CLIMATE CHANGE INFLUENCE ON AVIAN DIVERSITY OF WETLANDS, A STUDY WITH MANAGEMENT OPTIONS ON A RAMSAR SITE FROM PAKISTAN.

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Abstract:

Climatic factors were measured at Uchalli Wetlands Complex from 1992 to 2004. Maximum and minimum rainfall ranges for the years are 993.0 mm (1992) to 284.5 mm (2001). Water spread areas of three lakes have considerably reduced during the last ten years because of drought conditions prevailing in the Salt Range. Rainfall data depicts that almost 50% decline in rainfall has reduced the morphometry of lakes up to 73% (maximum 1241 ha in 1993 to only 336 ha in 2004). Khabbaki lake has totally dried up since 2002. Sedimentation and encroachments for agricultural activities have also had a profound impact on wetlands.

From 1992 to 2004, extensive surveys were conducted of avian distribution and abundance in the study area. During these 13 years, maximum numbers of birds recorded were 25,674 in 1994 and minimum 952 in 2003 with an annual average of 13,813 birds. Several ecological factors, such as habitat loss related to siltation, pollution, expanding agricultural activities and drastic hydrological fluctuations, have induced considerable changes in the dynamics and distribution pattern of sustained biota. Management options are proposed for restoration of the lakes.

Introduction:

The "Uchalli Wetlands Complex" (72 14°E, 32 29°N) is a special type of wetlands complex, found in the Salt Range, north-central part of the Punjab, Pakistan (Fig. 1).

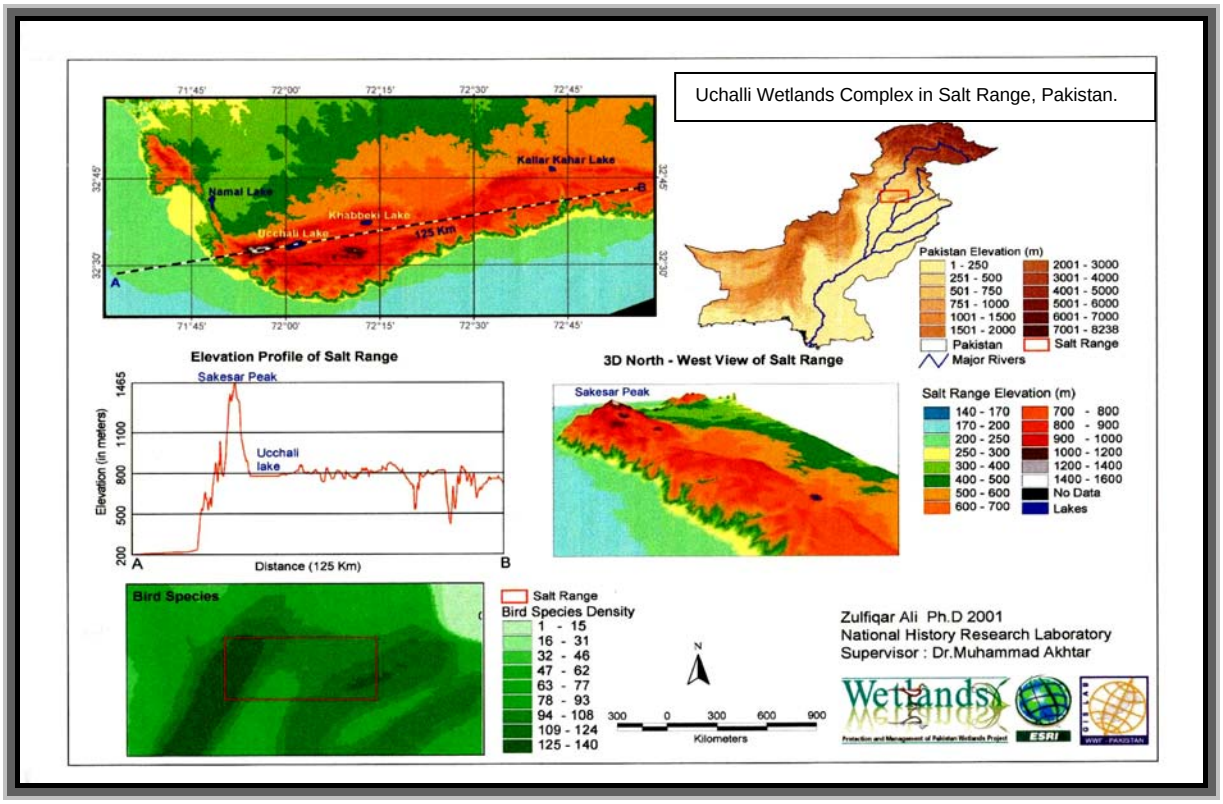


Figure: 1 Uchalli Wetlands Complex in Salt Range escarpment with distribution of birds.

This Complex is a Ramsar site (number 818 declared since 1996) and is a combination of three independent wetlands viz; Uchalli, Khabbaki and Jahlar. These lakes are an example of a wetland type that is important to migrating waterfowl. A number of globally threatened bird species visit these wetlands. Here the timing and duration of inundation and the salinity of the water are important factors in the production of plants and invertebrates used by birds. These, and many other wetland characteristics, are influenced by a number of things:

- Water-level fluctuations throughout the year, in response to rainfall, that maintain wetland
- Short-term (years) and long-term (decades) climatic trends that cycle wetlands between a wet and dry state
- Interaction of surface and ground water
- Interaction of ground water with rocks and soils that influence salinity and other wetland water chemistry

The wetlands over the years have shown that their extent depends on the climatic and human factors acting on them. The extent increases due to good rains and following loss of rains and human actions these are squeezed.

These wetlands are surrounded by mountain ranges formed by limestone, sandstone and clay scattered over the whole of the area. The sandstone is laminated by white

cream colour, dark red or purple brown. Limestone occurs in pure, laminated and compact form generally in the higher reaches. On the southern side strata of gypseous red-marl are greatly exposed. Salt layer normally lies at the lowest level but subsequent upheavals have so tiered the layers that at many places the salt layers are exposed, due to washing away of the topside. The geological interest of the site is very high and is also responsible for the nature of present landscape.

The area is rich in biodiversity and is a habitat of one of the endemic and endangered species of the country, the Punjab Urial (*Ovis vignei punjabiensis*). Other species, important from the conservation viewpoint are Chinkara gazelle (*Gazelle bennettii*) and Common Red fox (*Vulpes vulpes*). These wetlands are important for international conservation as they presently support the only wintering flock of White-headed Duck (*Oxyura leucocephala)* as reported by Li and Mundkur (2003). Besides this, these lakes support four other bird species listed in the *IUCN Red Data Book*, the Cinereous Vulture (*Aegypius monochus),* the Imperial Eagle (*Aquila heliaca)* the Sociable Plover *(Vanellus gregarius)* and White-backed Vulture (*Gyps bengalenis*). Furthermore, Greater Flamingos (*Phoenicopterus ruber),* Pied Harrier *(Circus melanoleucos)*, Greylag Goose (*Anser anser)* and the Ferruginous Duck (*Aythya nyroca)* also visit these wetlands. in addition to other species.

Area Statistics

Catchments area of lakes	381 km^2 (91, 718 Acres)
10 km^2 of three lakes	964 km^2
Cultivated area	123 km^2 (29,689 Acres)
Uncultivated areas (Culture able waste, and hilly area)	257 km^2 (62029 Acres)
Water surface areas of three lakes	12.43 km^2 (1243 ha)

These wetland sites covered about 1,243 hectares originally, while large portion of the water bodies is subjected to natural drought conditions. Human presence in recent times has resulted in substantial areas being reclaimed for agriculture. Large areas previously under water have been drained due to drought conditions and there has been a continuous trend in the last few years towards reduction of water in the lakes.

These lakes and the ecosystem they support are not only shrinking in their surface area but are also experiencing deterioration of water quality. This poses a serious health hazard to wildlife in general and birds in particular. As a consequence, a number of ecological changes mainly by natural and human pressure, the health and very life of the lakes is threatened.

The study will also provide an ecological base line data for Uchalli Wetlands Complex, where future ecosystem trends can be compared, as well as an overall assessment of ecosystem health.

Materials and Methods:

The present study entailed sampling and analysing the weather data, avian diversity, and conservation management of the Uchalli Wetlands Complex.

