pre monsoon & Post monsoon

	Parameters	Pre Monsoon	Post Monsoon
1	Temperature	30-32^{o}C	25-29^{o}C
2	Electrical Conductivity	47200-52700 µS/cm	1502-48400 µS/cm.
3	TDS	30208-33728 ppm	962-36608 ppm
4	pH	7.93-8.81	7.16-8.00
5	Turbidity	13.2-471	12.7-94.0
6	Total Hardness	5504-5804 ppm	300-5000 ppm
7	Calcium	900-1100 ppm	100-1000 ppm
8	Magnesium	4604-4704 ppm	200-4200 ppm
9	Sulphate	1650-1780 ppm	100-13380 ppm
10	Chlorine	18000-20000 ppm	350-20000 ppm
11	Alkalinity	113-113 ppm.	120.0-898.0 ppm.
12	Phenols	34 ppb	34-340ppb
13	Cr	10.44-41.32 ppb	3.53-12.64 ppm
14	Pb	16.20-17.20 ppb	8.08-75.84 ppm
15	Cd	2.20-2.92 ppb.	11.2-64.0 ppb
16	Ni	6.5-7.8 ppm	12.2-35.21 ppb
17	BOD	3.05-8.75 ppm	0.53-12.4 ppb
18	COD	9.2-51.5 ppm	1.9-25.9 ppm

3.8.3.1 Keti Bunder town area

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

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

The Waste water coming from Keti Bunder Town contains washing water (originally KB water /saline water) used for different purposes excluding the drinking water). The drinking water is an expensive commodity and comes in tankers. Since more water is used in non drinking house-hold activities, the waste water generated has high salinity/TDS and Ni content which is above the NEQs. The other parameters given in **Table 24** were within NEQs limits.

Table 24 - Water quality analysis of Keti Bunder town waste water and agriculture drainage effluent for pre and post monsoon

	Parameter	NEQ Standards for Effluents into sea (mg/l)	KB-B1	KB-KB-B2	KB-A1	KB-KB-A2	Remarks
1	TDS (mg/l	3500	33728	30208	962.0	25344	KB-B1,B2,and KB-A2 are high
2	pH	6-9	7.93	8.81	7.91	7.16	Within range
3	COD(mg/l)	600	9.20	51.5	10.87	75.84	Within range
4	BOD (mg/l)	200	3.05	8.75	4.81	12.64	Within range
5	Phenol (µg/l)	0.3	34	34	51	340.0	Within range
6	Cr (µg/l)	1.0	10.44	41.32	11.2	64.0	Within range
7	Cd (µg/l)	0.1	2.92	2.20	0.53	1.09	Within range
8	Pb (µg/l)	0.5	16.20	17.20	16.8	35.21	Within range
10	Ni (mg/l)	1.0	6.5	7.8	5.13	25.9	high

3.8.3.2 Keti Bunder Creeks Area

The values of Keti Bunder water quality in creek areas were compared with the Coastal Water Quality Standards. The marine water quality values are those specified values which are considered safe for the marine life, fish, and mangrove growth. The results show that except for the phenol and nickel, the values of all parameters are well suited for all type of fish, prawn, and Palla fish grown in marine water. The cause of high nickel and phenol contamination could be

attributed to the increasing level of pollution (municipal and industry waste) entering in to sea from Karachi.

Table 25 – Keti Bunder creeks area water quality assessment

	Parameter	Permissible As per Coastal Water Quality Standards	KB-A3	KB-A4	Remarks
1	TDS (mg/l)	29000-35000 (mg/l)	36608	30976	Within range
2	pH	7.5-8.5	8.0	7.94	Within range
3	DO mg/l	<< 4.0 mg/l	7.1	8.8	Normal
4	Phenol (µg/l)	>> 0.03 mg/l	340	340	High
5	Cr (µg/l)	>>0.1 mg/l	52.7	48.44	Within range
6	Cd (µg/l)	>>0.005 mg/l	12.4	2.35	KB-A3 slightly high
7	Pb (µg/l)	>>0.05 mg/l	13.2	30.06	Within range
8	Ni (mg/l)	>>0.002 mg/l	19.81	23.06	High

<< Not less than >> Not greater than

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 26** are within WHO safe limits.

Table 26 – Keti Bunder creek area hand-pump water quality assessment

	Parameter	WHO Drinking water Quality Standards (mg/l)	KB-A5	Remarks
1	TDS (mg/l	1000	1383	Slightly high
2	pH	6.5-8.5	7.39	normal
3	Turbidity (NUT)	5	78.0	
4	Total Hardness (mg/l)	500	535±0.15	normal
5	SO_4 (mg/l)	250	150±0.15	normal
6	Cl (mg/l)	250	505±0.08	High
7	Magnesium (mg/l)	150	335±0.13	High
9	Calcium (mg/l)	75	200±0.13	High
10	Phenol (µg/l)	0.002	34	High
11	Cr (µg/l)	0.05	12.13	normal
12	Cd (µg/l)	0.003	1.11	normal
13	Pb (µg/l)	0.01	12.2	normal
14	Ni (mg/l)	0.02	1.9	High

The ± values show the standard deviation

3.8.4 Discussion

The agriculture surface drain discharging in to the Hajamro creek near Keti Bunder Town does not pose any threat to the sea, as this water is relatively better and all its parameters are meeting the standards of NEQ for effluents disposal into sea. The waste water coming from Keti Bunder Town contains sea water, normally used for different non drinking house-hold activities causing high salinity/TDS, Nickel and phenol level in waste water, which is above the NEQ standards for disposal in the sea. Since the quantum of this water is far below the quantum available in Keti Bunder and there is no other pollution source available in town, the impact of this waste water on sea water quality will be negligible.

The water quality of Keti Bunder creeks when compared with the Coastal Water Quality Standards shows that, except the phenol and nickel content, the values of all other parameters are within permissible limits for all type of marine life (fish, prawn, and Palla fish, etc). The high values of nickel and phenol contamination could be attributed to the large municipal and industrial effluents coming from Karachi and discharging in to the sea. The hand pump sample representing the drinking water quality of creeks area was analyzed which is found influenced by the sea water underneath raising the level of TDS, salt concentration, nickel and phenol than the WHO drinking water quality standards. However, other parameters are within WHO safe limits.

The data of the last twelve years on flow downstream Kotri Barrage has been varying from 0.3- 91 million acre-feet (MAF). The previous studies have reported that coastal mangrove ecosystems in Pakistan have been seriously degraded over the last 50 years as a result of freshwater diversion for agriculture, industrial and urban water pollution, and over-fishing. These proximate causes are largely driven by national policies that have favored agriculture and industry over the coastal regions and that have given high priority to exports.

3.7.5 Threats and recommendations

3.7.4.1 Recommendations

There is no major source of pollution in Keti Bunder study area. The pollution of nickel and phenol which is present in Keti Bunder area is generated from municipal and industrial waste of Karachi and navigation activity occurring in the sea. Therefore it is suggested that these effluents should be treated before disposal in the sea.

Adequate fresh water flow along with silt containing nutrients is vital for the survival of the mangrove forest and its habitat. The fresh water availability in Indus delta is almost decreasing since many years. Consequently, the breeding of fish and shrimp species has affected and the migration of famous Palla fish to upstream has been hampered. In this connection, stricter local governmental regulations and enforcement protecting mangroves are necessary. Also, involvement of local communities for sustainable management and protection of their coastal resource base, including the nearby mangrove forests, should be ensured.

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

Table 27 – 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 28**.

Table 28 – 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 29** below.

