CHAPTER -1 INTRODUCTION

1.1 Background

Bio-diversity is one of the Nepal's strength. It's unique geographical location at the juncture of two biogeographic regions, Palaearctic to the north and the Indo-Malayan to the south, has resulted in an extraordinary assemblage of fauna and flora (Sharma, 1995). The topography, rainfall, altitudinal variation together with the bio-geographical location of Nepal at the meeting point of the oriental and Palaeartic realms are major factors that contribute to the country's high avian diversity. The subtropical lowlands are relatively richer in bird species and the eastern part is richer in birdlife than in the western Nepal (Inskipp and Inskipp, 1991). Although it's being a small country, Nepal is the meeting point of highland as well as lowland birds that is "crossroad" for Trans-Himalayan species of birds. It harbors one tenth of birds' species of the world (Giri, 1999). Nepal's birdlife is among the richest in Asia, particularly considering the small size of the country. To date, a total of 862 species of birds are recorded in Nepal (Baral and Inskipp, 2005). This form 8.8% of the world's known birds (9750 approx.) (Thapa, 2006). Two species Greater fronted Goose *Aser aliform* and Red-breasted flycatcher *Ficedula* (*prave*) *prava* are the latest addition for the list. This shows the number could raise in future (Chaudhari *et al.*, 2006).

Spiny Babbler *Turdoides nipalensis*, a unique Nepalese bird, is endemic to the country (Shrestha, 2000). The alarming numbers of 133 (15%) species of Nepal’s birds are considered threatened. As many as 72 bird species are thought to be Critically Threatened or Endangered meaning there is an extremely high or very high risk of their becoming extirpated in Nepal in the near future (BCN/DNPWC, 2004). Around 611 species of bird breed here in Nepal. About 62 species are summer visitor or partial migrants and 150 species are winter migratory (Grimmett *et al*., 2003). 11 species are considered extinct (Inskipp and Inskipp, 1991). 145 species are included in IUCN red data list (IUCN, 2006). Roughly 650 species of birds are resident that probably breed in Nepal (BCN, 1997). 226 birds species are included in National Red Data Book on the basis of the global, regional, national and ecological importance of these 184 (81%) are breeding

species, with the remainder being migrants (BPP, 1995). A total of 34 bird species have been recognized as globally threatened birds of Nepal (IUCN, 2007) but BCN has recently published a list of 33 globally threatened birds in the form of poster in the occasion of completion of 25 years by BCN.

Following 9 species are protected by National Parks and Wildlife Conservation Act 1973, Government of Nepal: White Stork (*Ciconia ciconia*), Black Stork (*Ciconia nigra*), Himalayan Monal (*Lophophorus inpejanus*), Satyr Tragopan (*Tragopan satyara*), Cheer Pheasant (*Catreous wallichii*), Bengal Florican (*Houbaropsis bengalensis*), Lesser Florican (*Sypheotides indicia*), Sarus Crane (*Grus antigone*) and Great Hornbill (*Uceros bicornis*) (Baral and Inskipp, 2004). Nepal's major bird habitat consists of forest, wetland and grassland (Grimmett *et al*., 2000).

Ramsar Convention on wetlands, defined that wetlands are "areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water, the depth of which at low tide does not exceed six meters" (Ramsar Convention Bureau, 1987; Article 1.1). Further, the convention defines that wetland "….may incorporate riparian and coastal zones adjacent to the wetlands, and islands or bodies of marine water deeper than six meters at low tide lying within the wetlands" (Article 2.1). These broad definitions cover the majority of all categories of wetlands including most of the world productive lands which are considered among the most productive ecosystems in the world (Halls, 1997).

Since, Nepal made little effort for the wetland conservation, the systematic study of wetlands in the country is very recent (GoN/MFSC, 2002). Generally wetlands mean rivers, lakes, reservoirs and forests, and water logged lands in and around human habitation. The Nepali term for wetlands is "Simsar", which means lands with perennial source of water. Swampy rice fields, water logged areas and ponds are also understood as wetlands in the country. There are about 50 different definitions of wetlands in the world. Plants, animals and birds are abundant in wetlands. Twelve different words are

commonly used to denote wetlands in Nepal. In this sense, wetlands could be defined in the following way-

"Wetlands denote perennial water bodies that originate from underground sources of water or rains. It means swampy areas with flowing or stagnant, fresh or salt water phat are natural or man-made, or permanent or temporary. Wetlands also mean marshy lands, riverine floodplains, lakes, ponds, water storage areas and` agricultural lands"(NWP 2003). This is the first concrete approach by the Government of Nepal to wetland biodiversity conservation for the future.

The Ramsar Convention defines “Waterfowls” as species of birds that are “ecologically dependent upon wetlands” and has defined “waterbird” as being synonymous with “waterfowls” for the purpose of the application of the convention. Waterbirds occur on Wetlands often in spectacular concentrations, and are one of 4he most obvious indicators of the richness and diversIty of these productive ecosystems. The long migrations of some waterbirds, and the fact that some species are the prized quarry of hunters, have made these birds a favoured subject for research, survey, education and recreation throughout the world (Delany and Derek, 2002).

Although Nepal is a land locked country, it has many types of wetlands scattered through the Mountain and Tarai regions. Because of its mountainous physiography bigger wetlands are rather very few. There are 33 wetlands within the protected area system (Manandhar, 2005). Many of Nepal's most important wetlands are included within these protected areas. Most of the important high land lakes are situated in three Himalayan National Parks (Langtang, Rara and Shey-Phoksundo) (Bhatt and Shrestha, 1982; Shakya, 1989; Manandhar, 1991). High altitude wetlands of Nepal are the source of aquatic system for whole country. The areas are important for altitudinal adapted fauna as well as for migratory birds as a resting ground. Due to Nepal's unique position its highland possess unique biodiversity and much more can be expected in wetlands of such areas. The animals that are, for one or more reasons, dependent on water bodies include, insects, fishes, herpetofauna, resident birds, migratory birds, as well as mammals (Chalise, 2007). The extensive marshes associated with oxbow lakes and floodplains in

the lowland are in the Suklaphanta Wildlife Reserve, Bardia National Park, Chitwan National Park and Koshi Tappu Wildlife Reserve (Bhatt and Shrestha, 1982; Shaky, 1989; Manandhar, 1991).

Biologically, wetlands have been found rich in resources and therefore they are also known as kidneys of the landscapes; biological supermarket; laboratory for education and research; integrated part of people's life styles and sources, sink and transporter of nutrients (Bhandari, 2006). The wetland is among the most productive ecosystem in the world. Wetland is an important base for economic development of the country and plays vital role of subsistence population. The wetlands occupy approximately 5% of the total area of Nepal, is in the form of the rivers, streams, lakes, reservoirs, village ponds, paddy fields, marshes sand swamplands (Shrestha, 2000). Wetlands are one of the most threatened habitats because of their vulnerability and attractiveness for development (Hollis *et al*., 1988). Wetlands are important in terms of their ecological, economical, cultural, sociological, recreational, religious and aesthetic values. Wetlands are transition and interposition between open water and terrestrial system, providing a major ecological benefit to the environment in terms of bio-diversity, habitat for aquatic flora and fauna, hydrological regime, sustaining of local communities and storing large quantity of water recharge (Suwal, 1992).