Temperature and Rainfall

Temperature acts as the most important factor inside the water as well as in the environment outside water modifying the effects of many other factors and affecting the ecology of the area directly or indirectly. Air and water temperatures were noted regularly and at the time of sample collection using simple mercury thermometer and through electronic meters. Rain gages were installed at Khabbaki lake, central town of Nowshera and at periphery of Soan valley in the village of Jaba. Average of all three rainfall gages was the mean of monthly rainfall of the study area.

Morphometry of the Lakes

To assess the morphometry of lakes Global Positioning System Megellan 315 was used. Coordinates were taken for different years all along the periphery of the lakes and after drawing theses coordinates on a graph paper total morphometry of lakes was calculated. Observation points were randomly selected to record birds. While visiting the area, data recording points (Table 1) were accessed by walking along the edge of the lake.

Table: 1 Observation Points of Uchalli Wetlands Complex, Pakistan.

Location	Lat.Degree	Lat.Min.	Long.Degree	Long.Min.	Elevation (m)
Jahlar Lake	32	29.806	72	5.425	824
Jahlar Lake	32	29.722	72	5.279	822
Jahlar Lake	32	29.812	72	5.081	819
Khabbaki Lake	32	37.063	72	13.341	745
Khabbaki Lake	32	37.484	72	12.517	740
Khabbaki Lake	32	37.242	72	11.914	747
Uchalli Lake	32	33.376	72	2.466	760
Uchalli Lake	32	33.253	72	1.985	755
Uchalli Lake	32	34.284	72	2.491	759

Migratory Birds Census and Monitoring

The bird census and monitoring is an extremely cost-effective way of monitoring the overall health of the ecosystem. Water birds are broadly defined as: “birds ecologically dependent on wetlands” and include traditionally recognised groups

popularly known as waterfowl, shorebirds and waders. Birds in the lakes were enumerated using point counts.

Point Counts

Point count is a count undertaken from a fixed location for a fixed time period. It can be undertaken at any time of the year, and is not restricted to the breeding season. Point counts can be used to provide estimates of the relative abundance of each species.

Surveys of the three lakes and adjacent areas were conducted monthly to identify, count and record the presence of different species of waterfowls visiting Uchalli Wetlands Complex. The same survey route was followed during all population-monitoring trips to minimise orientation errors. All the results of bird's data collected from January 1992 to March 2004 were analysed. For watching, counting and identifying birds, wide-range binoculars, spotting scope and counter were used.

The birds were identified by studying their characteristic features in accordance with the identification keys evolved by Whistler (1922), Ali (1979), Roberts (1991, 1992) and Grimmitt *et al* (2001). A taxonomic list prepared after field data collection at three lakes and for each species encountered.

Census Index (Density) and Relative Abundance

The area was divided into discrete census sectors in order to arrive at an overall total population size of birds, and sizes of populations of each species. Similarly relative abundance was calculated by individual numbers of birds counted to the total population of birds of all species.

RESULTS

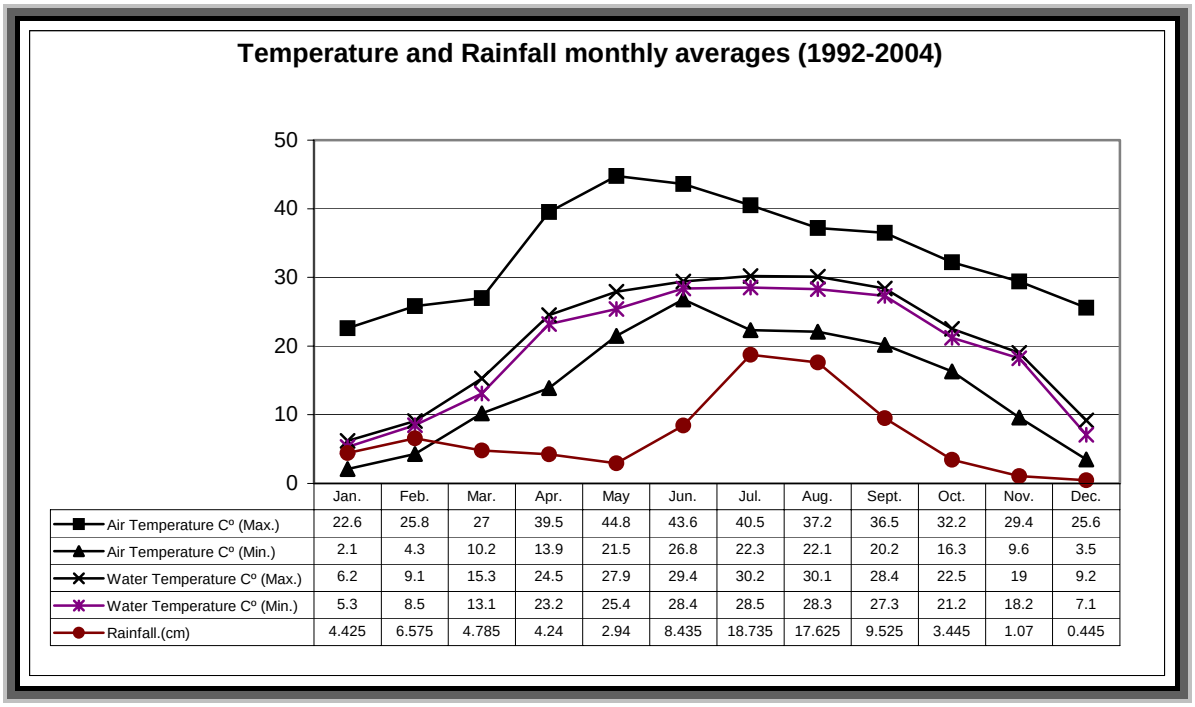
Climatic Factors of Uchalli Wetlands Complex

Temperature

Local climatic data have been recorded since January 1992. Maximum air temperature (46.8°C) was recorded in June 1998 and minimum air temperature (-0.5°C) in January 1994. Average monthly maximum temperature was (44.8°C) in June and the average monthly minimum temperature was (2.1°C) in January. Frosts were common during winter, and the vegetation around the lakes affected. Fig. 2 depicts average maximum and minimum temperatures for air and water at Uchalli Wetlands Complex.

Water temperature recorded from January 1992 to December 2003 was maximum (32.6°C) in June 1999 and minimum (3.2°C) in January 1998. Average monthly

maximum temperature was (30.2°C) in the month of July and the mean monthly minimum temperature was (5.3°C) in the month of January.



	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
Air Temperature Cº (Max.)	22.6	25.8	27	39.5	44.8	43.6	40.5	37.2	36.5	32.2	29.4	25.6
Air Temperature Cº (Min.)	2.1	4.3	10.2	13.9	21.5	26.8	22.3	22.1	20.2	16.3	9.6	3.5
Water Temperature Cº (Max.)	6.2	9.1	15.3	24.5	27.9	29.4	30.2	30.1	28.4	22.5	19	9.2
Water Temperature Cº (Min.)	5.3	8.5	13.1	23.2	25.4	28.4	28.5	28.3	27.3	21.2	18.2	7.1
Rainfall.(cm)	4.425	6.575	4.785	4.24	2.94	8.435	18.735	17.625	9.525	3.445	1.07	0.445

Figure: 2 Temperature and rainfall monthly averages (1992-2004)

Rainfall

Monthly rainfall figures show that maximum rainfall was observed in months of July and August, driest months were November and December. Rainfall records for the area were available since 1992. There were pronounced local variations. Year 1992 was, however, an exceptionally wet year. When heavy recharge of lakes and ground water was observed. The climatic conditions vary from year to year. But after 1997 drought conditions prevails, and more than 50% decline in rainfall has been observed (Fig. 3).