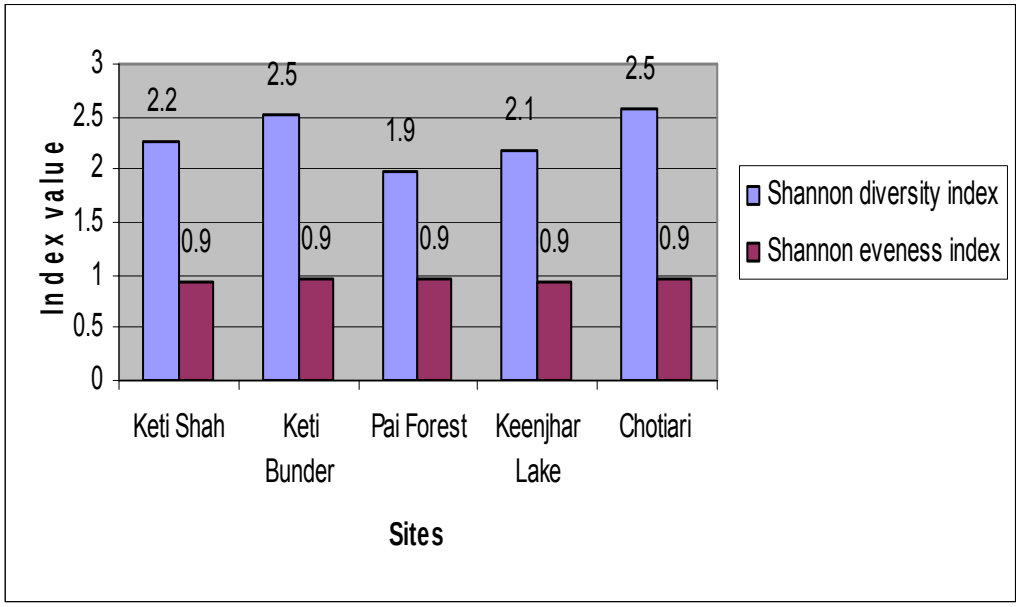
Table 29 – Conservation status of mammals found at Indus for All Programme sites

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 18**) 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 18 – 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 30 to 34**). 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 30 – 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 31 – 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 32 – 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

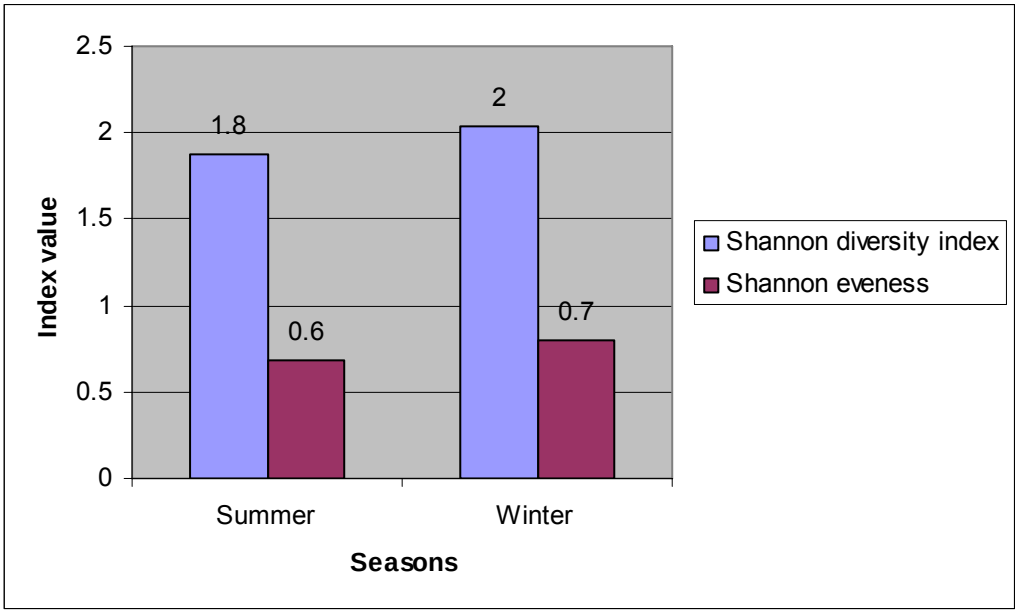
Table 33 - Mammals recorded from Keenjhar Lake during summer and winter surveys

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 34 – 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 19 – 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 35 and 36**.

Table 35 – 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 36 – 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

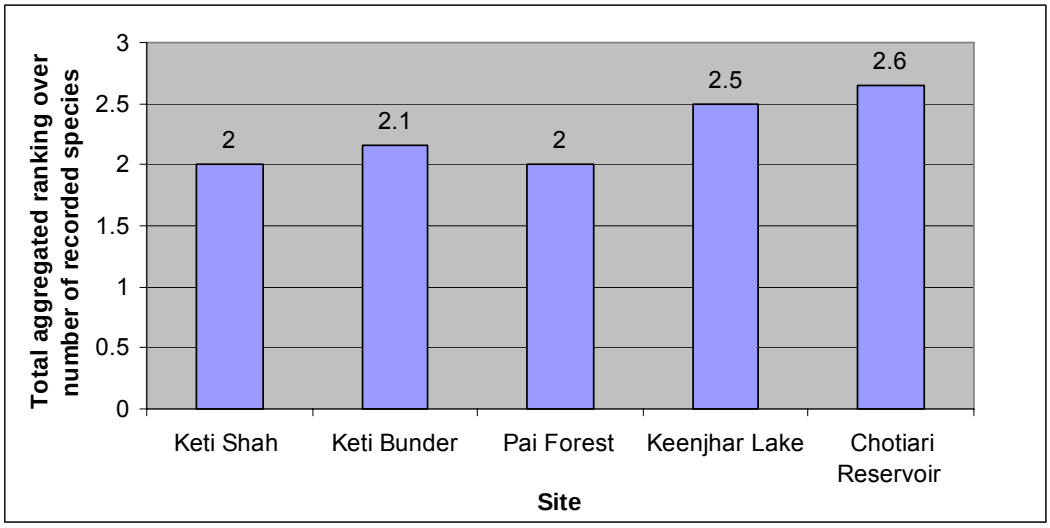
Various threats to different mammals were identified at five different study sites that include; habitat destruction, illegal hunting, poaching, live trapping, food competition, lack of awareness, law and order situation, weak enforcement of wildlife laws etc. Based on indirect and direct observations 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 37 – 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 20 – Aggregated threat ranking adjusted against number of species recorded from each site

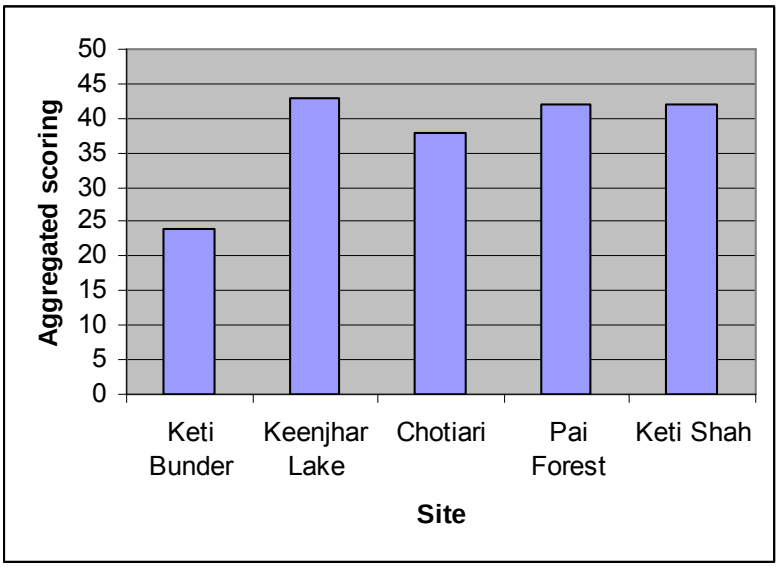


Chotiari Reservoir and Keenjhar Lake had the highest averaged disturbance factor against the species that were recorded there. Though this is an arbitrary scoring it does give an indication over the overall threat to large mammals at each site. Looking at general issues over the sites, Table 41 lists all the potential threats and attributes scores to them (ranging from 1 to 5, see legend below **Table 38**) across the sites. **Figure 21** gives the aggregated score for all sites.