Wetlands provide homes for a huge diversity of wildlife: birds, mammals, fish, frogs, insects and plants. They also provide habitat for humans- the one billion people who rely on fish as their primary source of animal protein, and the millions upon millions who rely on wetlands directly for some or all of their livelihoods. There is often great pressure on wetland resources because of this dependence (Buckton, 2007). Among the 862 birds' species, 195 are wetland birds, of which tarai wetlands support 187 species. The large percentages, 64% of wetland birds at risk (29 species) are considered critically threatened and endangered. Pink-headed Duck (*Rhodonessa caryophyllacea*) and Imperial or White-bellied heron (*Ardea insignis*) are the resident wetland birds that have become extinct from Nepal since last century (Thapa, 2006). But according to Shrestha (2000), in Nepal, more than 230 bird species are known to depend on wetlands. Nepal is being

transitionally lying between two realms; many bird species visit Nepal seasonally from different parts of the world such as India, China, Russia and Arabia. They also migrate from one place to another inside the country to escape from scorching heat and chilling cold. Most of the migrating birds are found to be wetland or water bird (Nepali, 1980). From the thorough study of IUCN in 1996, there are 163 wetlands in the Tarai and 79 in the Mountainous region (Kafle, 2007).The wetlands of the country's lowlands alone support 32 species of mammals, 461 species of birds (among which 15 species are rare), 9 species of turtle, 20 species of snake and 28 species of fish (NWP, 2003). Nepal's wetlands (approx. 743, 500ha) are particularly important for threatened species. These range from the tarai to the himalayas including rivers/streams/lakes/ponds, swamps/marshes, reservoirs and paddy field (DOAD, 1992). According to IUCN (2003) red list, about 123 globally threatened faunal species occur in Nepal, of which 42 species are found in freshwater biomes. Nearly half of the country's globally threatened birds (14 species) and 10 near threatened species regularly inhabit wetland (Baral and Inskipp, 2005). Consequently some of the wetland birds e.g. Pink headed Duck *Rhodonessa caryophyllacea* has become extinct in Nepal and are considered critically endangered (Possibly extinct) globally (Birdlife International, 2002). Similarly some wetland species have shown precipitous declines over recent years, for example Brahminy Kite *Haliastur indus*, Caspian Tern *Sterna caspia*, Black-bellied Tern *S. acuticauda* and River Tern *S. aurantia*. A total of 44 nationally threatened birds are wetland species (Baral and Inskipp, 2004).

1.2 Research Problem Statement

Bird population are highly sensitive to change and monitoring birds can give important early warning signs of future environmental crisis (Birdlife International, 2000). Birds are relatively easy to census as they are well known, easily recognizable and simpler to locate than many other taxonomic groups. Birds can be useful indicators of the state of the environment and are also key species for education and public awareness (Bibby *et al*., 2000a). Birds are good bio-indicators and useful models for studying a variety of environmental problems (Urfi *et al*., 2005) because they potentially detect aspects of wetlands landscape condition that are not detected by the other groups commonly used as

indicators (U.S. EPA, 2002). Migratory waterfowls are one of the most remarkable components of global biodiversity. They are important indicators of the ecological condition and productivity of wetland ecosystem (Li Zuo Wei and Mundkur, 2004).

Nepal's wetlands are facing tremendous anthropogenic pressure. Human induced activities such as deforestation, destructive means of wetland resources collection (e.g. fishing, gravel and driftwood collection) and water drainage for irrigation are the activities with the largest impact for the deterioration of wetland habitats (IUCN, 2004; Bhandari, 1998; Sah, 1997), which can greatly influence the structure of bird community (Francle and Schnell, 2002). In addition to this, wetlands are widely covered by invasive weeds. For some years, Nepal's wetlands have heavily suffered from invasive alien plant species primarily water hyacinth *Eichhornia crassipes* (Sah, 1993a). This alien species is native to Brazil and has become widespread on a global scale (Gopal, 1987). It was first reported in Nepal in 1966 and is now widely distributed in most of the Tarai protected areas (ranging from 75m to 1500m) of Nepal (Tiwari *et al*., 2005). It has been considered as one of the major problems everywhere in South Asia (Gopal and Krishnamurthy, 1993) and caused more damage to Nepal's aquatic habitats than any other invasive, allied species.

Lake Phewa is home for many fish species, birds, reptiles, invertebrates like snails and many insects. The lake is now infested with a floating macrophyte, the water hyacinth and blue green algae indicating enriched nutrient loading into the lake (NARC-FRCP, 2004/05). Presently, the lake is facing severe environmental problems as a result of nutrient loading from agriculture, landslides and rapid urbanization in the surrounding area. Sewage from the surrounding settlements is directed into the lake (Lamichhane, 2000), and the volume continues to rise dramatically in response to increased tourism (Oli, 1997). The recent trend is toward rapid eutrophication (Oli, 1997; Lamichhane, 2000; Rai, 2000). A great deal of natural soil erosion takes place in the Phewa Lake watershed area because of its fragile geo-structure. Man-made activities like agriculture and other have further accelerated soil erosion. In the watershed area, the rate of soil erosion was estimated to be 17.37 cubic meters per hectare during 1993/94 (DSCWM/

GoN, 1994: cited in Oli, 1995). During the same period, 175 to 225 thousand cubic meters of silt per year were estimated to have accumulated in the lake. If siltation continues at this rate, it is believed that the lake will be completely silted up within 100 to 175 years (Oli, 1995).

Ramsar Sites in Nepal

Nepal's wetlands (approx. 743,500ha) are particularly important for threatened species. These range from the tarai to the Himalayas including rivers/streams/lakes /ponds, swamps/marshes, reservoirs and paddy field (DOAD, 1992). The country has approximately 6000 rivers and rivulets, including permanent and seasonal rivers, streams and creeks. It has been estimated that there is over 405 wetland areas in Nepal from Tarai to the Himalayas (WECS, 2002). Considering the global significant values of Nepal's wetlands, some of the country's wetlands are listed under the Ramsar Convention. Koshi Tappu is one of the foremost outstanding wetlands, which was recognized as wetland of international significance especially for waterfowl habitat in 1987. Ghodaghodi Tal (Far western Nepal), Beeshazari Tal (Central Nepal) and Jagadishpur Reservoir (Western Nepal) were included in the Ramsar Lists in 2003. Now Nepal has eight Ramsar sites after the inclusion of four more wetlands in 23 September 2007 viz: Gokyo and Associated wetlands, Gosaikunda and Associated wetlands, Phoksundo Lake and Rara Lake. Now the total area covered by the Ramsar sites in Nepal is 34,365 hectares (Table: 1).

Table: 1 Detail of the Ramsar Sites of Nepal

SN	Site	Date of designation	Region, Province, State	Area in ha.	Coordinates
1.	Koshi Tappu	17/12/1987	Koshi River, Eatern Nepal	17,500	26°39'N 086°59'E
2.	Ghodaghodi Lake Area	13/08/2003	Kailali	2,563	28°41'N 080°57'E
3.	Beeshazari and Associated Lakes	13/08/2003	Chitwan	3,200	27°37'N 084°26'E
4.	Jagadishpur Reservoir	13/08/2003	Kapilvastu	225	27°35'N 083°05'E
5.	Gokyo and Associated wetlands	23/09/2007	Sagarmatha NP	7,770 #	27°52'N 080°42'E
6.	Rara Lake	23/09/2007	Rara NP, Mugu	1,583 #	29°30'N 082°05'E
7.	Gosaikunda and Associated wetlands	23/09/2007	Rasuwa/ Langtang NP	1,030 #	28°05'N 085°25'E
8.	Phoksundo Lake	23/09/2007	Shey-phoksundo NP	494 *	29°12'N 082°57'E

only water body * catchment area also

1.3 Objectives of the Study

1.3.1 General Objective

The main objective of the study is to know about the ornithological importance of Phewa Lake (focusing on water birds) and to discuss about the conservation threats to waterfowls as well as the lake.