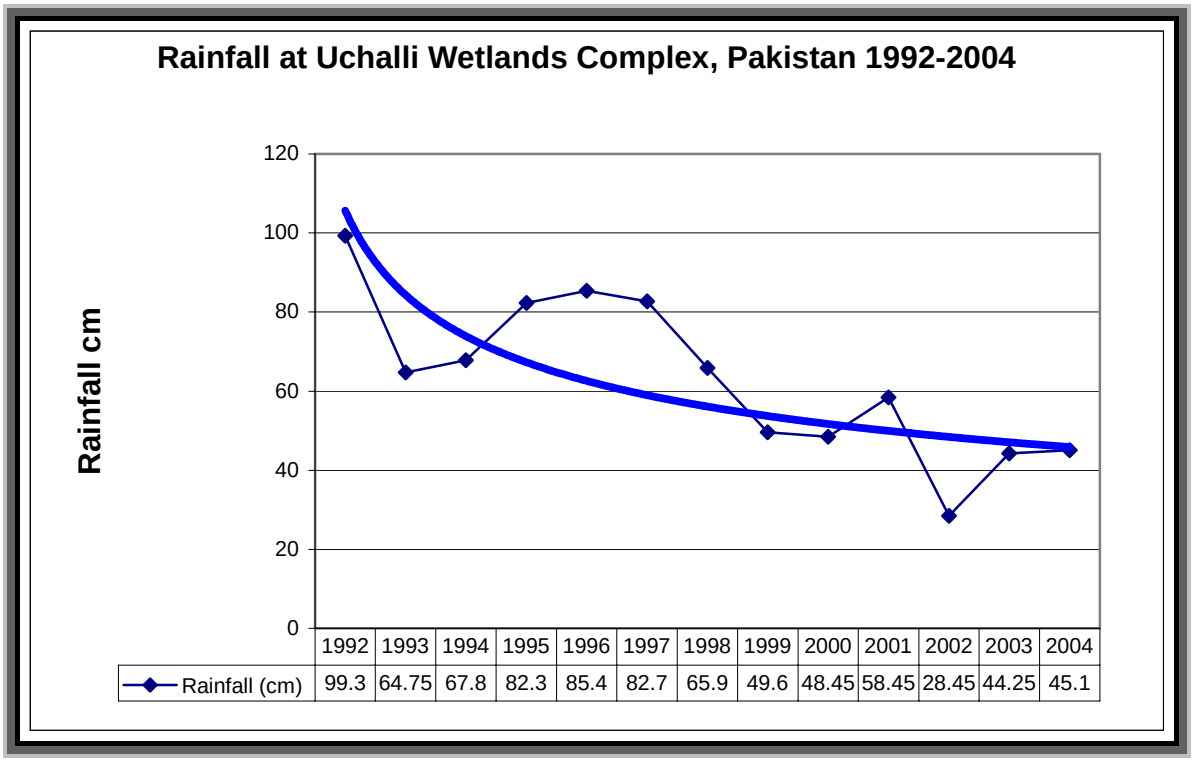


Figure: 3 Rainfall yearly data (1992-2004)

Morphometric Change at Uchalli Wetlands Complex

Morphometry refers to physical factors (shape, size, structure, etc) that determine the lake basin. The water in lakes is balanced by the basic hydrological relationship in which change in water storage is governed by inputs from all sources minus water losses. Water income from precipitation, surface influents and groundwater sources is balanced by outflows from surface effluents, seepage to groundwater and evapotranspiration. Each of these inflows and outflows vary seasonally and geographically and is governed by the characteristics of particular lake basins, their groundwater, drainage basins and climate. The hydrological cycle, which can be altered extensively by human induced changes of surface water systems, determines the water area of lakes in relation to the suitable catchment (watershed) area.

Morphometry of Uchalli Wetlands Complex was studied extensively and it was inferred that a huge negative change has occurred since 1994 (Table 2, Fig. 4 and 5). At present only 27 percent (336 ha) of the water area exists at Uchalli wetlands Complex out of the total 1,243 ha and this have a great impact on migratory birds population. Maximum water was present in 1993 at Khabbaki lake and it was totally dried up in June 2002. Drying process of three lakes from 1994 to 2004 is shown in Fig. 6.

Table: 2 Morphometric change at Uchalli Wetlands Complex from 1992 to 2004.

Year	Khabbaki	Uchalli	Jahlar	Total
1992	80% (226)	75% (707)	75% (13)	74% (926)
1993	100% (283)	100% (943)	90% (15)	99% (1241)
1994	90% (255)	90% (849)	90% (15)	90% (1119)
1995	80% (226)	85% (802)	85% (14)	84% (1042)
1996	70% (198)	80% (754)	85% (14)	78% (967)
1997	60% (170)	70% (660)	80% (14)	68% (844)
1998	50% (142)	65% (613)	70% (12)	63% (766)
1999	30% (85)	60% (566)	65% (11)	53% (662)
2000	20% (57)	60% (566)	60% (10)	51% (633)
2001	10% (28)	50% (472)	50% (9)	41% (508)
2002	0% (0)	40% (377)	40% (7)	31% (384)
2003	0%(0)	35% (330)	40% (7)	27% (337)
2004	0% (0)	35% (330)	35% (6)	27% (336)

Figures in parenthesis are area in hectares

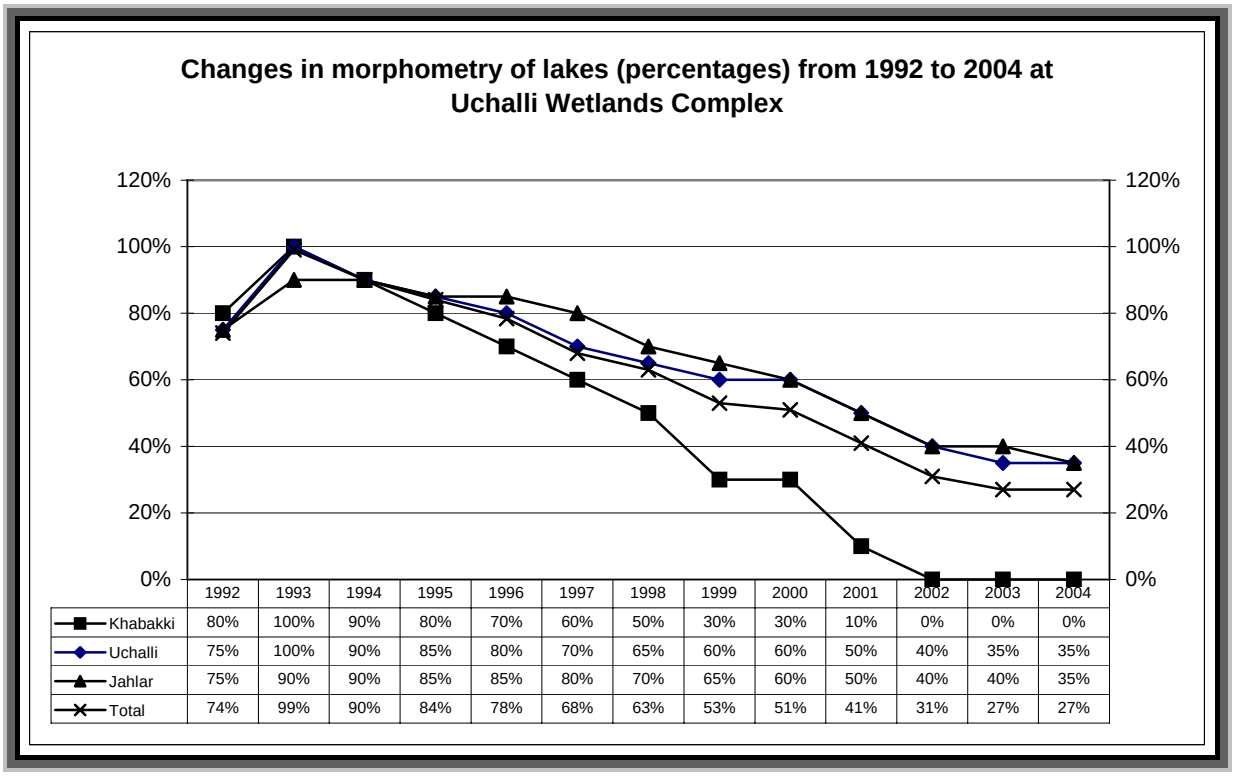
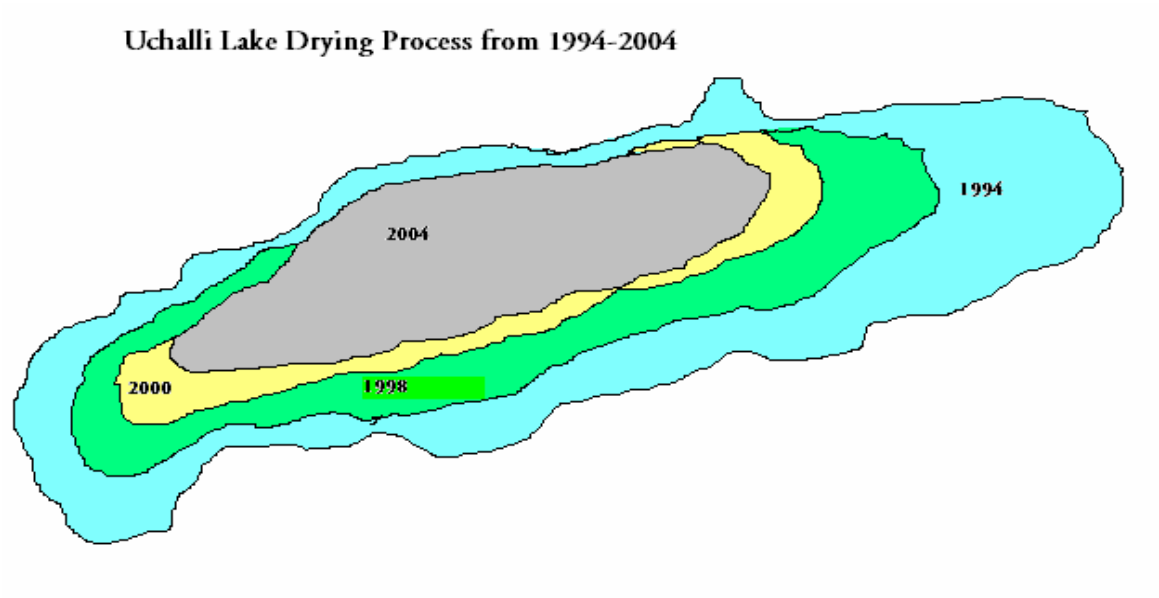
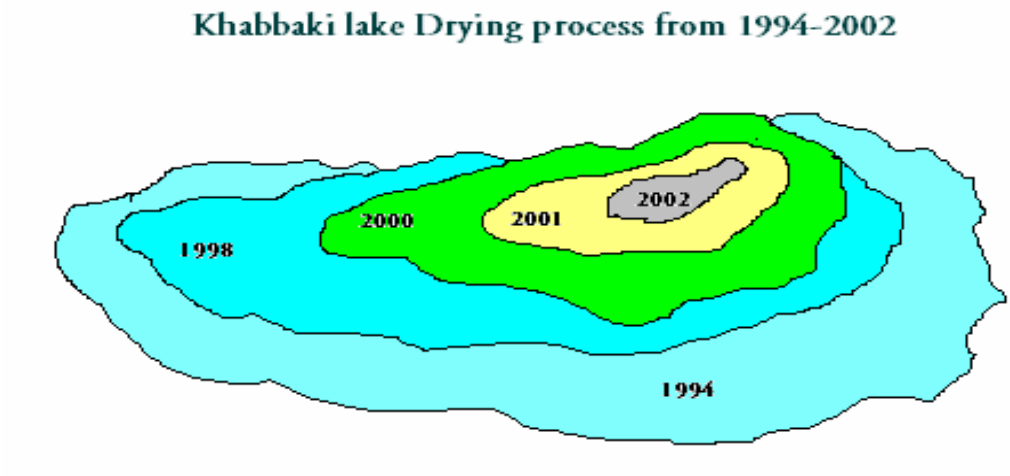