Table 38 – 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 21 – 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

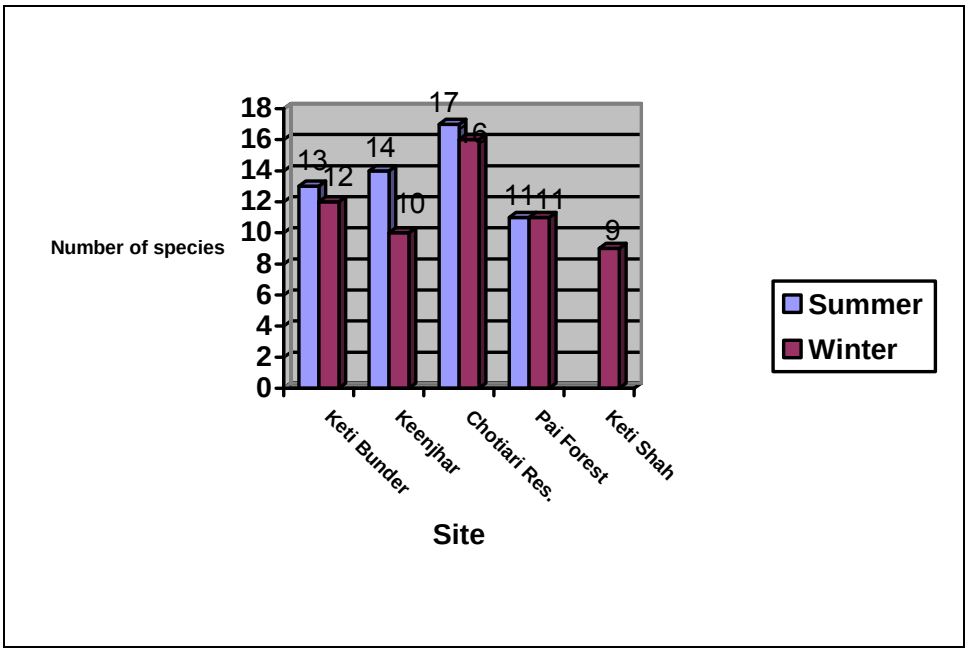
A total of 23 small mammal species were observed or collected from the five sites of the Indus for All Programme, 15 from Keti Bunder, 17 from Keenjhar, 19 from Chotiari, 14 from Pai forest and 9 from Keti Shah riverine forest. Most of these species were recorded in summer. The table (**Table 39**) below gives an account of species found at each site.

Table 39 – 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 22 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 22 – Comparison of number of small mammal species over summer and winter



4.2.2 Similarity index over sites and seasons

Figures 23 and 24 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 23 – Similarity index over five programme site during summer

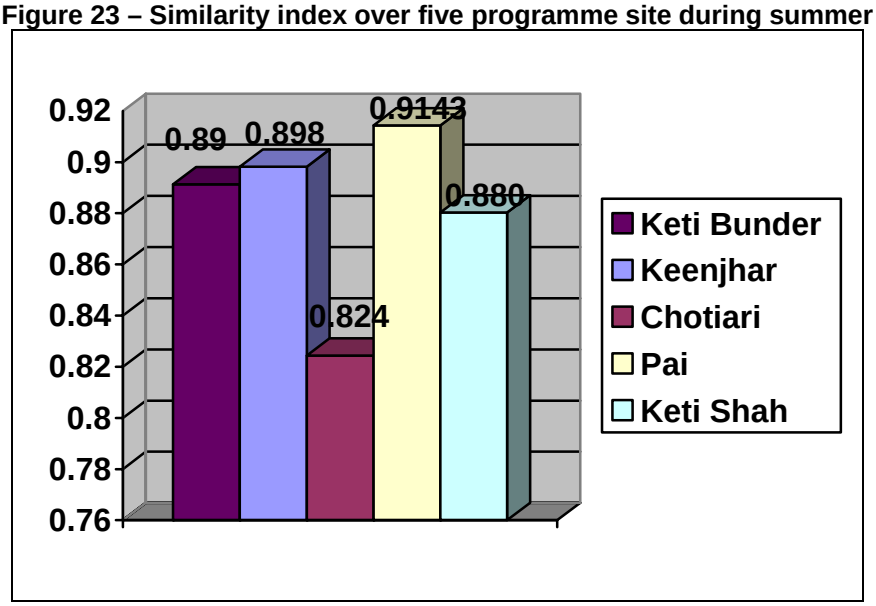
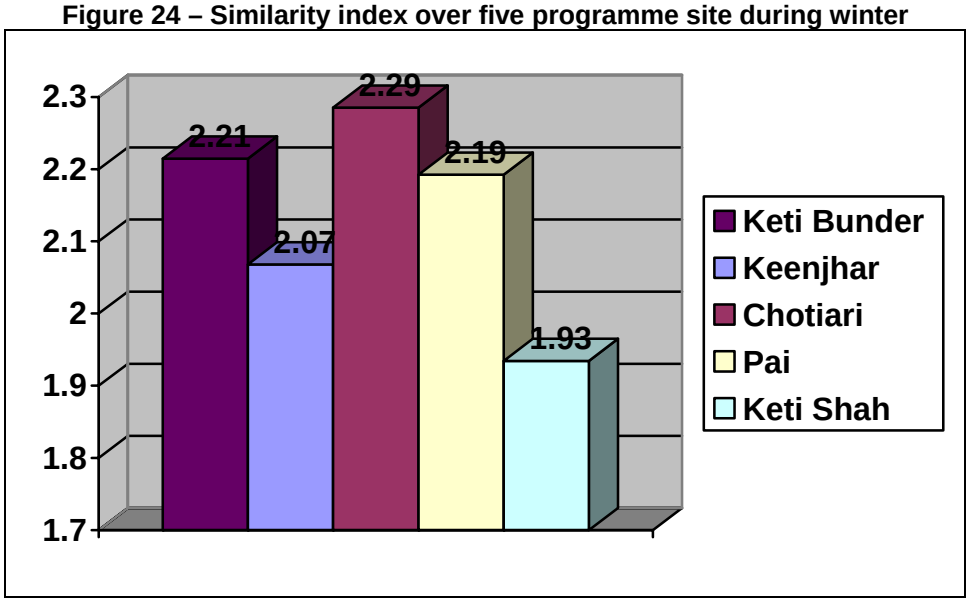


Figure 24 – Similarity index over five programme site during winter



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 25 and 26** give details of the percentage of species in each site against the main feeding habits.