1.3.2 Specific objectives

The specific objectives are-

- To know seasonal population of wetland birds including migratory birds.
- To know seasonal diversity of wetland birds including migratory birds.
- To find out conservation threats to the wetland birds in Phewa Lake.

1.4 Theoretical Framework

Birds are very interesting creatures and can attract the attention because of their uniqueness and beauty. The population in particular habitat indicates the whole environmental condition of that habitat. The habitat with integration of all the components like hiding places, food availability, nesting sites, and undisturbed roosting site can only support the larger number of population. So the population of the particular habitat can be important for the indication of the productivity of that habitat in terms of biodiversity. Migration of birds into particular place is the clear indication of productivity of that place. The migratory birds use those habitats which are rich in terms of food availability, nesting site, safe places for roosting and hiding. If we become able for the assessment of the threats, we will be able to protect the biodiversity and can protect that habitat. Unnatural threats like hunting and overuse of the resources are important because without minimizing these threats, natural changes of the environment of habitats, using its biotic component like waterbirds as indicator, cannot be possible. The biodiversity of a site can play as a resource for the human population and can support the livelihood. Different types of biotic components can play important role, for example wetland habitat including its birds can be a source of economy development through tourism industry.

For the long term protection of the habitat and its biological components, conservation and management plans are necessary. Longer the life of the habitat and its components, benefits will be for the longer time.

1.5 Research Hypothesis

- The diversity of the waterbird species (species richness) depends upon the seasons.
- The fluctuation in the number of individuals of the species recorded depends upon the seasons.
- The cattle grazing in the study area of the lake has negative effect on the total population of the waterbird species.

1.6 Importance of the study

Phewa Lake is the largest lake (433 ha.) of Pokhara valley. On one hand it has become the home of different floral and faunal species and on the other hand it is the main source of income for many local people. Many tourists visit the area to have boating in the lake and this has directly or indirectly helped the local people to perform the business activities in order to develop their economic conditions. After the establishment of Fisheries Development Center in 1961/62, a sustainable fishery is also helping for poor people whose main source is fishing. So this lake should be conserved for the economic development of the local people, Pokhara valley and the country as a whole. But, in the recent time the area of Phewa Lake is decreasing. Now a day the lake is becoming highly disturbed because of high, external as well as internal tourist flow for the purpose of recreation. The lake is also becoming polluted day by day and the invasive plant species, water hyacinth has become problem in the lake. These factors can be huge barrier for economic development of the local people and conservation of Phewa Lake as well as its biodiversity. These probably will be the cause for the vanishing biodiversity and environment of the lake. Thus, there is urgent need to find out its causes so that the probable scientific solutions can be applied for the conservation of the lake.

Counting is the central to ecological studies and conservation research in ornithology. Birds are ideal bio-indicators and useful model for studying a variety of environmental

problems (Urfi *et al*., 2005). While discussing about the conservation of aquatic flora and fauna, it may automatically include many aspects of conservation issues of wetland habitat. So that the study which deals with the population status and the diversity of the water birds in Phewa Lake was thought to contribute for the initiation of the conservation and management activities relating to aquatic flora and fauna, and obviously their habitat.

CHAPTER-2 REVIEW OF THE LITERATURE

The first detail ornithological records were described by Hodgson in 1820-1843. His collection includes 667 species along with mammals, reptiles and amphibians representing 9,500 birds' skins. Proud's ornithological accounts between 1948 and 1961 of Gandak watershed and Kathmandu valley summarized valuable and comprehensive records. Polunin was first scientist to describe the birds of western Himalayas during his botanical expedition with the British museum of Natural History during 1952. The first field guide to the birds of Nepal was published by Fleming along with Bangdel in 1976. Fleming traveled Nepal to study the ornithology extensively. Their collections are hold at Chicago Field Museum of Natural History. The publications on them were 35 papers and articles related to Nepalese ornithology. Hari Sharan Nepali "Kazi" a leading Nepalese ornithologist traveled extensively for ornithological expedition and collected more than 650 species and several species were new to Nepal, his life time birds collection are now displayed in the Natural History Museum Nepal (Inskipp and Inskipp, 1991).

Gautam and Kafle (2007) had presented records of water bird species combining two survey results conducted by the first and second authors independently in August 2003 to July 2004 and 1-5 January 2004 respectively in the Phewa Lake. Subedi (2006) studied wetland avifauna in Rupa Lake of Pokhara valley. Shah (2000) studied the bird diversity in and around the Taudaha lake of Kirtipur, Kathmandu. She focused on the importance of Taudaha Lake for migratory bird species. Basnet (2001) studied the status and diversity of avian fauna in Siwalik of Morang and recorded 114 bird species belonging to 13 orders and 40 families. Chalise (1998), in Ghodaghodi Tal, recorded 75 species of birds most of which were wetland birds and winter migratory and also residential. Bhatt and Shrestha (1977) reported a total of 85 species of birds from Suklaphanta Wildlife Reserve belonging to 15 orders and 39 families. Baral and Buckton (1997) studied the distribution and ecology of river birds in the Langtng National Park in 1995 and 1996. Panthi (1997) studied the seasonal bird's diversity in Gokarna sanitary landfill site Kathmandu and recorded 59 species of birds. Rai (1998) studied the avifauna of Tamur river basin and recorded a total of 73 bird species. Dhakal (2001) studied the bird

diversity and conservation aspects of Beeshazari Lake and suggested Beeshazari Lake of Chitwan as a potential sanctuary in Nepal that hosts about 273 bird species. Subedi (2003) conducted mid-winter waterfowl count in Pokhara valley and total of 20 species of waterfowls belonging to 9 families were recorded during the two year waterfowl survey. Sharma (2004) studied the diversity of threatened birds and their conservation threats in Barandabhar corridor forest (BCF), Chitwan and recorded 160 bird species in BCF. 12 of them were nationally threatened. Thakuri, (2007), in Satikhel Community Forest and Dallu Community Forest in Seshanarayan VDC, recorded 118 species of birds belonging to 10 orders and 29 families.

