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CLIMATE CHANGE, BIODIVERSITY PAKISTAN's SCENARIO

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ABSTRACT

Climate is the major factor which controls the global pattern of vegetative structure, productivity and species composition of plant and animal. Its implications for ecosystems have appalling consequences related economic and social systems. Many plants can reproduce and grow within specific range of temperature and specific amounts of precipitation. Same is the case with the animals and are also dependent on the persistent of their food species. Therefore, climate change can affect the ecosystems and the biodiversity within them in many ways. The changes that have been observed in the terrestrial and aquatic ecosystems in the recent decades have been discussed include few examples of distribution of marine turtles, salt lake wetlands complex and the Indus River ecosystem. Although, biodiversity under threatened due to anthropogenic stresses along with the climate change but the apt management of biodiversity can reduce the blow of climate change.

Keywords: Anthropogenic climate change, marine turtles, Uchalli Wetlands Complex, community structure, distribution, Indus River.

INTRODUCTION

The global climate has changed over the last century. The average surface temperature of the world has increased since 1900 by 0.6 ± 0.2° C. Consequently, this has been followed by a retreat of glaciers and sea-ice, an increase in the number of heat waves, warming of the oceans, a sea-level rise (10–20 cm), a change in precipitations with increase in heavy rainfall and droughts in many regions and less incidence of frosts (IPCC, 2001). Empirical evidences reveal recent climate change is driven by the increased concentrations of greenhouse gases in the atmosphere are due human activities.

Temperature is predicted to rise by up to 4 °C by 2100 that will alter precipitation patterns. Changes in the normal patterns of temperatures and humidity generally delimit species boundaries. Each 1°C of temperature change moves the ecological zones to approximately 160 km either in latitude or altitude. High temperatures will also influence the geographical and seasonal distribution of precipitation. However, the ability of species to respond to climate change will depend on the ability to adapt to the changing climate through colonizing new territory, or to modify their physiology and seasonal behaviours.

The association between temperature and individual life has been well studied and most of the long term climate-related research focuses on possible shifts in distribution and abundance that are due to temperature changes. Therefore, recent work has revealed that both abiotic changes and biological responses in the ocean will be substantially more complex. For example, changes in ocean chemistry may be more important than changes in temperature for the performance and continued existence of many organisms. Ocean circulation, which drives larval transport, will also change, with important consequences for population dynamics. Furthermore, climatic impacts on one or a few influenced species may result in all-encompassing community-level changes. Finally, synergistic effects between climate and other anthropogenic variables, mainly fishing pressure, will likely make worse climate-induced changes.

Carbon dioxide is one of the main source of greenhouse effect and therefore of increasing temperatures. Increased CO_2 in atmosphere may results in an increase in rate of photosynthesis that can balance the effect of temperature increase. Similarly an increase of anthropogenic atmospheric nitrogen deposition provides a better growth in plants. Climate change will affect all the ecosystems but in different ways. The vulnerable ecosystems include tropical and boreal forests, mountains, polar region, savannahs, marine ecosystems, wetlands and island ecosystems. For example, in marine ecosystems the possible consequences include increased thermal stratification, reduced upwelling of nutrients, decreased pH and loss of sea ice. These changes will influence the timing and extent of the spring bloom of phytoplankton and the associated food chain.

Biodiversity: The definition of biodiversity as proposed in 1992 Convention on Biological Diversity (CBD) Rio de Janeiro says "the variability among living organisms from all sources, including, *inter-alia*, terrestrial, marine and other aquatic ecosystems and the ecological processes of which they are part. This includes diversity

within species (genetic diversity) between species (species diversity) and of ecosystems". The fundamental role of biodiversity has been recognized that it maintains and enhance the well-being of people by providing livelihood security, agriculture, energy and health in addition to provide other services such as nutrient cycling and soil formation, pest and disease control, flood regulation, etc. The number of species worldwide is 13 million, out of these only 1.7 million have been reported. There are certain hot spots areas in some tropical forest, coral reefs and Mediterranean ecosystems which show high concentration of species with endemism and unusually rapid rates of depletion.