Figure 25 – Percentage of species recorded for each site over feeding habit

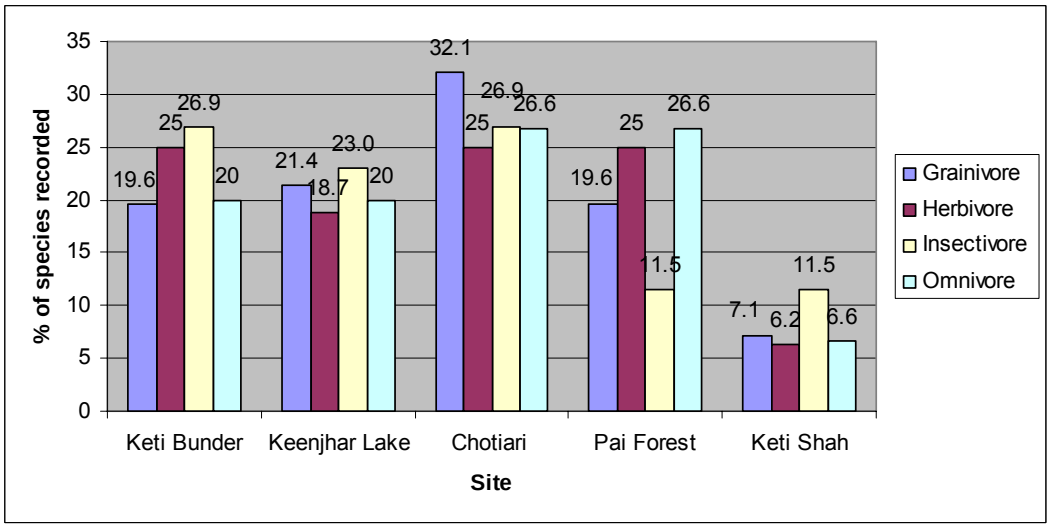
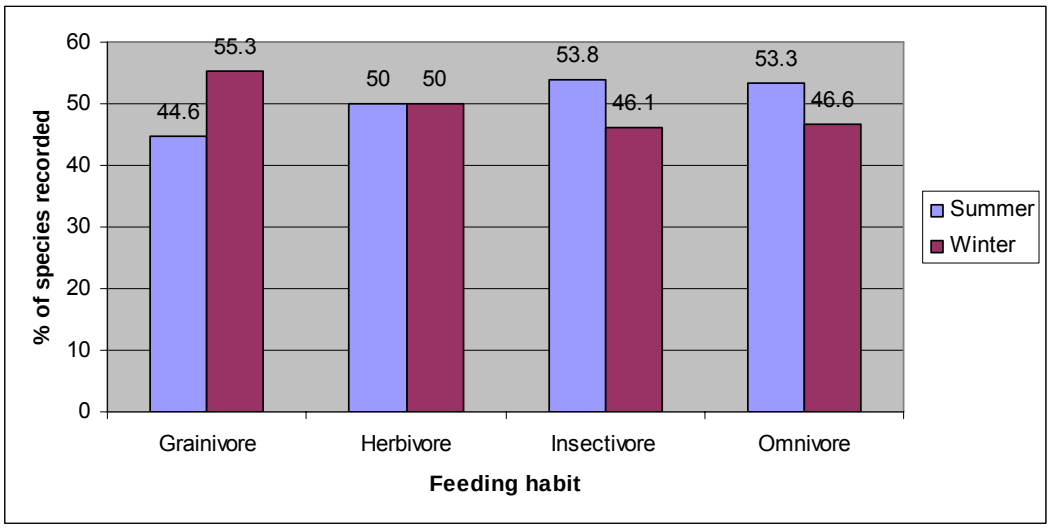


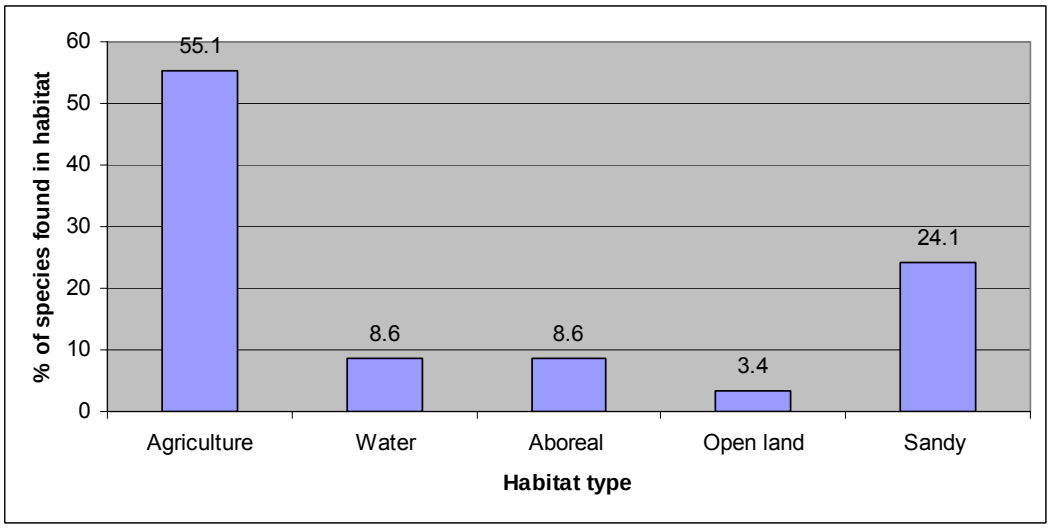
Figure 26 – Percentage of species recorded over season and against feeding habits



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 27** 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 27 – 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 28 and 29** show the results over site and season.

Figure 28 – Percentage of species recorded across sites against status categories

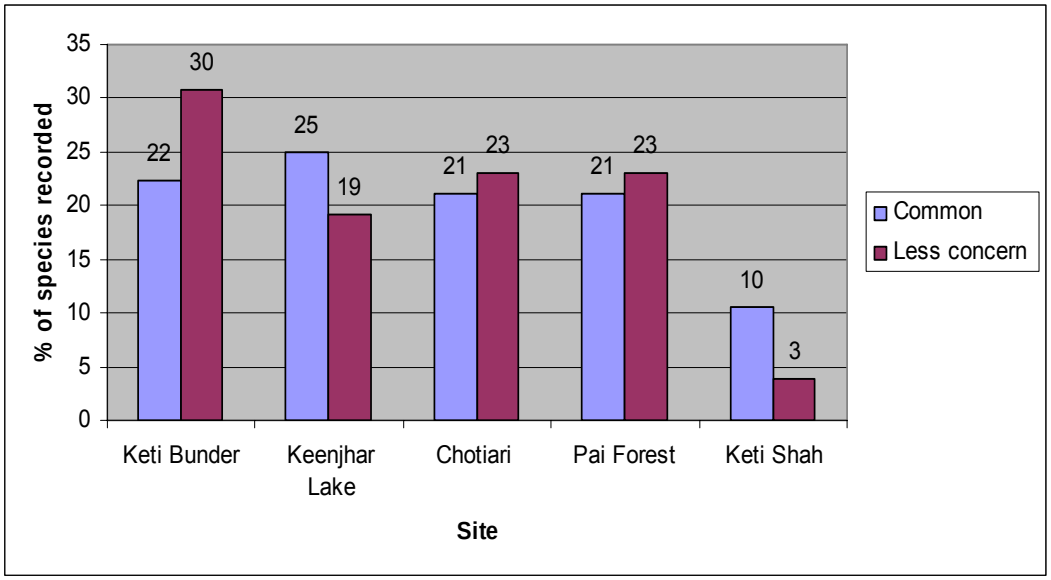
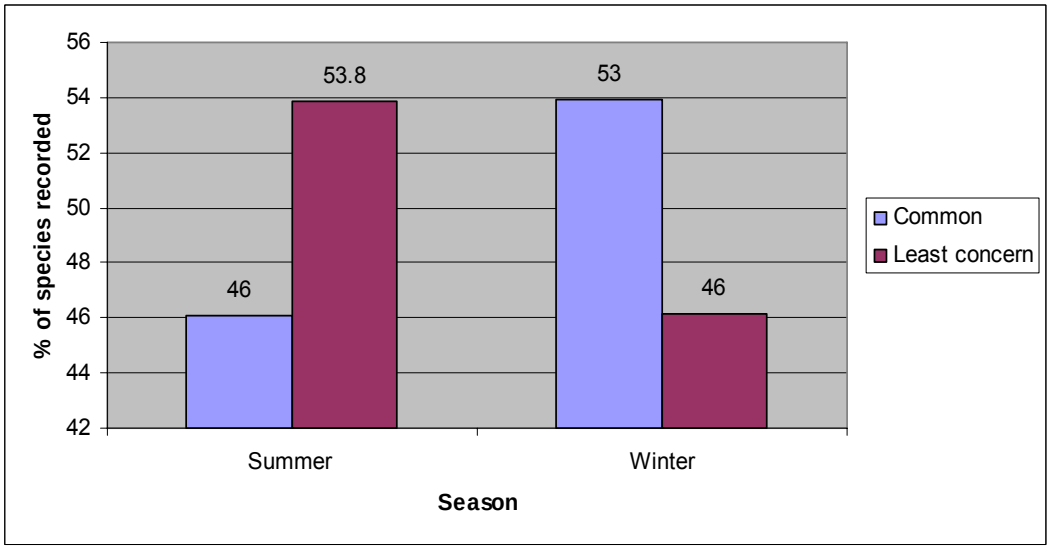