Figure: 4 Changes in morphometry of lakes from 1992 to2004.





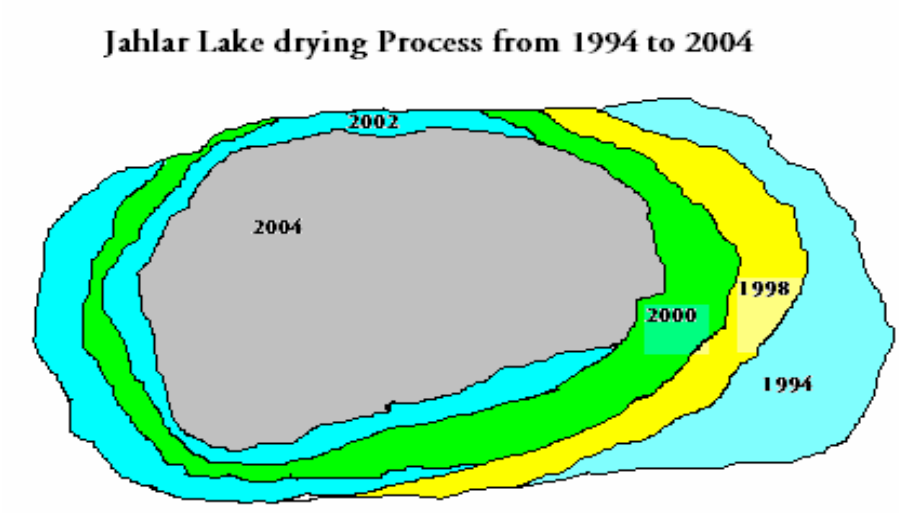
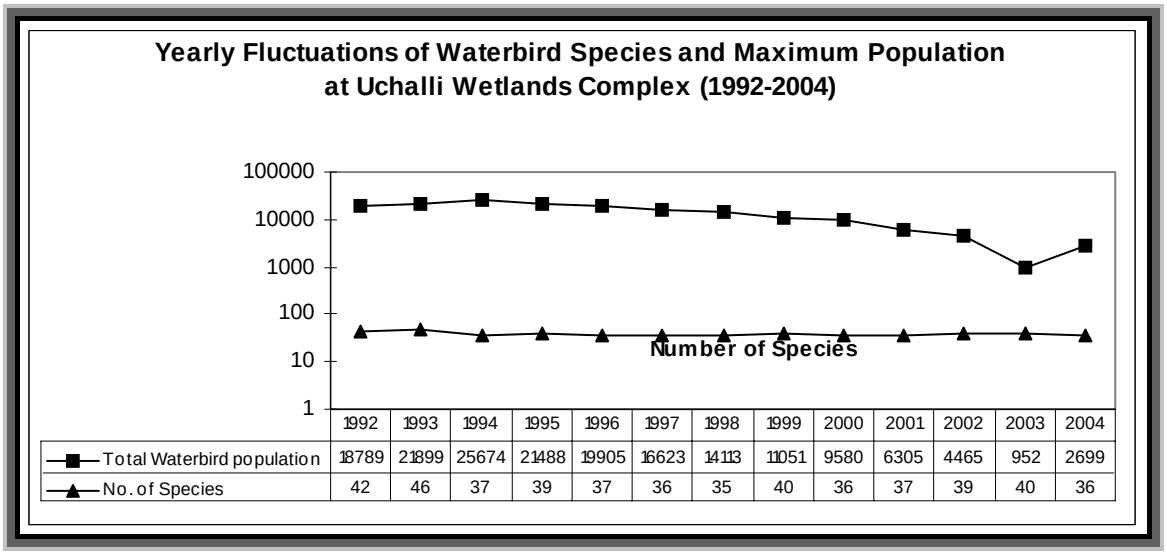


Figure: 6 Drying process of Uchalli Wetlands Complex, from 1994 to 2004.

Avian Diversity of the Uchalli Wetlands Complex

Monthly maximum waterfowl counts were taken every year since 1992 for estimation of their population at Uchalli Wetlands Complex. During the years, 1992-2004 maximum numbers of birds recorded were 25,674 in 1994 and minimum 952 in 2003 with an annual average of 13,813 birds. At Uchalli lake the maximum count was 13,460 in 1994 and minimum 799 birds in 2003 with an annual average of 7,494 birds, at Khabbaki lake the maximum count, was 11,598 in 1994 and minimum 22 birds in 2003 with an annual average of 4,927 birds, the maximum and minimum counts at Jahlar lake were 725 and 131 in 1992 and 2003 respectively with an annual average of 475 birds (Fig 7).



	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Total Waterbird population	18789	21899	25674	21488	19905	16623	14113	11051	9580	6305	4465	952	2699
No. of Species	42	46	37	39	37	36	35	40	36	37	39	40	36

Figure: 7 Waterbird species and maximum population recorded (1992-2004) at Uchalli Wetlands Complex.