Factors affecting Biodiversity: Ecosystems are a dynamic complex of microorganisms, fungi, plants and animals communities associated with abiotic environment that make an ecological unit with human beings as a vital part. Ecosystems vary in size and composition and the extent of biodiversity is related to the size and the health of ecosystem. The anthropogenic impact on the terrestrial and aquatic ecosystems affects the biodiversity. Human populations depend on ecosystem as the services provider and include products such as food, fuel, and fiber; regulating services such as climate regulation and disease control; and nonmaterial benefits such as spiritual or aesthetic. For example, the services provided by water are supporting, regulating or provisioning. Glaciers and precipitation are the ultimate source of water that support ecosystems and any change in this due to climate change will ultimately affect the human being.

The habitat destruction is another factor that is threat to biodiversity through changes in land use in addition to over-exploitation of resources, pollution, invasion by non-native species, biological consequences of increased level of carbon dioxide in the atmosphere and climate change. The impact on the ecology and environment due to climate change is usually slow and difficult to measure but more often irreversible. It is expected that with time the effects of climate change are likely to increase in relation to the other factors.

Consequences of Climate Change on Biodiversity: *Changes in distribution, reproduction timings, growing seasons and extinction rates*

Temperature and rainfall play major roles in determining where individual species of plants and animals can live, grow and reproduce. It is known that the temperature has direct effects on the physiology of organisms. One of the examples is: the sex of developing embryo of turtle and alligator depends on environmental temperature. The effects of climate change on species and ecosystems can be both direct and indirect. There are a number of direct impacts of climate change on species and ecosystems.

Changes in global forest cover in response to climate change are expected to occur. There will be shifts of vegetation zones or biomes. There will also be shifts in ranges of species and in species composition. The shift of species is expected towards higher altitude (Pole and peaks). The changes in climate will affect the physiology, phenology, and interaction between species and resulting in changes in geographic distributions.

The changes in reproduction timings and the length of growing seasons for plant i.e., phenology may disrupt important correlations within the ecosystem. Numerous studies have documented the long-term changes in the biological events or phenology of animals and plants. Precipitation also has direct effect on species abundance and distribution. Pressures from longer dry periods and reduced living spaces are making African elephants vulnerable to climate change.

In United Kingdom, systematic data on bird nesting collected for 60 years showed that 78% of 65 species of birds studied showed they started breeding earlier. Twenty five percent of Australian eucalypts have distributions that span less than 1°C of mean annual temperature (Hughes *et al.,* 1996) this makes them more vulnerable to even small changes in climate. In Western Australia, a significant number of frog, mammal and plant species can be restricted to smaller areas or go extinct with a warming of only 0.5°C (Pouliquen-Young and Newman, 2000).

There is strong interaction between effects of climate change and habitat fragmentation or degradation that may lead to depletion of biodiversity at local, regional and global levels. Habitat fragmentation results in geographic isolation of species population and therefore genetic variations are reduced. The migration and dispersal of species to more suitable habitats in response to climate change is also not possible thus can have a greater impact on the climate.

Changes in Ecosystem functioning: The impact of climate change may change ecosystem functioning as the physiology of species is affected by changes in temperature and availability of water. The ecosystem functioning depends on the relationships between respiration, carbon dioxide fixation, nitrification, litter decomposition, etc. Climate change can influence the ecosystem functioning by reducing biodiversity due to extinction or migration of species. Also, opportunistic and invasive species will dominate and their ranges will be extended in comparison to endemic or native species. There will be *c*hanges in coastal and estuarine habitat due to rising sea levels. Mangroves, coastal wetlands, corals and seagrass communities will be affected in various ways, depending on erosion, depositional processes and consequent changes in the coastline and their ability to cope with it.

Scientific evidence shows these changes are already occurring along with the warming trends over the past century (Hughes, 2000, 2003; Parmesan and Yohe,

2003; Root *et al.,* 2003). These changes are expected to accelerate and become more obvious over the next few decades, though the precise nature and rate of change for individual species and ecosystems is uncertain.

Examples from Pakistan

Distribution of Marine Turtles in Pakistan: Marine Turtles are imperative group of reptiles that visit the near all the sandy beaches from the coast of Sindh to the coast of Baluchistan. Generally in their breeding or egg laying season they migrate from deeper ocean to the coastal areas to lay eggs. Two species of marine turtles, the Green turtle (*Chelonia mydas*) and the Olive Ridley turtle (*Lepidochelys olivacea*) are commonly found along the coastal areas of Pakistan, and the other two species the Loggerhead and Hawksbill turtle are rarely observed (Firdous, 2001). The distribution and biological aspects have been studied in a long term study, from the coastal areas (Hawkes Bay and Sandspit ranks among major tropical grounds of the world) of Karachi by the wildlife department (Firdous, 2001). The green turtle is listed in the IUCN Red List of Threatened Species.