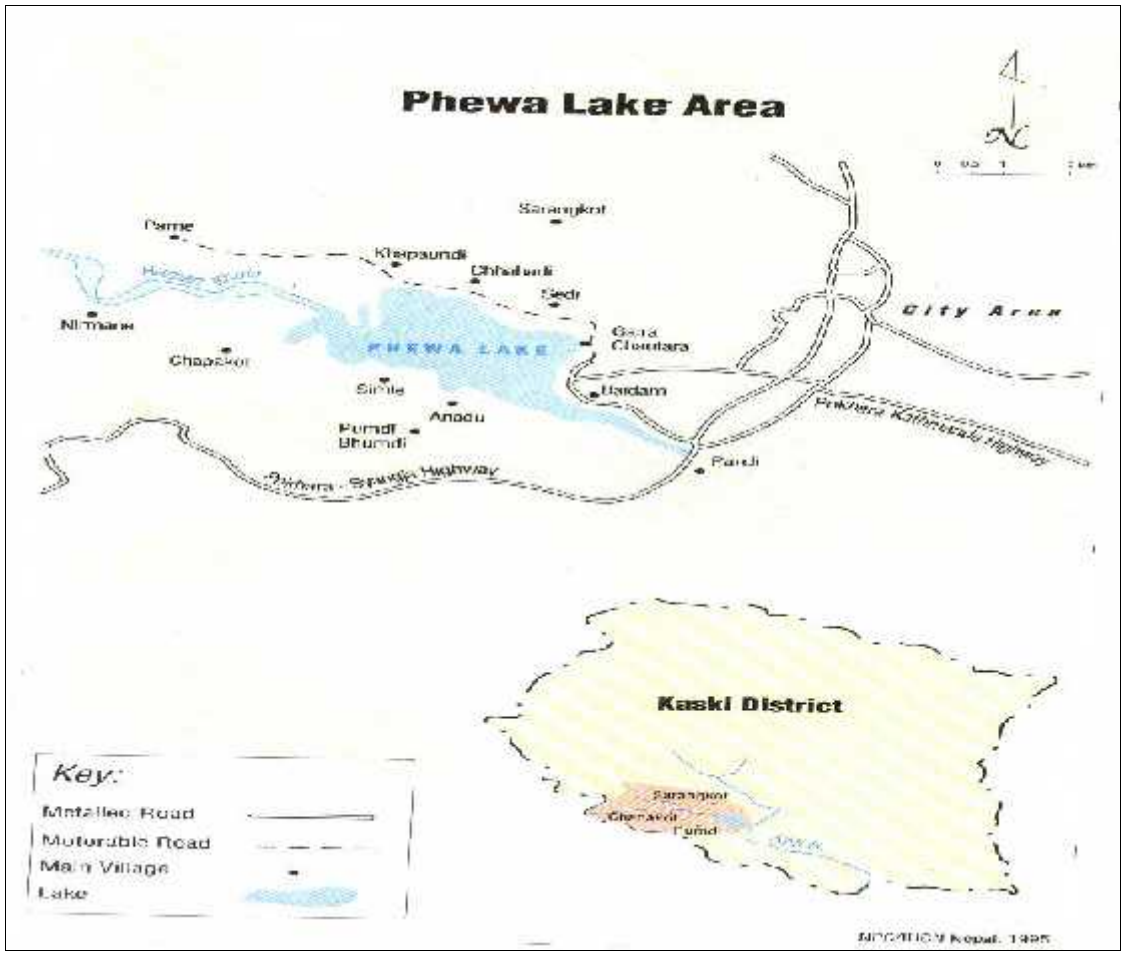
CHAPTER-3 RESEARCH METHODS

3.1 Research Site

3.1.1 Physical Description

Lake Phewa is one of the largest lakes of Nepal. It is situated in Pokhara Valley in the western part of the country. Phewa lake is situated at the southwestern edge of Pokhara Valley (28˚1′N, 82˚5′E. alt. 742m) with a watershed area of approximately 110 km2 (Ferro and Swar, 1978). It is spreading over six village development committee viz: Sarangkot, Kaskikot, Dhikurpokhari, Bhadaure Tamagi, Chapakot and Pumdi Bhumdi; and the southwestern part of Pokhara sub-metropolitan city of the Kaski district. The total surface area of the lake was estimated at 500 ha by Ferro and Swar (1978), while Rai *et al.* (1995) reported 525 ha. More recently, Lamichhane (2000) estimated 443 ha of water surface area with a maximum depth of 23m. Phewa Lake is fed by two perennial streams: Harpan Khola and Andheri Khola, as well as several seasonal streams. The lake has a single outlet, where water is diverted for irrigation and hydropower generation. About 1700 wooden plank boat and other craft are operating in the lake, mainly for tourism services. It is estimated that 16% of Pokhara's total income is generated through tourism (Oli, 1997), with many hotels and restaurants that are operated in. There are two versions of the formation of this lake. According to Hagen (1969), there was a "Paleo-Pokhara Lake" filling whole Pokhara basin and the existing lakes are the remains of the former huge lake. But Gurung (1970) and several other workers agree with the view that this lake was formed by damming of tributaries by sediments of Seti River. Several studies have revealed the mesotrophic status of Phewa Lake (Ferro, 1980, 1981/82; Fleming, 1981; Nakanishi *et al*., 1988; Rai, 1998, Davis *et al*., 1998). However, the lake is also seasonally oligotrophic due to heavy rainfall in its wide catchment area (Rai, 2000). Phewa Lake receives as much as ten times more run-offs during the monsoon season than the rest of the year (Ferro, 1981/82).

The total study area covered was 8.5 sq. km incorporating the western swampy areas, ponds and paddy field area



Map: 1 Location of study area in Kaski district, Nepal

3.1.2 Fauna and Flora

The surrounding area of the Phewa lake is mainly dominated by tree species like *Castanopsis indica* (Katus), *Schima walichi* (Chilaune) and the other species found are *Bombax ceiba* (Simal), *Rush walichii*, *Sapium insigne*, *Syzygium* sp., *Myrica esculanta*,

Albizzia sp. etc. The species like *Clerodendron indica* (Tube flower), *Phylanthus* species, *Solanum xanthocarpum*, *Eupatorium* sp (Crofton weed), *Osbeckia* sp., *Rubus ellipticus* (Ainselu), etc. are the shrubs found around the Phewa Lake. Other species found are Ferns, *Dioscorea bulbifera* (Githa), *Drymeria* sp., *Ageratum* Sp., *Centella asiatica* (Ghodtapre), etc. The water body of the lake is dominated by the invasive free floating weed Water Hyacinth and Hydrilla plant. Other species like White lotus (*Nelumbo nucifera*), *Vallisneria* sp., *Utricularia* sp. etc. and phytoplanktons like *Merismopedia esegans*, *Microcystis* spp., *Surirella robusta*, *Tetraedron hastatum*, etc. are also present.

The Phewa Lake is habitat for many bird species like Ruddy Shelduck, Common Teal, Common Pochard, Little Grebe and Cattle Egret, etc. This is also a home for mollusks, snakes, lizards, frogs and many fish species.

The lake harbors 18 species of the fishes. Many types of insects and zooplanktons like Rotifera (*Conochilus unicornis*, *Hexarthra mira*, *Keratella cochlearis*, etc.), Cladocera (*Daphnia longispina*, *D. lumholtzi*, *Ceriodaphnia reticulata*, etc), Copepodes (*Neodiaptomus strigilipes*, *Phyllodiaptomus blanci*, etc.).

3.1.3 Climate

The Phewa watershed falls in the humid subtropical monsoon region. The temperature is moderate, neither hot nor very cold with maximum temperature peaks at 25.5˚C in July-August and falls to minimum of 13.2˚C in January.

This is heavy monsoonal rainfall area where mean total annual rainfall is 3,710mm. Rain starts from January and the maximum rainfall occurs in the month of July. By November, the winter rain from westerly starts and it continues to April. During the year 2004, highest rainfall occurred during the month of September (864mm). There was no rainfall during December (Fig: 1 And Appendix: 3). Average rainfall during this year was 341.29mm.