Figure 29 – Percentage of species recorded across season against status categories



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 40.**

Table 40 – Amphibian and reptilian diversity among sites (Figures are number of individuals observed/collected)

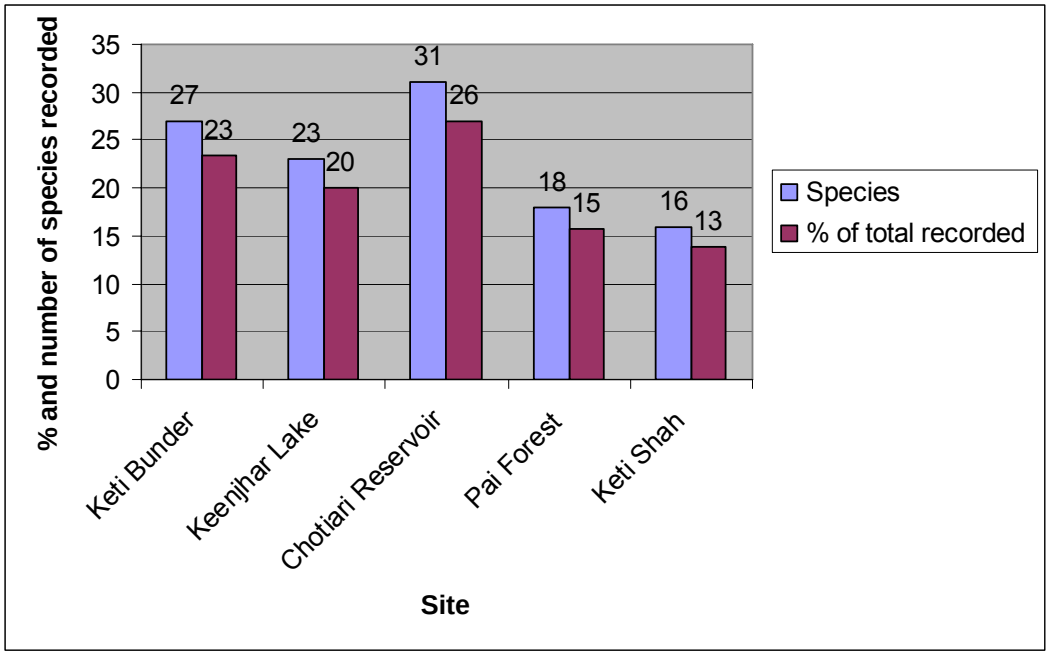
S. No.	Species Name	Total	Keti Bunder	Keenjhar Lake	Chotiari Reservoir	Pai Forest	Keti Shah
1	*Bufo stomaticus*	387	117	74	139	42	15
2	*Euphlyctis c. cyanophlyctis*	138	39	32	47	20	0
3	*Hoplobatrachus tigerinus*	126	31	50	33	08	04
4	*Kachuga smithi*	128	0	0	66	0	62
5	*Kachuga tecta*	33	0	0	14	0	19
6	*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 30 – 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 41** 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 41 – 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 31 – Evenness of reptile and amphibian species across sites

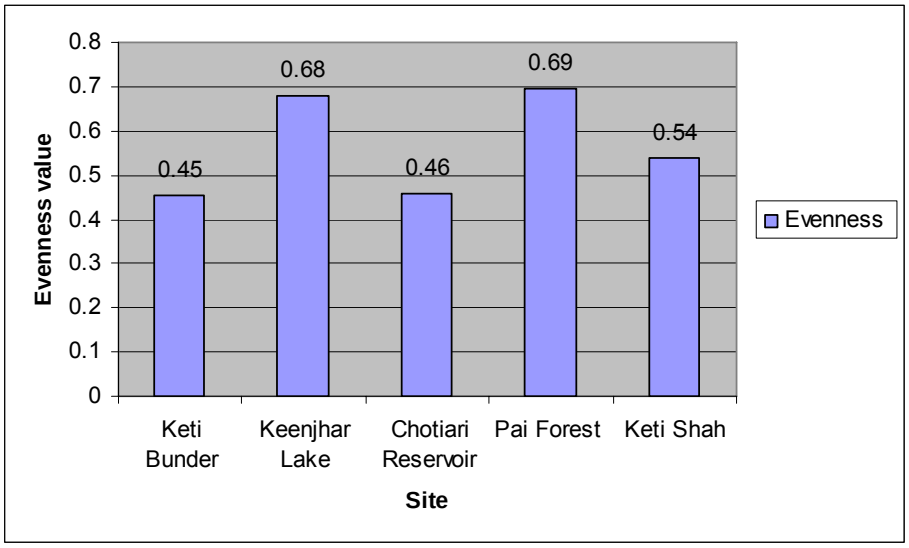
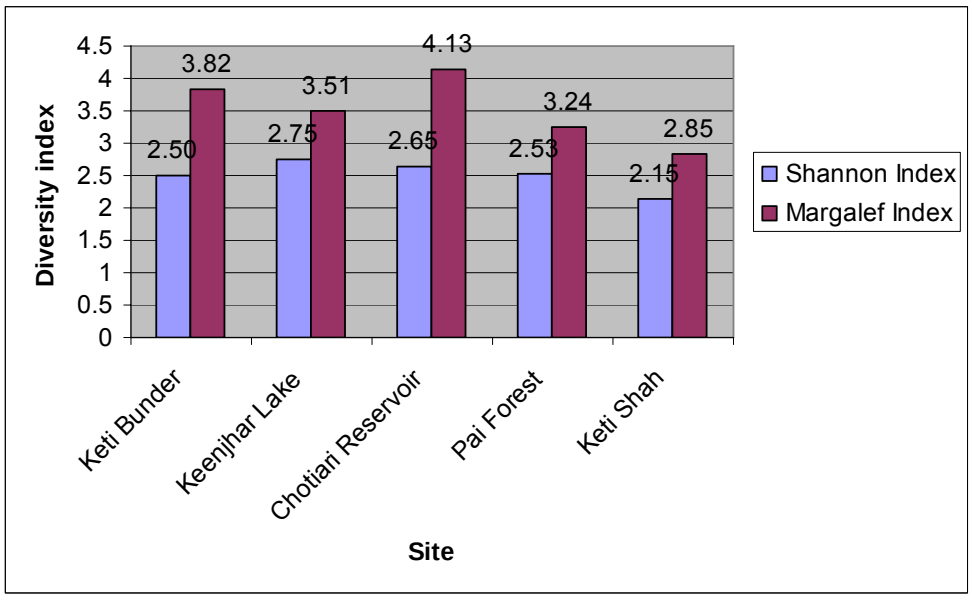


Figure 32 – Shannon and Margalef index for reptile and amphibian species for all sites



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 Avi-fauna

4.4.1 Summary

4.4.1.1 Keti Bunder

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

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

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

4.4.1.2 Keenjhar Lake

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

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

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

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

4.4.1.3 Chotiari Reservoir

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

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

The main habitats in the area are wetland and associated marshes, desert habitat and agriculture areas. During the winter surveys, the nearby dhands were also surveyed such as Dogriyoon, Naughno, Panihal, Sanghriaro, Rarr & 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 42.**