Sindh Wildlife Protection Ordinance 1972 provides protection to turtles under the regulatory provisions; Being a signatory to the Conservation on International Trade in Endangered Species of Wild Fauna and Flora (CITES); the clause 5 in the Pakistan Fish Inspection and Quality Act 1997, of MINFAL (the Federal Ministry of Food, Agriculture and Livestock, Government of Pakistan) that forbids the export and domestic consumption of all aquatic turtles. A long terms study (1981 to 1997) of the distribution of nesting incidences of these turtles show a decreasing trends in the number of egg laying females recorded at Sandspit for both *C. mydas* and *L. olivacea* (web address); this can be attributed anthropogenic impacts like pollution and degradation of habitat.

Avian biodiversity: The influence of climate change on avian diversity in a Ramsar designated wetland complex in Pakistan and its management options were studied (Ali, 2005). Pakistan has the strategic and geographic location that allows serving as the Palearctic to Asia bird migration routes. All the rivers in Pakistan contribute to this major migrating rout of migrating birds it the considered as the fourth major bird migration flyway in order of importance. The seasonal birds in transit; and winter and summer visitors tumble down from northern mountain regions in prominent numbers.

The Uchalli Wetland Complex is a combination of three independent wetlands viz; Uchalli, Khabbaki and Jahlar and was declared as Ramsar site in 1996. A number of globally threatened bird species visit these wetlands (Ali, 2005). The study showed wetland characteristics, were influenced by a number of things that include water-level fluctuations throughout the year, in response to rainfall, that maintain wetland (Figure 1 and Table-1). The climatic conditions vary from year to year. But after 1997 drought conditions prevailed, and more than 50% decline in rainfall was observed. Morphometry of Uchalli Wetlands Complex showed negative change with only 27 percent (336 ha) of the water area at Uchalli wetlands Complex compared to 1,243 ha and this had a great impact on migratory birds population (Ali, 2005). There was significant positive correlation between the amount of precipitation and birds counts in this wetlands complex (Figure. 2). Short-term (years) and long-term (decades) climatic trends create wetlands cycle between a wet and dry state: Interaction of surface and ground water with rocks and soils influence salinity and other wetland water chemistry. The physical effects on the lakes due to climate change include increase in evapo-transpiration due to high temperature, long growing season and extended ice-free period. Increase in evapo-transpiration decreases water levels, whereas increase in precipitation increases water level of lakes. Increase in both evapo-transpiration and precipitation affect on the water level is not significant but it shortens the water resident time in the lakes (Ali, 2005). This study identified the major threats to Uchalli complex avian biodiversity include climate change, drought, encroachments of land, agriculture, use of agrochemicals, decrease in wetlands vegetation, deforestation, ground water extraction, illegal hunting and lack of implementation of Wildlife Protection Laws.

The Indus River: Aquatic systems are highly sensitive to variations in weather and climate. The accretions of greenhouse gases in the atmosphere causes global climate change and have an effect on pattern of precipitation, evaporation, snow pack, flood, drought and other factors affecting freshwater supply and quality (IPCC, 2001a). Similar to other rivers in the world the Indus River faces risk from climate change because of its high reliance on glacier water. Indus River originates from Mansarovar Lake in Tibet at an elevation of about 5182 m, and flows for about 2880 km down into the Arabian Sea through the Indus Delta. The drainage area, which expands into India, is 450,000 square miles and contributes to an average annual inflow of 175 million acre feet. The flow of the Indus fluctuates seasonally, with melting of Himalayan glaciers accounting the highest proportion (70-80%) of its water to Indus compared to any river in Asia (Kiani, 2005). The Indus Basin lies in the arid zone, scarce in rainfall (<10 inches annually), however, abundant flow is present during the monsoon season (July-September), which accounts for 51% of the annual flow. The Indus basin is already affliction from severe water scarcity due to over extraction for agriculture, causing salt water infringement in the delta (WRI, 2003). Additionally, the Indus basin has already lost over 90% of its original forest cover (Revenga *et al*., 1998; WRI, 2003). Although

most of nearly 10% of the rainfall is lost by evaporation and nearly 41 million acre feet is lost by seepage from unlined canals, which results in waterlogging rendering the land useless for agriculture.