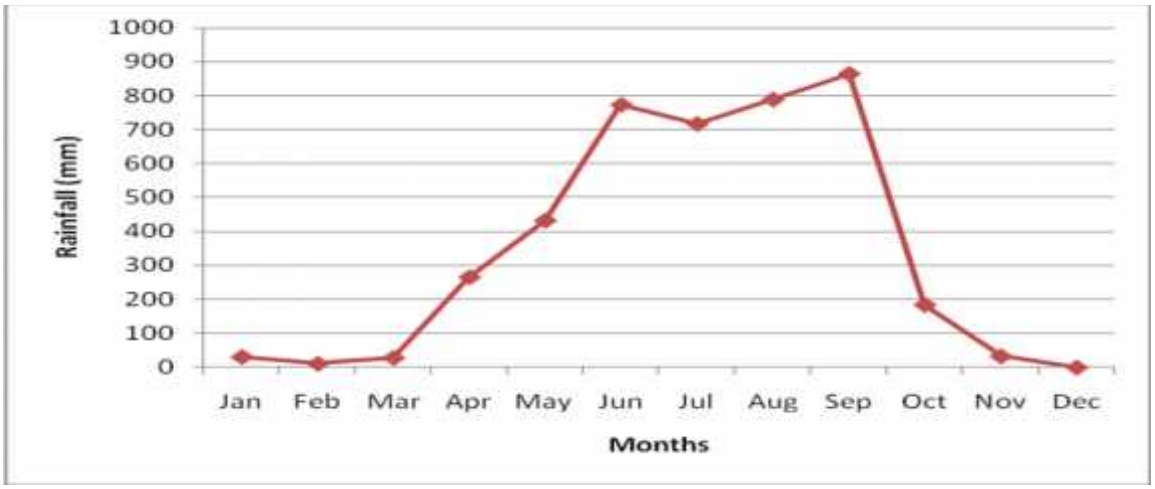


Fig. 1: Rainfall in Pokhara valley in the year 2004

But in the year 2005 highest rainfall was in August (924.5mm) (Fig: 2 and Appendix: 4). In this year also, there was no rainfall in December. Average rainfall during this year was 247.26mm.

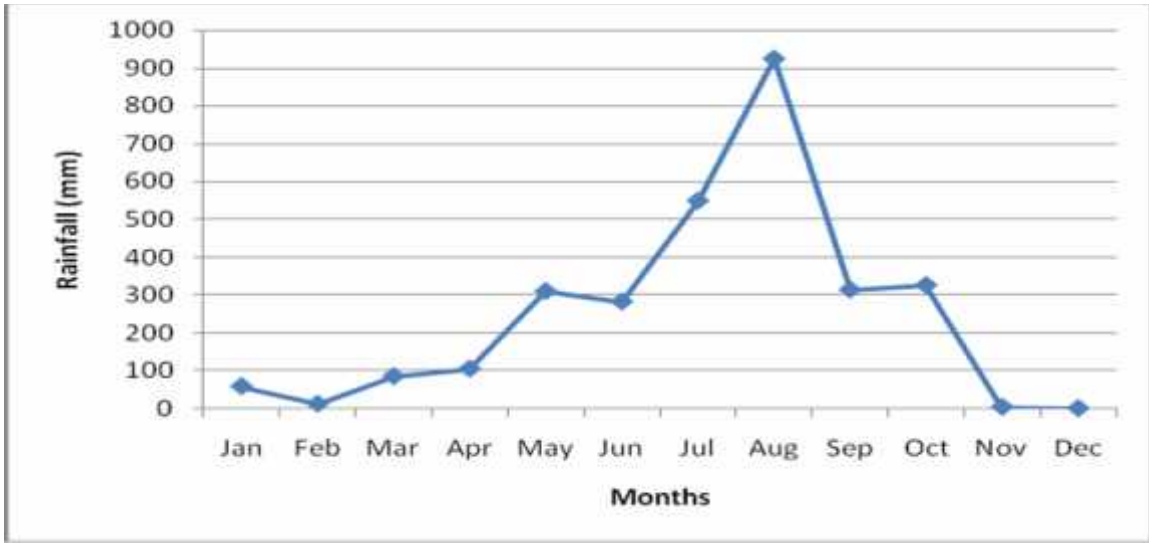


Fig. 2: Rainfall in the Pokhara Valley in the year 2005

Highest maximum temperature was recorded in August (31.4°C) and lowest in January (19.8°C) with average maximum temperature of 27.13°C during the year 2004. Likewise, highest minimum temperature (22.6°C) and lowest minimum temperature (7.5°C) were also recorded in the same months respectively with average minimum temperature of 16.03°C (Fig: 3 and Appendix: 3).

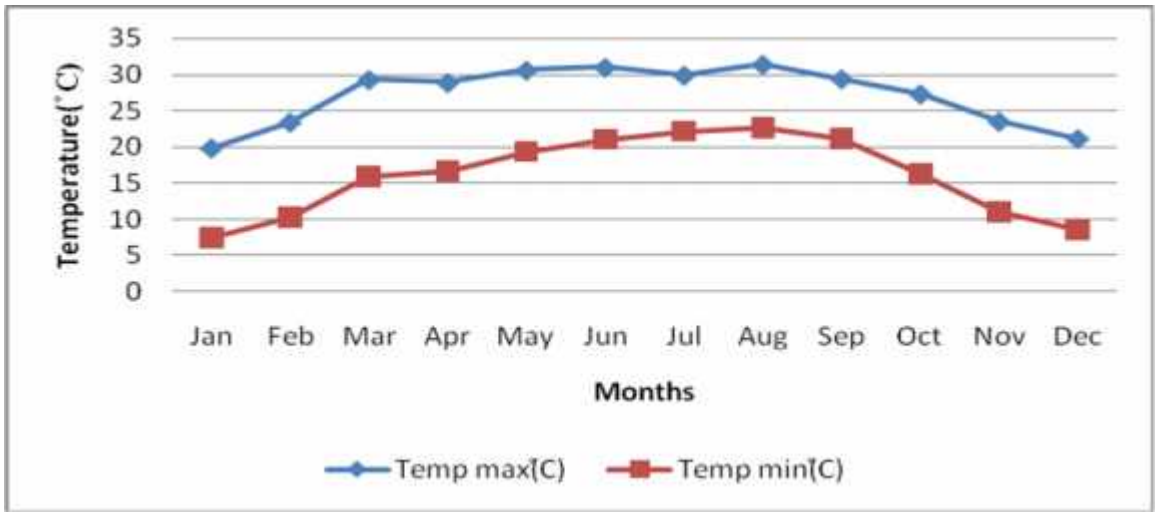


Fig.3: Temperature recorded (max and min) in the year 2004 in Pokhara

But during the year 2005, highest maximum temperature was recorded in June (31.8°C). The lowest maximum temperature was recorded in January (19.3°C) with average maximum temperature of 27.12°C during the year. The lowest temperature was recorded in December (7.2°C) with average minimum temperature of 15.58°C during the year 2005 (Fig: 4 and Appendix: 4).

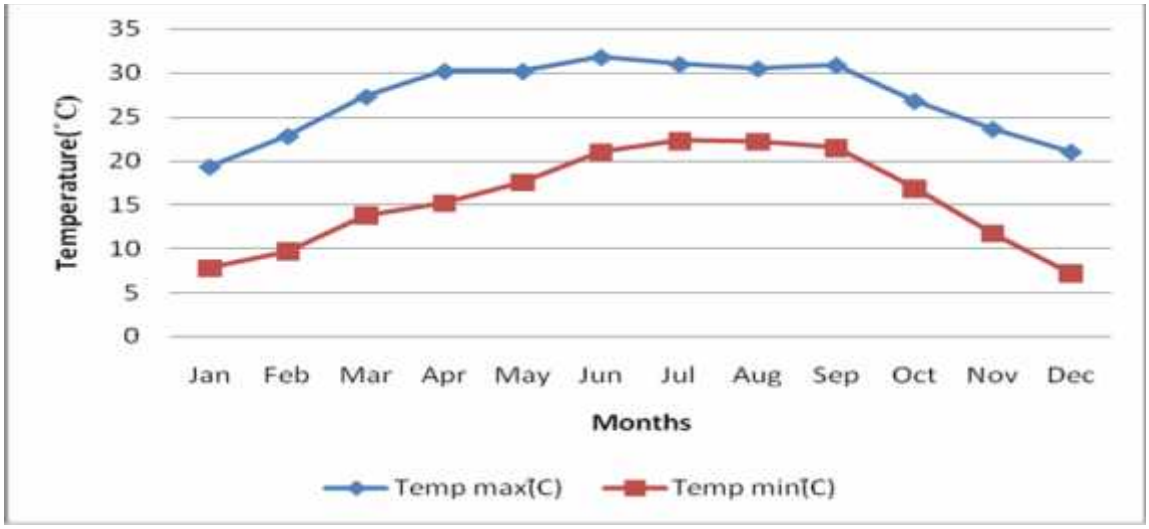


Fig. 4: Temperature recorded (max and min) of Pokhara valley in the year 2005

In the year 2004, maximum relative humidity (92.3%) recorded in the morning (8:45am) was in January and in evening (17:45 pm) was in September (79.9%). The lowest relative humidity was recorded in May (78.5% in morning) and in March (45.1% in evening) (Fig: 5 and Appendix: 3).