Table 42 – 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 43 – 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

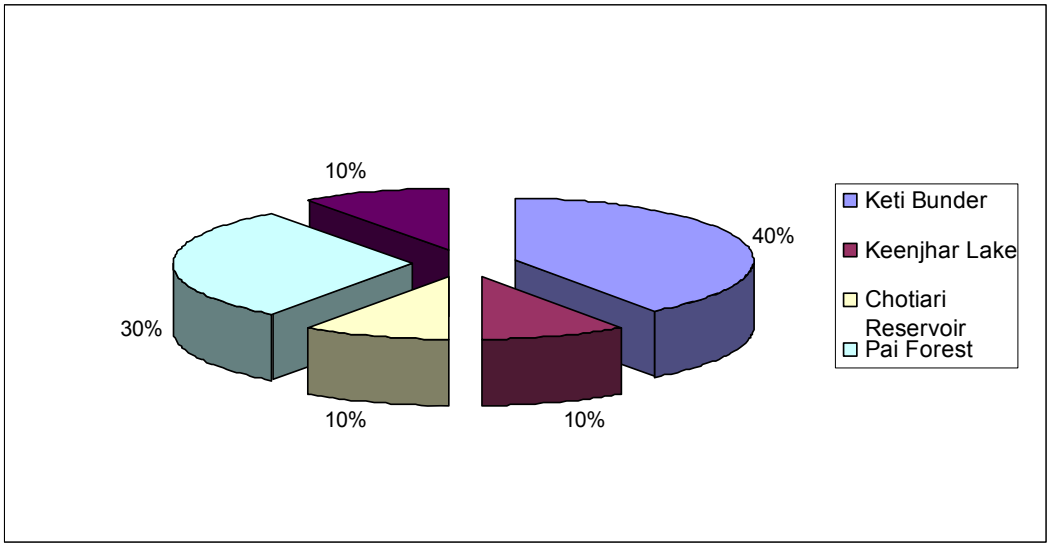
4.4.3.1 Summer survey

The following table **(Table 44)** shows the biodiversity index for each. This is also graphically shown in **Figure 33** as a pie-graph

Table 44 – 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 33 – Biodiversity Index of bird species during summer across all sites



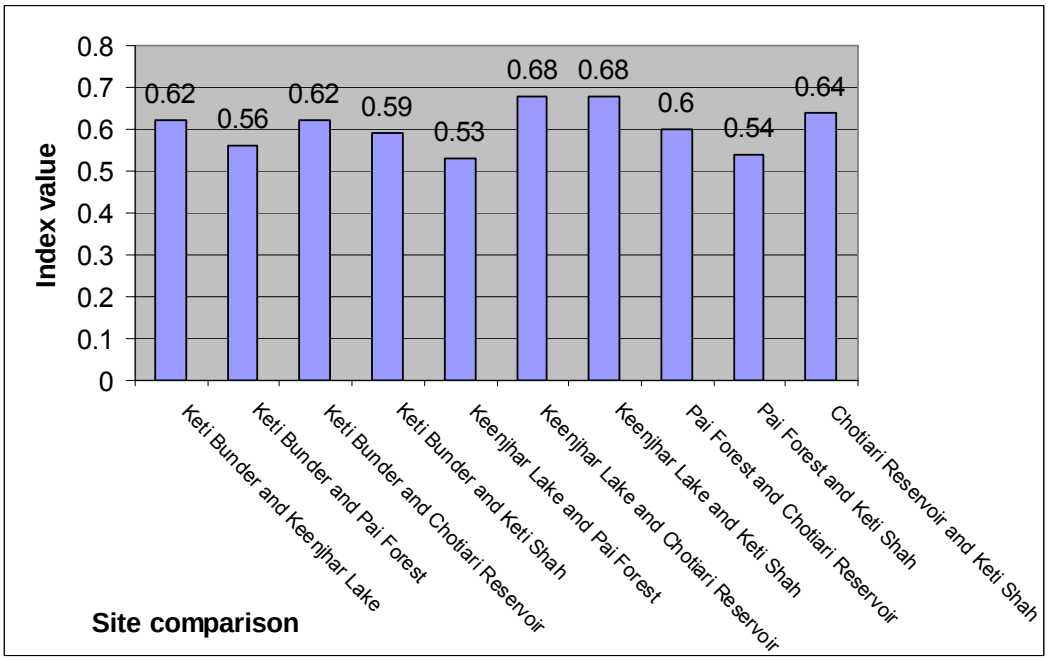
It can be inferred the biodiversity runs (highest first) from Keti Bunder >Pai Forest >Keenjhar Lake> Chotiari Reservoir>Shah Belo.

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 34** 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 34 – Similarity Index for birds recorded during summer across all sites

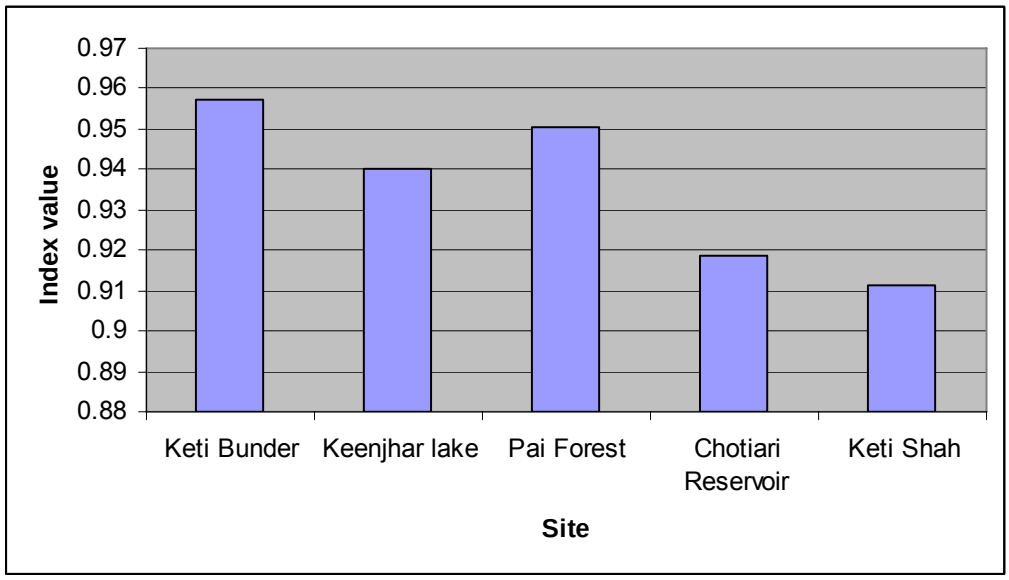


Finally coming to the biodiversity index, **Table 45** shows the indexes for each site and **Figure 35** gives a graphical portrayal of the same figures.