The amount of water in Indus River has decreased from 185,000 million m3 per year to 12300 million m3 per year in 1990 (Iftikhar, 2002). Food and crop production in Pakistan depends up to 90 % on irrigation and water resources. The Indus Waters Treaty, between India and Pakistan in 1960 is regarded as one of the few successful settlements of a transboundary water basin clash. India was granted the three eastern tributaries (Ravi, Beas, and Sutlej) and Pakistan assumed the flow of the three western rivers (Indus, Jhelum, and Chenab). The Indus Waters Treaty was established to facilitate exploitation of the basin's economic potential for most favorable benefit of India and Pakistan, by building up of new dams and irrigation canals, the agricultural production in the Indus basin has increased. Pakistan irrigation system infrastructure include three major reservoirs along with 19 barrages and 57, 000 km long channels and 89,000 water courses running length of 1.65 *106 km. Water discharge below Kotri barrage that was constructed in 1955 was 70 MFA before 1960 Indus Water treaty, after commissioning of Mangla Dam (1964), Tarbella (1972) and barrages (19) the water discharge reduced to 30 MFA. In 1991, the Water Apportionment Accord (WAA) was an agreement to share waters of the Indus River between the four provinces based on the water supply for existent and future needs. The approved discharge post WAA was 27 to 34 MFA however present discharge now has decreased (0.72 MFA in 2000 to 2001).

Indus river fall into Arabian Sea creating Indus Delta, the fifth largest in the world shaping 563 km of the entire coast of Sindh. Indus Delta Creek system covers 600,000 ha is the prominent feature of Sindh coast. The Indus Delta consists of a network of 17 major creeks and numerous minor creeks, mud flats and fringing mangroves cover 37% and are the largest arid climate mangroves (13th) in the world.

The catchment is also an area of rich biodiversity, predominantly where it opens to the Arabian Sea. The Indus river delta is a prolific area for freshwater fauna and an important region for water birds (Ramsar Convention on Wetlands, 2003). The Indus is habitat to 25 amphibian species and 147 fish species of which 22 are found nowhere else in the world. It havens the endangered Indus River Dolphin, one of the world's rarest mammals, with a population of no more than 1,100 individuals (WRI, 2003; Ramsar Convention on Wetlands, 2003; WWF, 2005f). In addition, due to reduced river inflows, the delta has lost significant portions of its mangroves (WWF, 2004).

The shortage of precipitation coupled with high evaporation rate and decreased flow has increased the salinity of the creeks in the coastal area due to salt water intrusion. The anthropogenic impact of upstream damming and diversion has caused shrinking of active delta that has consequently reduced the mangrove cover. There is immediate need for assessment of minimum release of freshwater and sediment bad or other delta progradation engineering solutions. The management of Indus River should have holistic approach and all ecosystems not only the coastal zone from the source in the catchment area of delta.