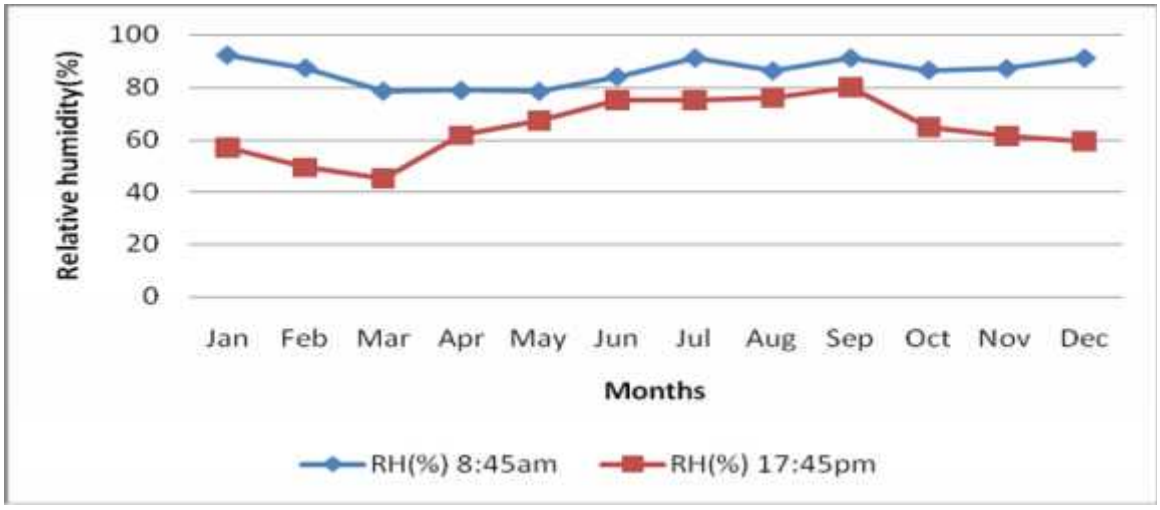


Fig.5: Relative Humidity recorded in Pokhara Valley in the year 2004

In the year 2005, highest relative humidity (92.6%) was recorded in January (8:45am) and in August (79.2%, recorded at 17:45 pm). And lowest relative humidity was recorded in April for both morning (66.8%, recorded at 8:45 am) and evening (42.2%, recorded at 17:45 pm) (Fig: 6 and Appendix: 4).

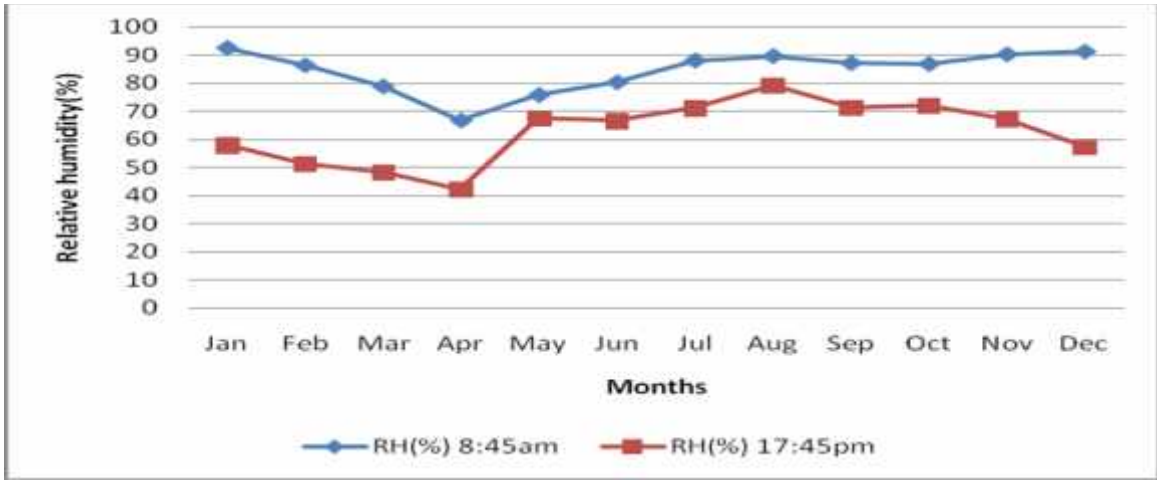


Fig. 6: Relative Humidity recorded in Pokhara Valley in the year 2005

The temperature of the water recorded in the year 2007 was highest in June (31.5°C) and the lowest temperature was recorded in January (Fig: 7 and Appendix: 10).

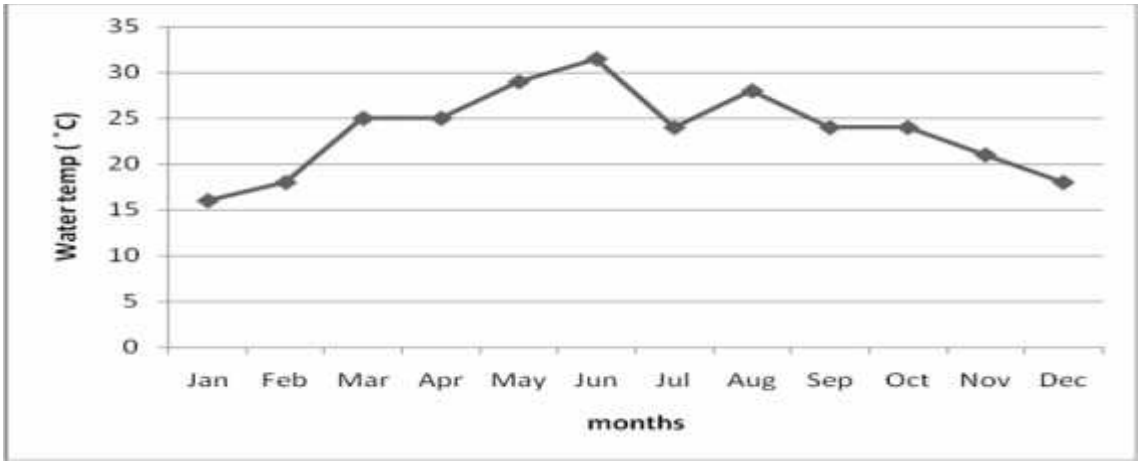


Fig. 7: Water temperature of Phewa Lake recorded during year 2007

The pH value of the water in Phewa Lake was found nearly constant throughout the year 2007. But the highest pH value was recorded in March (7.4) (Fig: 8 and Appendix: 10).