Table 45 - 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 35 – 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

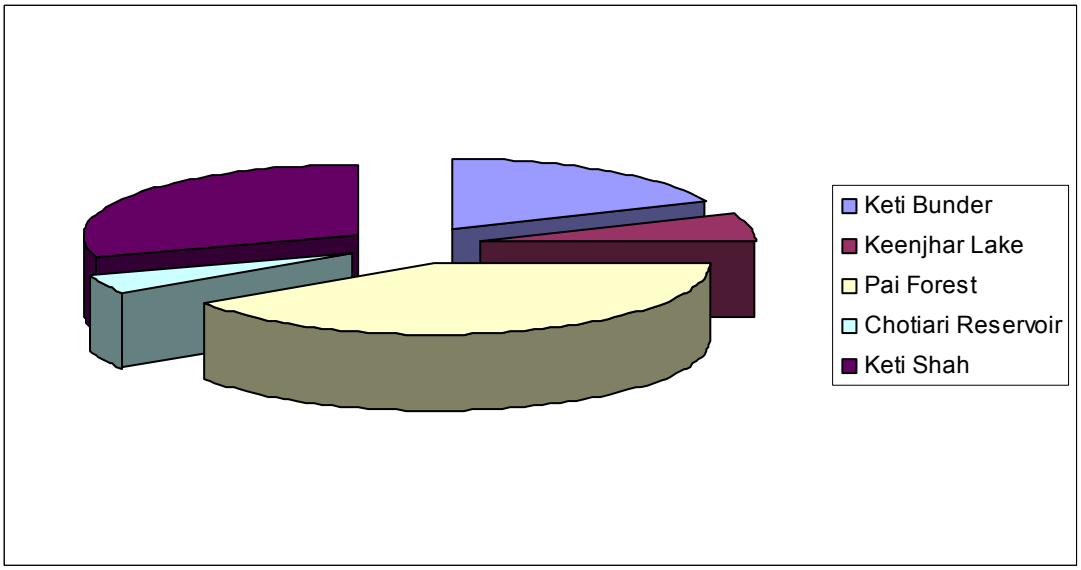
4.4.3.2 Winter surveys

Table 46 and **Figure 36** show the biodiversity index for winter results at Keenjhar Lake.

Table 46 – 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 36 – 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:

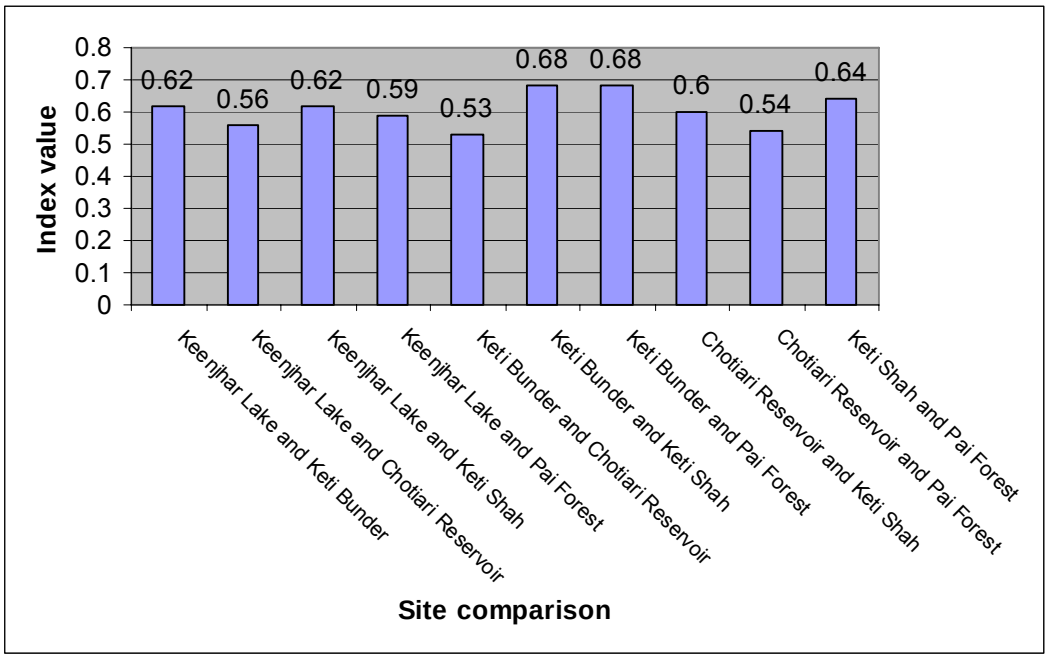
Pai Forest > Keti Shah > Keti Bunder> Keenjhar lake > Chotiari Reservoir

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 X 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 37 – 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:

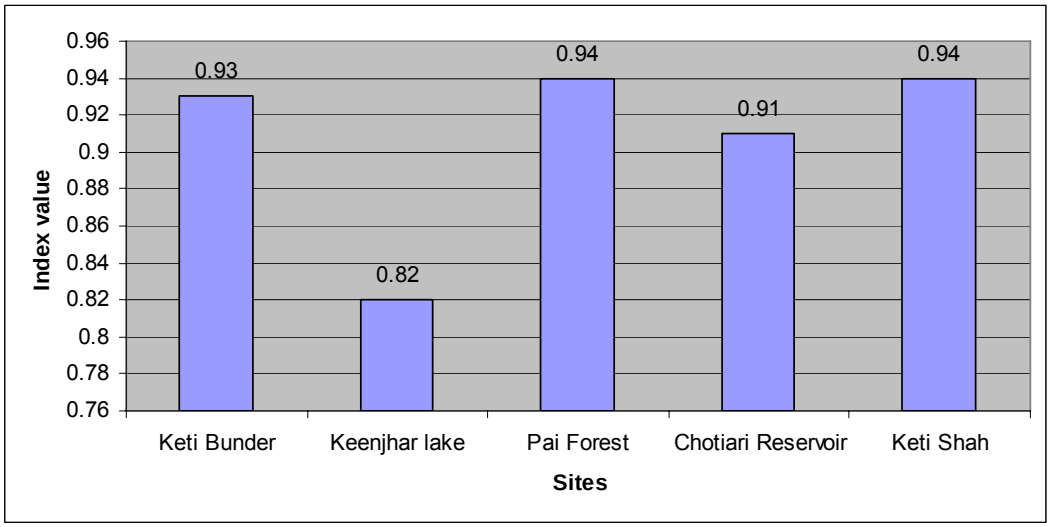
Keenjhar lake -Chotiari Wetlands Complex and Keenjhar- Pai Forest **>** Shah Belo-Pai Forest **>** Chotiari Wetlands Complex- Shah Belo > Keenjhar lake- Keti Bunder> Keenjhar lake- Shah Belo**>** Keti Bunder- Pai Forest> Keti Bunder- Shah Belo > Keti Bunder- Chotiari Wetlands Complex > Chotiari Wetlands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

Finally coming to the diversity index for the sites, **Table 47** and **Figure 38** show the Simpson's index for all the sites during winter.

Table 47 – 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 38 – 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

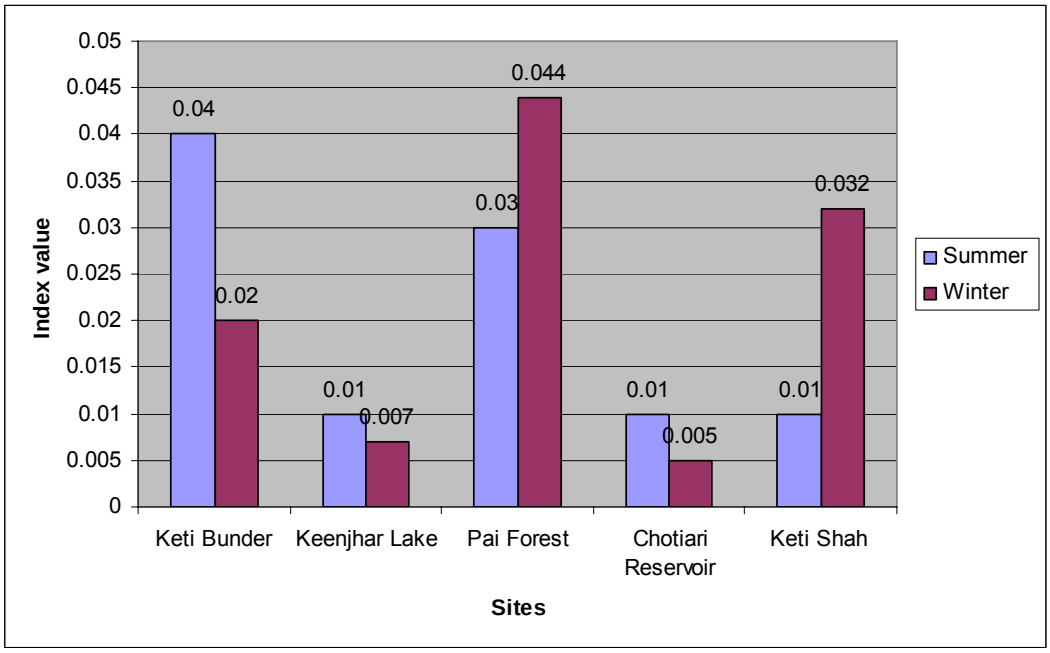
The following table and figures compare the biodiversity index, similarity and Simpson's index over the sites and over the season.