Great variations in numbers of recorded birds, however, points out towards a high irregularity in the number of wintering birds, which in turn correlated with fluctuations in water level. Water level of the lakes itself was dependent on rainfall, all factors collectively depicting the complexity of the ecology of the lakes.

A total of 173 bird species representing 46 families and sub-families were recorded from 10 Km^2 (964 Km^2) buffer zone of the Uchalli Wetlands Complex (Fig. 8), which constitute nearly 24% of the birds in the territorial range of Pakistan (729), almost 13% of Indian Sub-Continent (1,295), more than 5% of Asia (3,388) and about 2% of the world (9,225). Among families, the Anatidae and Accipitridae show the highest abundance of bird species in this region. Other best represented families and sub-families (more than five species) were Ardidae, Phasianidae, Charadriidae, Tringinae, Columbidae, Alaudidae, Hirundinidae, Motacillidae, Turdidae and Sylviidae.

The frequency with which different bird species were observed varied from a single observation to more than a thousand records.

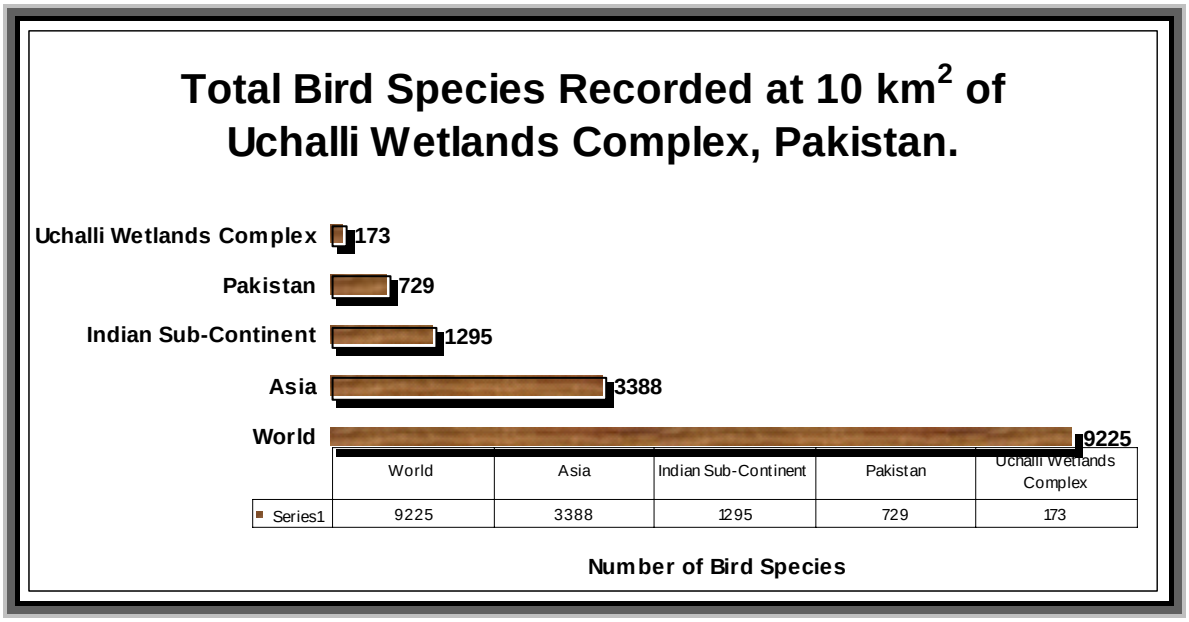


Figure: 8 Total Birds species recorded at Uchalli Wetlands Complex from 1992 to 2004.

Waterbirds

The waterbirds of Uchalli Wetlands Complex (1,243 ha), comprising 56 forms (Annexure), constitute nearly 29% of the inland waterbirds of Pakistan (192), 23% of Indian Sub-Continent (245), almost 17% of Asia (328) and about 7% of the world (767) (Fig. 9).

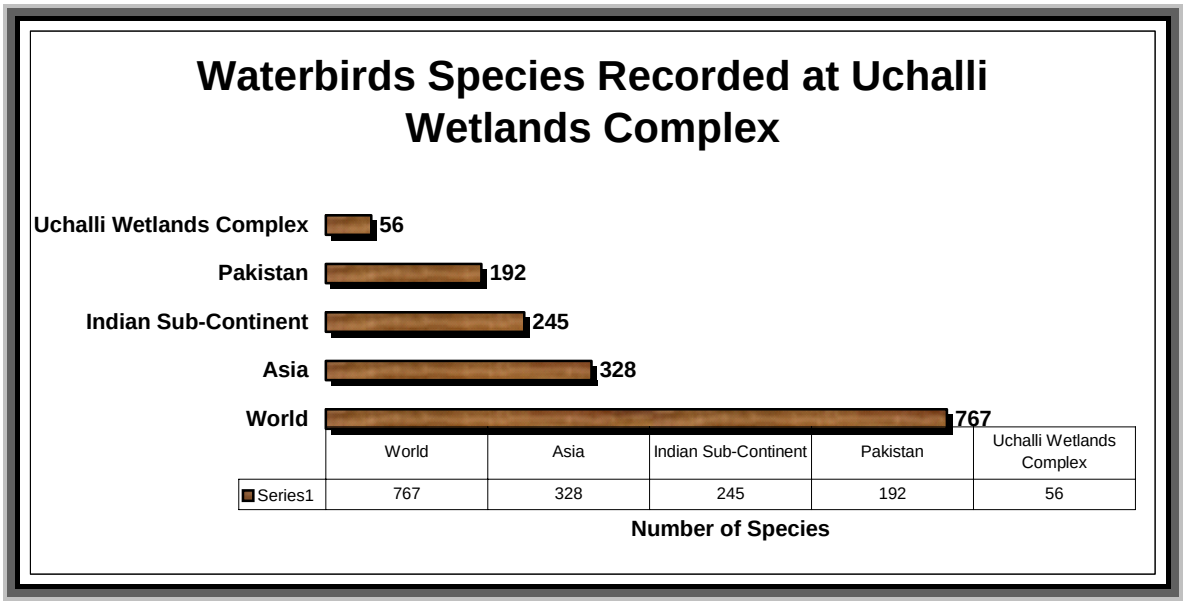


Figure: 9 Waterbird species recorded at Uchalli Wetlands Complex from 1992 to 2004

Uchalli lake has been observed as a place of heronry where a large congregation of Greater Flamingos *Phoenicopterus ruber* lasts throughout the year. Occurrence of large number of Coots *Fulica atra* and Common Pochards *Aythya ferina* at all the lakes is a remarkable feature in the distribution of waterfowl species. White-headed

duck *Oxyura leucocephala* once commonly found in this area has become scanty and could be designated in the category of extinct species from Pakistan. Overall, due to various ecological degradations bird *fauna* in this area is under tremendous stress.

CENSUS INDEX (DENSITY)

The area covered by each lake was calculated using GIS techniques to calculate avi-fauna density. Minimum number of birds was recorded during study period (2001-2004) with population density 283 birds per square kilometre, the density of waterfowl was 2,295 birds per square kilometre in 1994 (Table 3 and Fig. 10). Most of these birds inhabited Uchalli lake due to having much bigger size than Khabbaki and Jahlar lakes. Yearwise density figures show a gradual decline after 1994 because of morphometry of lakes has been reduced.

Table 3: Census Index (density) of Avi-fauna at different lakes.