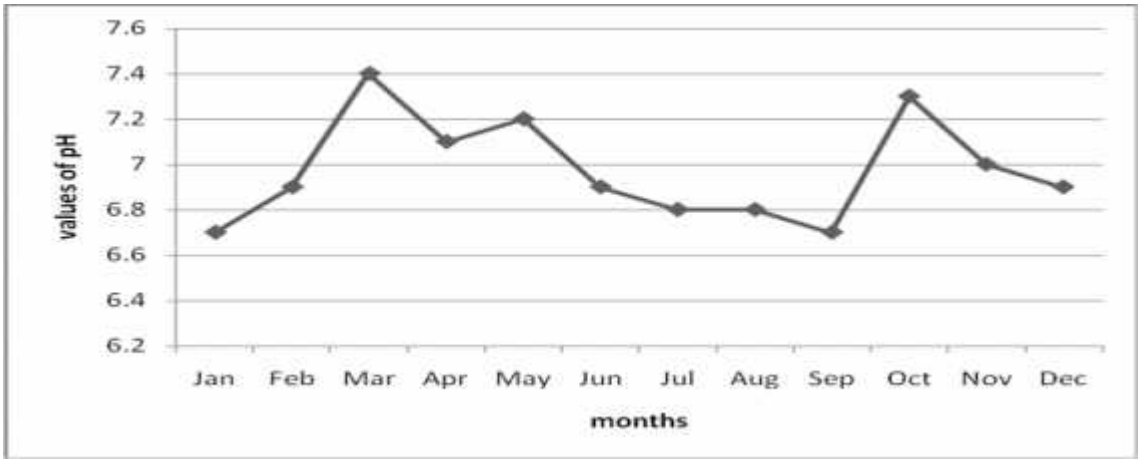


Fig. 8: pH of water in Phewa Lake recorded during year 2007

Highest amount of dissolved oxygen (DO) was recorded in October (9.9 gm/lit.) and the lowest amount of DO was recorded in January (5.7 gm/lit.) (Fig: 9 and Appendix: 10).

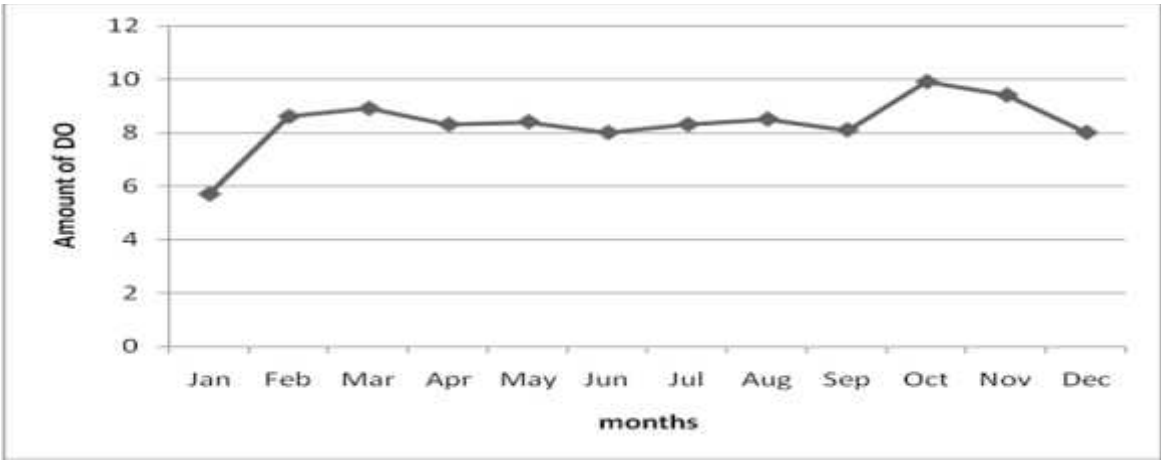


Fig. 9: Amount of DO in water of Phewa Lake recorded during year 2007

3.2 Research Procedures

A preliminary survey was done during October 30 to November 2, 2006 to become familiar with the study area and to collect general attitude of the people (local as well as visitors) about the wetland birds in Phewa Lake (Resident and migratory). For this research work in Phewa Lake, field work was carried out from June 2007 to February 2008. The total time spent in the field was 176 hours and the total working period was 155 hours, spending about 17 hours in each visit. As the study area was small the time was sufficient for the data collection. Bird counting was done by using binoculars (Shakura, 20×50 magnification) and pictures were were taken by Cannon F1 Camera with 200mm lens. For the identification of the bird species, a popular field guide,Helm Field Guides "Nepal ka Charaharu" (Grimmett *et al.*,2003; Nepali version) which was translated into Nepali by a well known Bird Specialist of Nepal, Dr. Hem Sagar Baral was used.

3.2.1 Direct Observation/Direct Count Method

Birds were counted by the direct observation i.e. direct counting method. It was considered appropriate because the study area was small and there were no any obstructions like tall grasses and other factors. According to Bibby et al. (2000b), a direct counting method is generally used if congregation is no more than 3000 birds. Weller (1999) described that birds in wetlands are best inventoried by direct count method where visibility is unobstructed, such as open water areas, mudflats and short-grass flats.

Vantage Points: Ten vantage points were chosen randomly considering that the important sites would not have been missed. First the area was divided into small grid system and small blocks were numbered, and then selected randomly each code of block representing a vantage point. In each vantage point, time of ten to fifteen minutes was spent tending towards as shorter time period as possible to avoid multiple counting of a single individual of the bird species.

3.2.2 Questionnaires

Questionnaire survey was carried out to collect the attitude of local people and some visitors in the Phewa Lake. The aim was also to collect the information about the illegal activities like unauthorized hunting of birds, collecting eggs, etc and how much they are aware about the deteriorating condition of Phewa Lake (Appendix:13).

3.2.3 Literature Collection

The secondary informations and subject related informations were collected from different sources like books, journals, booklets, reports, etc. These all were collected from the library of BCN, DNPWC, WWF, IUCN, LI-BIRD (Pokhara) and some were downloaded from the related websites. Some information was collected from annual reports of the Agricultural Research Council- Fishery Research Center Pokhara.

3.4 Data Analysis and Interpretation

3.4.1 Shannon's Index of Diversity ($\overline{H}$)

The widely used Shannon's Index of Diversity ($\overline{H}$) was used to find the diversity of wetland birds. Mathematically it can be expressed as-

$$\overline{H} = - \sum Pi \log ePi \quad \text{or} \quad \overline{H} = - \sum \frac{ni}{N} \log_e \frac{ni}{N}$$

Where, $Pi = \frac{ni}{N}$

$\overline{H}$ = Shannon's Index of Diversity

ni = Importance value for each species

N = Total of importance values

The total diversity depends upon the number of species and distributions of species or evenness component. The higher diversity occurs when number of species and evenness are large.

Relative diversity/ Index of evenness

$$(e) = J = \frac{\overline{H}}{\log eS}$$

Where, S = No. of species

$\overline{H}$ = Shannon's Index of Diversity

The diversity is higher if the value of 'e' is in between 0.6-0.9. If the value of 'e' is closer to zero, then there will be no diversity.