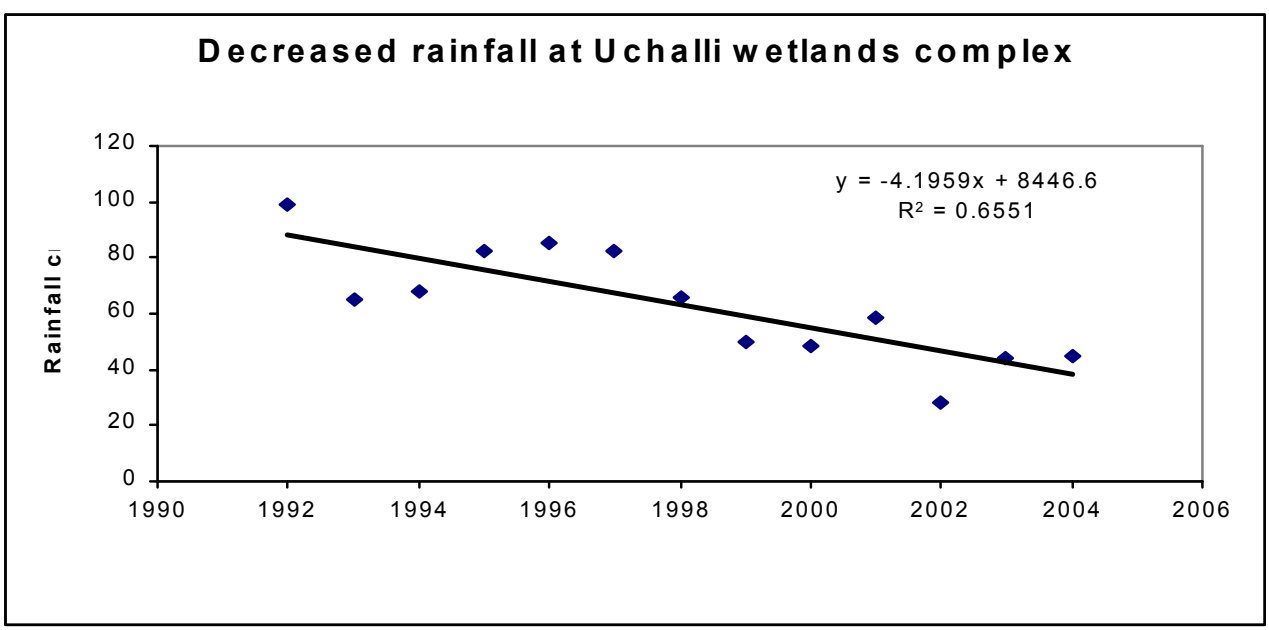

Figure 1. Decrease in rainfall

Table: 1 Precipitation and changes in the size of lakes.

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

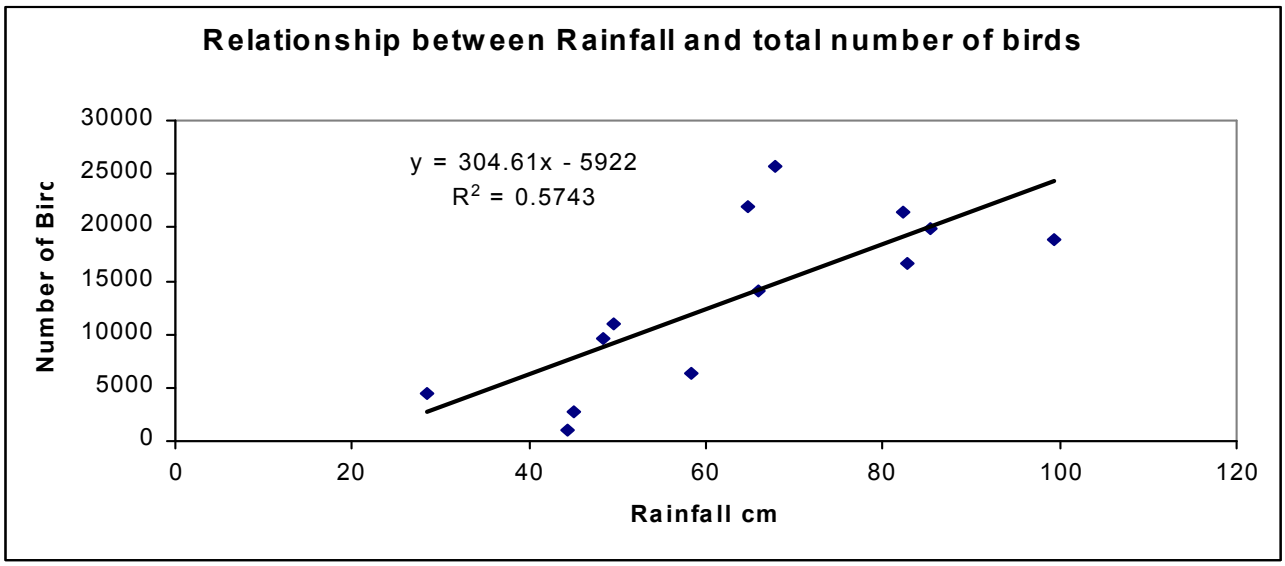

Figure 2. Relationship of rainfall and number of birds B.

The adverse effect of sea level rise will be more visible in Indus Delta. The rate of sea level rise along Karachi (1.1 mm per year) is expected to double in next century and will result in 20 to 50 cm rise in sea level (Tabrez *et al*., 2008). The present trend continues the Indus Delta will modify as transgressive beach similar to San Franscisco due to lack of sediment input and impact of erosion due to high energy waves (Haq, 1999). There is a need to devise adaptation strategy that accommodates climate change, this will be based on the short term and long term monitoring studies as well as modeling projections of expected climate changes in Pakistan over the coming decades to evaluate the corresponding impacts on the water inflows of our rivers and productivity and health of various ecosystems.

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