Year	Area (ha)	Bird population	Census Index (birds/km^2)
1992	946	18789	1985
1993	1241	21899	1764
1994	1119	25674	2295
1995	1042	21488	2061
1996	967	19905	2059
1997	844	16623	1971
1998	766	15113	1972
1999	662	11051	1670
2000	633	9580	1450
2001	508	6305	1240
2002	384	4465	1163
2003	337	952	283
2004	336	2699	803
Average	699	12467	1484

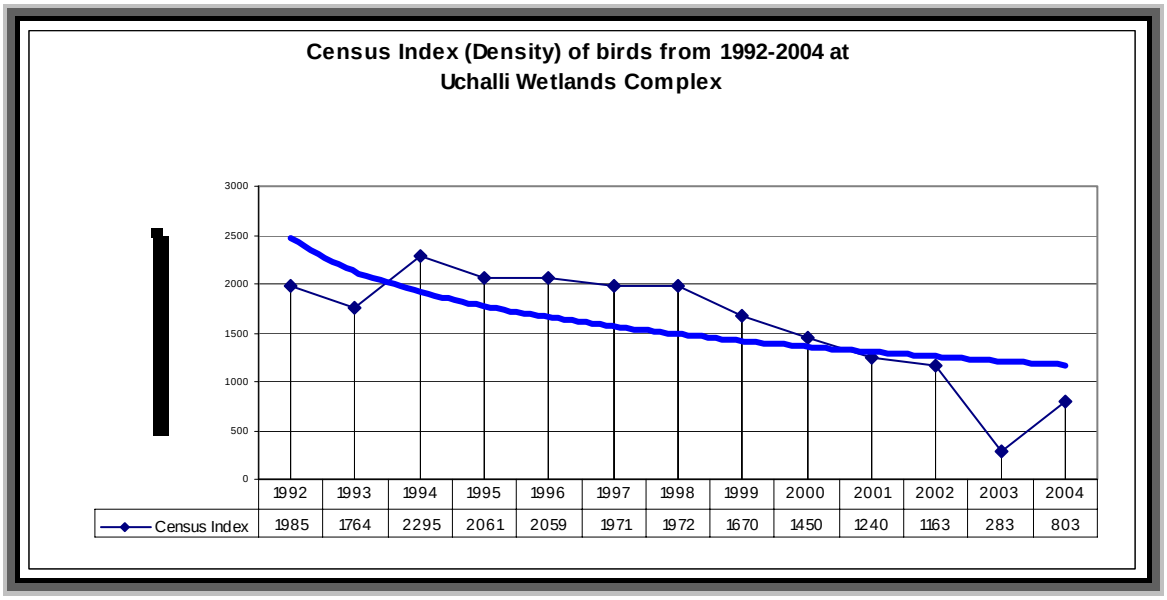


Figure 10: Census Index (density) of Avi-fauna in different lakes.

Conservation of waterbird species

Studies of the migratory birds at Uchalli Wetlands Complex revealed that most of the bird species requires conservation at national level and because of sharp decline in their population during recent years at Uchalli Wetlands Complex and a significant number (73 per cent) of recorded bird species needs restoration efforts. Among them some species needs immediate attention like, White-headed Duck, Grey-lag Goose, Ferruginous Duck, and Sociable Plover. Besides waterbirds some internationally threatened species like White-backed Vulture, Cinereous Vulture, Imperial Eagle and few Passerines which visits regularly this important area also needs to be conserved.

Major threats for Uchalli Wetlands Complex

Uchalli Wetlands Complex is under great pressure on account of many threats which have led to shrinking of lakes and their biological resource potential. A breief discussion of the major threats confronting the lakes may be broadly categorized as followings:

Drought

The drought in the Central Asian region between 1998 and 2002 greatly reduced wetland habitat for migratory birds and other wildlife (Li & Mundkur 2003). Many important sites for the Waterbirds totally dried out, or their area and water level were greatly reduced. In 2001, the International Research Institute for Climate Prediction reported “a persistent multi-year drought in central and south-west Asia has affected close to 60 million people as of November 2001”. The principal conclusions of this report were: central and south-west Asia represent the largest region of persistent drought over the past three years anywhere in the world; from a regional perspective, the ongoing drought has been the most severe in recent decades; significant shortfalls in precipitation have led to widespread social and economic impact, particularly in Iran, Afghanistan, Pakistan, Tajikistan, Uzbekistan and Turkmenistan. Agriculture, animal husbandry, water resources, and public health have been particularly under stress throughout the region. Preliminary analysis suggests that the drought is related to large-scale variations in the climate across the Indian and Pacific Oceans, including the recent "La Niña" in the eastern Pacific. The long-term effects of drought on the viability of waterbird’s populations are unknown although potentially critical. The lack of water has resulted in degradation and desiccation of important breeding sites in Kazakhstan, Mongolia, Russia and Uzbekistan; And wintering sites in Pakistan, Iran and Turkmenistan; and also on

staging sites in Afghanistan, Kazakhstan, Uzbekistan, Iran, Turkmenistan and possibly Tajikistan (Li & Mundkur 2003).

Climate Change

Climate change is thought to be causing more frequent droughts resulting in reduced water levels and the drying out of many lakes in central Asia. This phenomenon may be a great threat to the survival of the migratory birds.

Land Encroachment

Uchalli Wetlands Complex's essentially agrarian economy places persistent pressure on the need for more agricultural land. In the context of wetland conservation, this tension materialises in the form of encroachment of agricultural practices into wetland sites. The scope of the encroachment ranges from relatively passive practices such as the use of land that is exposed seasonally or during extended periods of drought to practical interventions such as drainage and permanent land reclamation.

Encroachment on wetlands resulting from the extension of agricultural land has substantially reduced the permanent and seasonal extent of wetlands. Exposed areas of lakebed have traditionally been claimed by individuals to the extent that the ownership of the entire surface of some of the lakes is currently in dispute.

Agricultural Farming

Habitat loss and degradation due to human developments is the most significant factor in the past decline of the migratory birds. Agricultural practices in and around lakes have a negative impact by increasing run off and sedimentation rates in wetlands that affect productivity and food availability for the migratory birds The land around the Uchalli wetland complex is privately owned and any reduction in the extent of the lakes prompts landowners to start cultivating exposed areas.

Groundwater Extraction

The ground water table in Uchalli Wetlands Complex catchment area ranges from 5 m in the immediate vicinity and up to 100 m at farther places (2-3 kms). This is mainly due to sediments accumulated in lake beds, which has become impervious hindering recharging. Sediment accumulation is due to siltation, which is a result of removal of vegetative cover in the catchment area. Apart from this, waste disposal in lakes has resulted in eutrophic condition of the lakes as a consequence of degradation in water quality and by agricultural run-off.

Since 1980's for irrigation needs, local people have started to dig more wells due to successful practices introduced of off-season vegetables like cauliflowers and an

increase in demand of underground water was observed in the area. Before 1980 very few wells were used for both irrigation and drinking water. But, now their number has been increased substantially to cope with growing agricultural needs, which have a profound impact on underground water table and on lakes as well.

Overuse/unsustainable use of water resources for irrigation and man-made modifications to wetlands are critical threats to the migratory birds. Similarly, Uchalli Wetlands Complex is under threat of drying out completely due to a combination of the change in the water-regime in the catchments and the extended drought in Central Asia between 1998 and 2002. This over-abstraction of groundwater, both for drinking and for agricultural purposes, has caused a lowering of the water table and a subsequent reduction in the extent of lakes/wetlands.

Hunting

Though these lakes have been declared protected as wildlife sanctuaries, under the Punjab Wildlife (Protection, Preservation, Conservation and management) Act, 1974 and no hunting was allowed but there was observed incidences of illegal hunting on all the three lakes. The wildlife department with present situation of improper staffing is unable to check illegal hunting.

Subsistence hunting by rural communities and sport hunting by elite or otherwise privileged members of society are well-established traditions in the region. The scope of both forms of hunting has increased over time with the advent of new and more effective weapons. Migratory waterfowl are the most effected component of the *avifauna*.

In Pakistan, fisheries departments without the consent of wildlife departments auctions the rights of fishing in lakes. Many wetlands sanctuaries are also auctioned, which leads to a heavy mortality of waterfowl during the migratory season (Khurshid, 1991). The same was happen to Khabbaki lake in mid-1980's, when fish stocking was auctioned and as a result of great ecological change food competition of fish with waterfowls was observed and large number of piscivorous birds like Great Black-headed Gull *Larus rudibundus* were attracted to the lake. Human disturbance in the form of fishing nets and hunting of waterfowl by fishermen was again a very serious threat to globally endangered species like White-headed Duck, which was a regular winter visitor to the lakes. More than 32 White-headed Ducks were observed in the backyard of fishermen's house in February 1993 as their favourite hunt during fish catch. Fishing was not possible at Khabbaki lake after 2000, due to shortage of water and afterward a complete dryness of the lake.