Table 48 and **Figure 39** show the biodiversity index over site and season

Table 48 – 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 39 – Biodiversity indexes for all sites over summer and winter

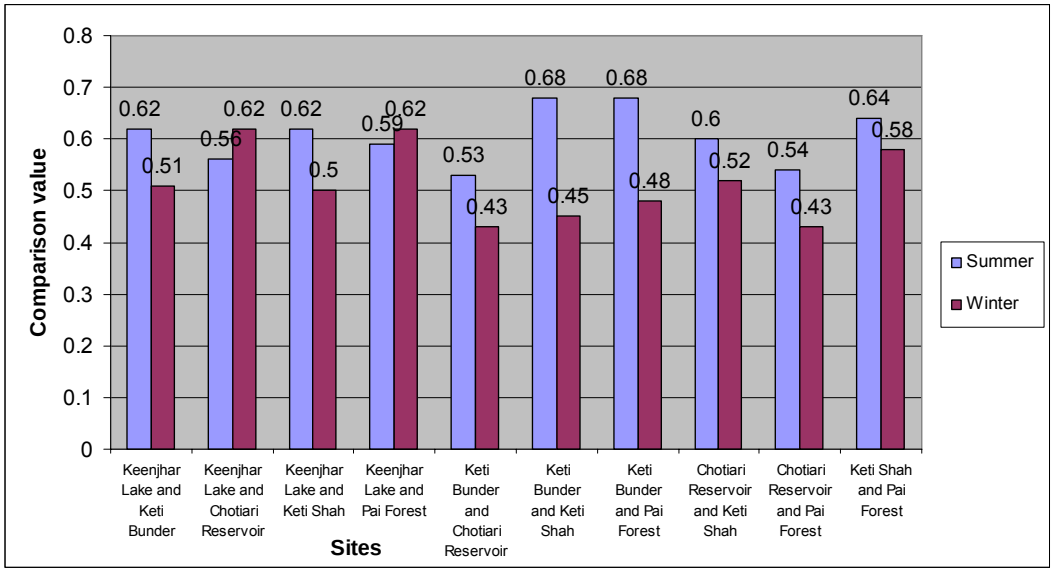


As can be seen in **Figure 39**, diversity is quite changeable over time and space. Pai Forest has the highest diversity in winter whereas Keti Bunder had the highest diversity in summer. Chotiari Reservoir is thought to be the most diverse site under the Indus for All Programme. However it is on par 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 40 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 40 – Similarity index between sites and over season



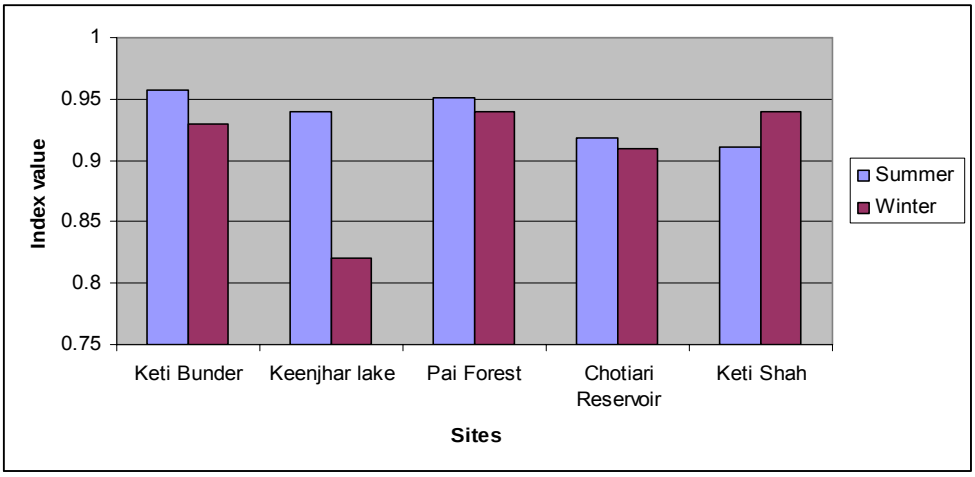
As with the diversity index, there is significant variation over winter and summer seasons. In summer there is more similarity with Keti Bunder – Keti Shah and Keti Bunder – Pai Forest whereas in winter the similarity lies in Keenjhar Lake – Pai Forest and Keenjhar Lake – Chotiari Reservoir. Again this 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 49** and **Figure 41** show the Simpson's index over sites and season.

Table 49 – 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 41 – Simpson's index over sites and seasons



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

Image 12 – Oriental reed-warbler at Keenjhar Lake

Image 13 – White wagtail at Keenjhar Lake

Image 14 – Indian Robin at Keti Shah

Image 15 – Striated babbler at Keti Shah

4.5 Phytoplankton

4.5.1 Summary

4.5.1.1 Keti Bunder

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

4.5.1.2 Keenjhar Lake

In Keenjhar Lake a total of 65 algal/phytoplankton samples were collected during this period out of which 155 algal species belonging to 53 genera of 7 phyla (Cyanophyta, Volvocophyta, Bacillariophyta, Chrysophyta, Dinophyta, Chlorophyta, and Charophyta in the summer. In Chotiari 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 42 below**). This may be due to better water quality and lack of salinity which was observed in the summer months.

Figure 42 – summer and winter comparison of the number of species collected in the four sites

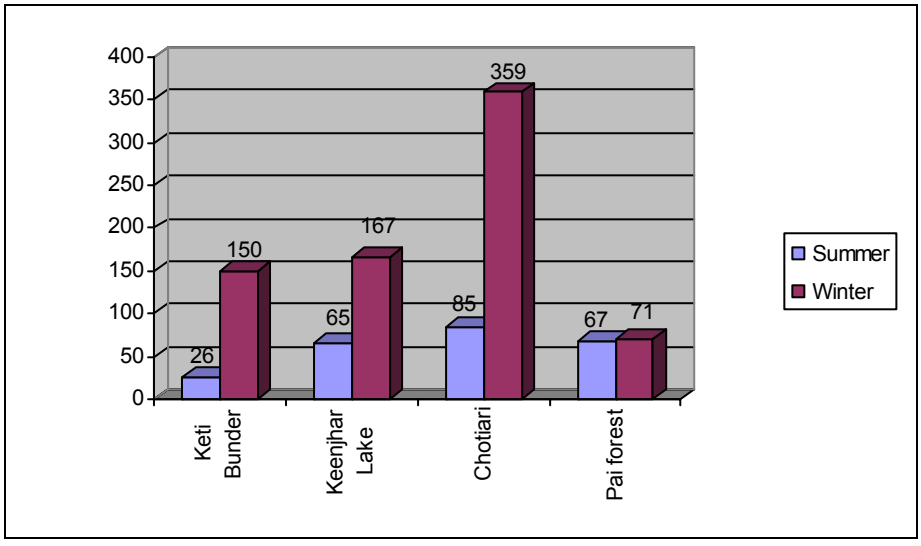


Table 50 – Comparison of phylum during the summer and winter survey in all four sites.

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 report for Keti Bunder under marine fisheries.

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 51 – 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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