As stated by Lampio (1982), waterfowl have been hunted in many countries for thousands of years, and the customs and traditions that have grown up during this period differ greatly, sometimes because of varying circumstances but sometimes for no obvious reason. Traditions are essential part of hunting and often deeply affect the character of the whole activity. It has been often said that catch is not as important as the hunting itself. The philosophy is illustrated by the following saying from Finland. “The fox is so valuable, that he is worth hunting even if there is no chance of catching him.”

In recent decades, in many countries, the number of people seeking recreational activity in the country-side has increased sharply. So has their personal mobility, placing hitherto remote areas at risk. Of course, when more than one type of activity takes place on water, the disturbance is greater, although the increase is not necessarily simply additive. The intensity of the activity must also be considered, though again there are complicating factors, one boat may be as disturbing as ten if the water is small, or narrow for its size. The duration of the activity is also important. If short, the birds fly up and then return to the same area; if prolonged, they will seek other areas and not return for some long time. If the disturbance to birds continues day after day, the area will be abandoned by the birds permanently. If most activity is concentrated at the weekends, then the area will continue to be used during the week, provided alternative waters, available nearby (Matthews, 1982). Tuite (1982) was able to demonstrate a wide range of susceptibility to disturbance, ranking the species of wintering wildfowl in increasing order: Pochard *Aythya ferina,* Tufted duck *Aythya fuligula,* Mallard *Anas platyrhynchos,* Wigeon *Anas penelope* and Shovelor *Anas clypeata.*

Inefficient Wildlife Protection Laws

Prevailing laws are ineffective as far as the protection or conservation of aquatic ecosystems and are concerned as most of them indirectly touch wetland protection (fragmented approach). Pakistan, in spite of being a signatory to the Ramsar Convention on Wetlands and the Convention of Biological Diversity, there is no significant development towards sustaining these ecosystems, either due to lack of coordination among agencies involved or lack of awareness of the values of wetlands among the policy makers and implementation agencies. The effective management of these wetlands requires a thorough appraisal of the existing laws, institutions and practices. The involvement of various people from different sectors is essential in the sustainable management of these wetlands. Apart from government

regulation, better monitoring mechanisms are needed to increase the knowledge of the physical, chemical and biological characteristics of wetland resources, their values and a better understanding of wetland dynamics. Management based on accurate knowledge and increased awareness of wetland issues involving all stakeholders and all components of ecosystem help in long-term sustenance involving restoration and conservation. This would enhance the function and value of the system in terms of natural and socioeconomic factors to satisfy critical resource needs of the human population.

Reduction of Wetlands Vegetation

Reduction of peripheral and emergent wetland vegetation like has reduced the habitat for a wide range of bird.

Deforestation

Timber extraction, primarily for fuel and local construction but also for commercial purpose, poses an indirect threat to wetlands. Reduction in forest cover in the watersheds increases soil erosion and leads to siltation of wetlands. In particular, the community-owned forest has been severely extracted at Uchalli Wetlands Complex.

Use of Agrochemicals

Chemicals and sediments that move from agricultural areas into wetlands are two of the most pervasive sources of degradation. The introduction of off-season vegetables has caused problems in Uchalli Wetlands Complex through overloaded of pesticides. Agrochemical and solid waste pollution indirectly threaten wetlands by leading to eutrophication and other forms of habitat degradation. Agrochemical pollution through increased use of pesticides and insecticides is increasing steadily. Field surveys revealed that many farmers have recently switched to cash crops with concomitant increases in the application of agrochemicals. In the Uchalli Wetlands Complex there has been a clear trend towards crop substitution with farmers switching to vegetables. The fact that lakes are endorreic makes them particularly vulnerable to hyper-eutrophication and pollution. Leaching and run-off of fertilizers and pesticides from agricultural fields that surround the wetlands is known to pollute the water, although their impact has not been determined.

Grazing Grounds and Livestock

Livestock grazing is a common practice along the water line of all three lakes as well as in the catchment areas resulting in the degradation of vegetation cover. As a result the erosion of soil from the watershed goes on silting the lakes with the

passage of time. Damage to emergent vegetation in wetlands, by cattle grazing results in the loss of nesting habitat of wetlands birds especially waders.

Livestock grazing pressure is high, to the point of being excessive, in several parts of Uchalli Wetlands Complex. Although communal grazing lands have been most affected, Government forests also suffer from grazing pressure where access is uncontrolled. Statistics reveal that in Uchalli Wetlands Complex, stocking rates are significantly higher than in other areas of the provinces concerned (Salma, 2002). Increased grazing pressure has led to soil erosion and watershed degradation causing siltation of wetlands.

DISCUSSION

Wetlands have been famously described as “biological supermarkets” because of the exclusive food webs and rich biodiversity they support as “kidneys of the landscapes” because of the functions they perform in the hydrological and chemical cycles (Mitsch and Gosselink, 1993).

Wetlands dependent species are often rare, threatened or found only in a very restricted geographical area. Freshwater lakes and rivers contain just 0.008 per cent of the world’s water but are of great importance for biodiversity as they contain twelve percent of all animal species (Shine and de Klemm, 1999).

Wetlands are dynamic ecosystems that are in continual change through ongoing processes of subsidence, drought, erosion and siltation. Whilst certain pressures on wetlands arise from natural causes, it is human activities that have significantly altered the rate and nature of wetlands change particularly in recent decades.

The continent of Asia, the largest on the planet earth, has all the major ecosystems from arctic tundra to deserts, temperate to tropical rain forest and coral reefs. These extremely variable climatic conditions in Asia play the fundamental role in determining the suitability of waterbird habitat and their annual to and fro movements from their breeding grounds.

The migratory birds breed in Europe and northern Asia in early summer, when the days are long and food abundant, they raise their young during the short temperate summer. Each year, when wetlands in Europe, north and central Asia become frozen due to the onset of winter, and the food disappears under snow cover, a large number of waterfowl that breed in these areas in summer undertake migratory journeys along major river valleys to spend the winter in more hospitable shelters in

southerly latitudes. This annual movement of the waterbirds is very taxing and obligatory involving many complicated processes.

There is a growing realization that genuinely sustainable development depends on conserving the Earth's biodiversity. Biodiversity underpins our lives, providing many vital goods and services to people. There are also strong ethical and aesthetic arguments why we should care for it well (BirdLife International 2004). Birds help to create positive change, through a public that understands and values biodiversity conservation. They also play a vital part in bringing about the social and political solutions that we need for a more sustainable world.

Morphometry of the lakes is a determining factor in the distribution of the waterfowl. At Uchalli Wetlands Complex, migratory birds were much attracted when water was maximum in the lakes. Deeper wetlands with a growth of aquatic plants attract more waterbirds, where they could dabble to acquire their feed (Weller, 1975).

The last ten years have witnessed dramatic changes in the structure and processes of the Uchalli Wetlands Complex, which have affected its ability to function as habitat for waterfowl, shorebirds, and migratory birds.

The only convincing evidence of real population trends in waterbirds populations at Uchalli Wetlands Complex is of negative trend in all species that is heavily correlated with change in the morphometry of the lakes and rainfall.

The loss or impairment of wetland ecosystem is usually accompanied by irreversible loss in both the valuable environmental functions and amenities important to the society (Zentner, 1988). Appropriate management and restoration mechanisms need to be implemented in order to regain and protect the physical, chemical and biological integrity of wetland ecosystems.

Protecting these wetland's existing functions proves to be incredibly complex as it involves building a partnership among the various agencies, working in a co-ordinated effort in addressing the common goal of minimizing the human-induced changes that affect the hydrology, biogeochemical fluxes and the quality of wetlands.

The wetland management program generally involves activities to protect, restore, manipulate, and provide for the functions and values emphasizing both quality and acreage by advocating sustainable usage of them (Walters, 1986). Management of wetland ecosystems requires an intense monitoring, increased interaction and co-operation among the various agencies (state departments concerned with environment, soil, natural resource management, public interest groups, citizen groups, agriculture, forestry, urban planning and development, research institutions,

government, policy makers, etc). Such management goals should not only involve buffering wetlands from any direct human pressures that could affect the wetlands normal functions, but also in maintaining important natural processes that operate on them that may be altered by human activities. Wetland management has to be an integrated approach in terms of planning, execution and monitoring requiring effective knowledge on a range of subjects from ecology, economics, watershed management, and planners and decision makers, etc. All this would help in understanding wetlands better and evolving a more comprehensive solution for long-term conservation and management strategies.

The proposed management would include the management of water, vegetation and the biotic factors. This would essentially involve human management. The local population will have to be taken into confidence to help in increasing the water level of the lakes, through manipulation of water use, vegetative cover improvement through planting of trees and reseeding with palatable grasses and reduction of human pressure by controlling live stock grazing and eliminating illegal hunting or poaching on the waterfowl. Increased production from trees, better live stock production and creation of job opportunities on a sustained basis would help raise the income of farmers owning the lands under and around the wetlands.

Management Options

In order to save the migratory birds from further decline in the aquatic habitats of the valley some immediate management options needs to be taken.

To continue natural development processes and minimize the damaging effects of man induced factors.

- Maintain the size of all three wetlands at least at 75% of their original size.
- Prevent the deterioration of water quality and habitat characteristics
- Improve the naturalness of all three lakes
- Maintain and enhance the viable population of endangered species of waterfowl and other birds
- Promote awareness of site importance amongst local communities
- Monitor the public use of the site
- Ensure that public use does not impair the quality of the site.

To improve and develop the socio-economic conditions of neighboring villages through devising conservation activities.

- Plant trees in the vicinity of lakes and on all conceivable sites

- Provide substantial amount of fodder both shrubs and full grasses through range management
- Develop ecotourism in the area
- Improve the existing hygienic conditions in the neighboring villages.
- Provide social facilities at concerned public areas.
- Increase the literacy rate in the adjacent villages.
- Help increase earnings of local populations

To safeguard whenever possible, all notable wildlife species and to control pest species.

- Monitor all important species.
- Evaluate and maintain conditions suitable for migratory and breeding waterfowl and other species.
- Measure human and other disturbances.
- Control pest species.
- Manage visitor use regarding wildlife.

To provide strict protection and evaluate the flyway for conservation of endangered species at other points of migration and to start captive breeding of threatened species.

- Provide strict protection to endangered bird fauna.
- Monitor the population of endangered bird fauna.
- Conduct research on the biology and ecology of endangered birds and all migratory birds.
- Improve upon the management of endangered birds.
- Liaise with national and international organization in order to promote further research to enhance the existing population of endangered birds.
- Start captive breeding programmes for endangered birds and other waterfowl species.

To promote study and research

- Establish wildlife information/education centre
- Promote research activities in relation to safeguarding the habitat and bird fauna.
- Promote cooperation with government and non-government organizations to share their research experiences.
- Gather and record the scientific data.
- Monitor changes in the habitat and species status.

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Annexure: Maximum counts, average counts, and relative abundance, of Waterbirds at Uchalli Wetlands Complex.

Common Name	Scientific Name	Max. Count 1992-2004	Average 1992-2004	Relative Abundance	Census Index (birds/ha)
Little Grebe	*Tachybaputus ruficollis*	669	284.9231	2.0626974	0.40761527
Great crested Grebe	*Podiceps cristatus*	192	55.15385	0.3992857	0.07890393
Black-necked Grebe	*Podiceps nigricollis*	334	119.5385	0.8653974	0.17101354
Little Cormorant	*Phalacrocorax niger*	19	8.5	0.0615357	0.01216023
Great Bittern	*Botaurus stellaris*	9	4.75	0.0343876	0.00679542
Little Bittern	*Ixobrychus minutes*	7	5	0.0361974	0.00715308
Night Heron	*Nycticorax Nycticorax*	66	23.66667	0.1713346	0.03385789
Indian Pond Heron	*Ardeola grayii*	56	27.69231	0.2004782	0.03961704
Cattle Egret	*Bubulcus ibis*	112	34.41667	0.2491591	0.04923701
Little Egret	*Egretta garzetta*	655	171.1538	1.2390664	0.24485529
Intermediate Egret	*Egretta intermedia*	67	25.84615	0.1871129	0.0369759
Great Egret	*Egretta alba*	33	12	0.0868739	0.01716738
Grey Heron	*Ardea cinerea*	31	8.461538	0.0612572	0.01210521
Purple Heron	*Ardea purpurea*	13	4.090909	0.0296161	0.00585252
Greater Flamingo	*Phoenicopterus rubber*	1099	588.1538	4.2579332	0.84142181
Greylag Goose	*Anser anser*	17	6	0.0434369	0.00858369
Ruddy Shelduck	*Tadorna ferruginea*	125	56	0.4054114	0.08011445
Common Shelduck	*Tadorna Tadorna*	145	109.3333	0.7915174	0.15641392
Eurasian Wigeon	*Anas penelope*	651	306.4615	2.2186249	0.43842852
Falcated (Teal) Duck	*Anas falcata*	6	6	0.0434369	0.00858369
Gadwall	*Anas strepera*	856	553.8462	4.009563	0.79234071
Common Teal	*Anas crecca*	186	68.08333	0.4928885	0.09740105
Mallard	*Anas platyrhynchos*	1633	710	5.1400371	1.01573677
Spot-billed Duck	*Anas poecilorhyncha*	11	7.333333	0.0530896	0.01049118
Northern Pintail	*Anas acuta*	1025	437.8462	3.1697823	0.62638935
Garganey	*Anas querquedula*	6	4	0.028958	0.00572246
Northern Shoveler	*Anas clypeata*	1701	608.0769	4.4021661	0.86992407
Red-crested Pochard	*Netta rufina*	58	28.6	0.2070494	0.04091559
Common Pochard	*Aythya ferina*	6900	2821.385	20.425382	4.03631562

Common Name	***Scientific Name***	**Max. Count 1992-2004**	**Average 1992-2004**	**Relative Abundance**	**Census Index (birds/ha)**
Ferruginous Duck	*Aythya nyroca*	668	271.0909	1.9625596	0.38782677
Tufted Duck	*Aythya fuligula*	990	501.0769	3.6275408	0.71684824
White-headed Duck	*Oxyura leucocephala*	163	60.07692	0.4349262	0.08594696
Water Rail	*Rallus aquaticus*	6	6	0.0434369	0.00858369
Black or Eurasian Coot	*Fulica atra*	8220	4352.231	31.507926	6.22636734
Common Crane	*Grus grus*	11	7.714286	0.0558475	0.01103617
Greater-painted Snipe	*Rostratula benghalensis*	34	15.07692	0.1091492	0.02156927
Black-winged Stilt	*Himantopus himantopus*	670	410.8462	2.9743161	0.58776274
Pied Avocet	*Recurvirostra avosetta*	16	9	0.0651554	0.01287554
Indian Courser	*Cursorius coromandelicus*	6	6	0.0434369	0.00858369
Little Ringed Plover	*Charadrius dubius*	61	20.58333	0.1490128	0.02944683
Grey Plover	*Pulvialis squqtorola*	58	36.90909	0.267203	0.05280271
Kentish or Snowy Plover	*Charadrius alexandrinus*	23	11.6	0.0839781	0.01659514
Red-wattled Lapwing	*Hoplopterus indicus*	580	431.2308	3.1218903	0.61692528
Sociable Plover	*Chettusia gregaria*	7	5.5	0.0398172	0.00786838
White-tailed Lapwing	*Chettusia leucura*	37	20.58333	0.1490128	0.02944683
Green Plover	*Vanellus vanellus*	15	8.4	0.0608117	0.01201717
Little Stint	*Calidris minuta*	44	23.5	0.170128	0.03361946
Temminck's Stint	*Calidris temminckii*	15	7.666667	0.0555027	0.01096805
Common Snipe	*Gallinago gallinago*	18	8.636364	0.0625229	0.01235531
Common Redshank	*Tringa tetanus*	7	3.75	0.0271481	0.00536481
Common Greenshank	*Tringa nebularia*	12	8.333333	0.0603291	0.01192179
Green Sandpiper	*Tringa ochropus*	42	21.07692	0.1525861	0.03015297
Wood Sandpiper	*Tringa glareola*	13	6.333333	0.0458501	0.00906056
Common Sandpiper	*Actitis hypoleucos*	31	24.27273	0.1757221	0.03472493
Great Black-headed Gull	*Larus ridibundus*	1308	434	3.1419381	0.62088698
Herring Gull	*Larus argentatus*	8	5.333333	0.0386106	0.00762995
Total		25674	13813.13	100.00000	19.7612801