3.4.2 Simpson's Index of Dominance(C)

The degree to which dominance is concentrated in one, several or many species can be expressed by an appropriate index of dominance that sums each species importance in relation to the community as a whole. Simpson's Index of dominance was used to find out the seasonal as well as monthly dominance of the species. It is given as-

$$\text{Index of Dominance (C)} = \sum\left(\frac{ni}{N}\right)^2$$

Where, ni = Importance value for each species

N = Total of importance values

The value of 'C' ranges from 0 to 1. If its value is near zero, it shows high diversity in the community. The relative dominance or % species dominance can be calculated as-

$$\% \text{ species dominance} = \frac{ni}{N} \times 100$$

3.4.3 Similarity Index(S)

Index of Similarity(S) was used to find the similarity of bird communities in the different seasons. The index can be given as-

$$S = \frac{2C}{A + B}$$

Where, A= number of species in season A

B= number of species in season B

C= number of species common in both seasons

(Odum, 1996)

3.4.4 Correlation

The relationship between the population of birds and number of cattle which were found within the study area was tested by using simple correlation co-efficient. As the Cattle were abundant in the area mainly feeding ground of the birds, it was considered as disturbance factor.

3.4.5 Student's t-test

Here, student's t-test was used to test the significance of correlation co-efficient between the number of birds and cattle number to confirm whether statistically significant relationship exists between these two variables. Test statistic used is-

$$t = \frac{r\sqrt{n-2}}{\sqrt{1-r^2}}$$

This statistic is distributed as Student's t with n-2 degree of freedom.

H_o: There is no relationship of statistical significance between two variables.

H_1: There is relationship of statistical significance between two variables.

3.4.6 Analysis of variance (One way-ANOVA)

One way ANOVA test was carried out to test whether there was fluctuation in number of individuals of bird species recorded or not according to the seasons (months).

3.4.7 Chi-square (¡ ^{2}) Test

Chi-square test (¡ ^{2}) was used to test whether there was prevalence of the significant seasonality in the species richness of the waterbirds.

$$¡^2 = \sum_{i=1}^{k} \frac{(Oi - Ei)^2}{Ei}$$

Where, Oi = Observed values

Ei =Expected values

k = Number of categories

CHAPTER- 4: RESULTS

4.1 Species richness (Number of species)

During the study, a total of 39 species belonging to 17 families and 5 orders was recorded (Appendix: 1). Highest number of species (18 species) was belonged to order Ciconiformes. The order Anceriformes was represented by 12 species. Other orders Ciconiiformes, Gruiformes and Pesseriformes were represented by 3 species each.

Out of 39 species, 11 species were belonged to the family Anatidae. The family Ardeidae was represented by 7 species. Rest of the species (21) were of the families Dendrocygidae (1 species), Alcedinidae (1), Dacelonidae (1), Cerylidae (1), Rallidae (3), Scolopacidae (2), Jacanidae (1), Charadriidae (2), Glareolidae (1), Laridae (1), Podicipedidae (2), Phlacrocoracidae (1), Ciconiidae (1), Muscicapidae (1) and Passeridae (2 species). Seasonally, winter season was the most diverged season in terms of the number of species. In a total of 39 species, 35 waterbird species were recorded in winter season and 17 species in each during summer and autumn (Fig: 10).

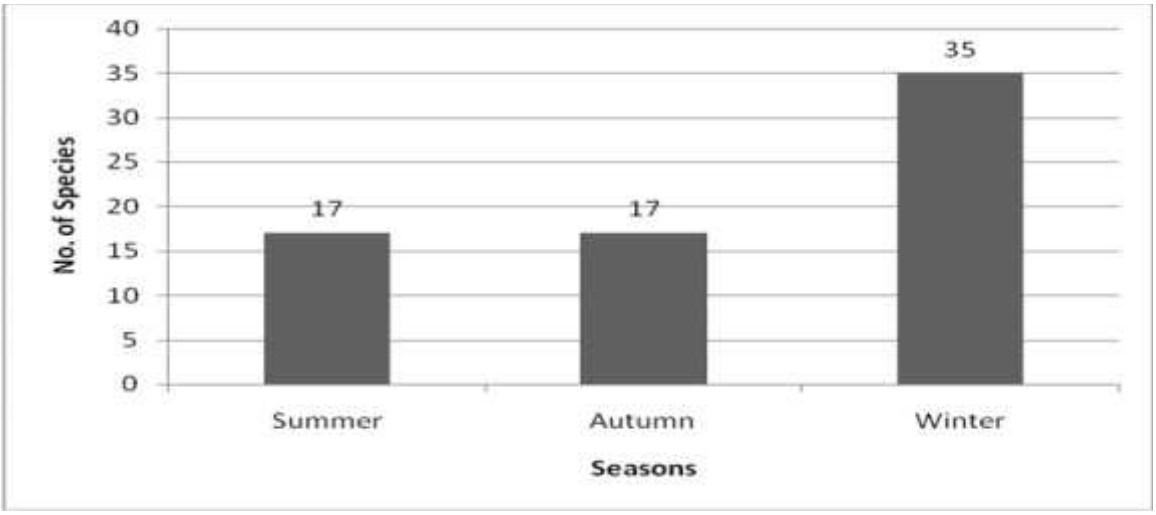


Fig.10: Number of bird species recorded in different seasons

The highest number of bird species (31) was found in the months of December and January followed by February with 21 species (Fig: 11).

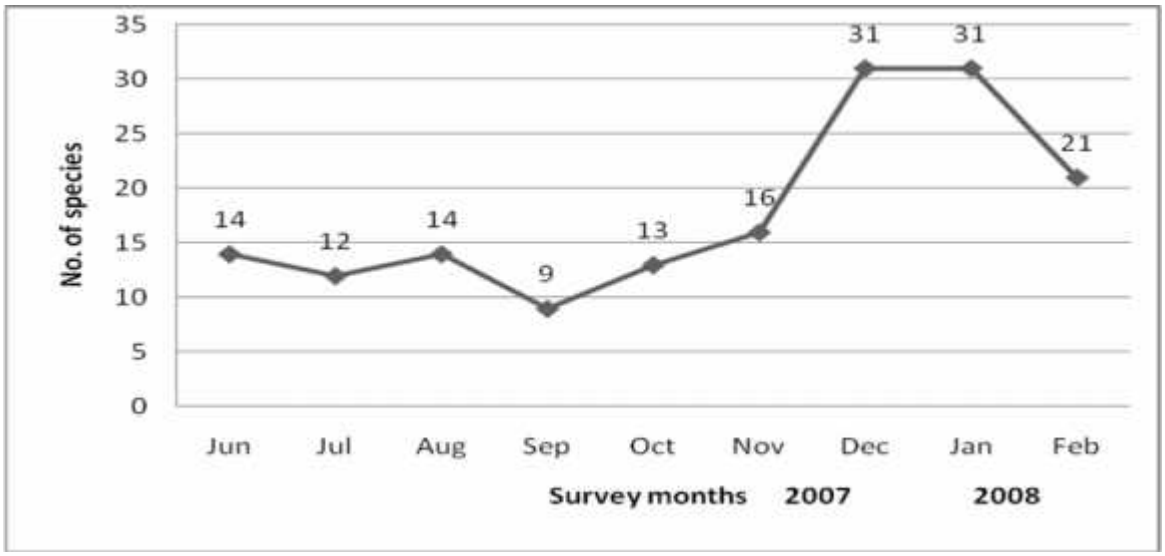


Fig.11: Numbers of Bird species recorded in different months

4.2 Population Abundance

The total number of individuals of bird species was found varied in different survey period (Appendix: 2). The highest number of the birds was found in January (1584) and second largest number was in December (1472 individuals). And the months of June, July, and February showed comparatively higher number than the months August, September, October and November. September had the less number of the water birds (345 individuals) (Fig: 12).

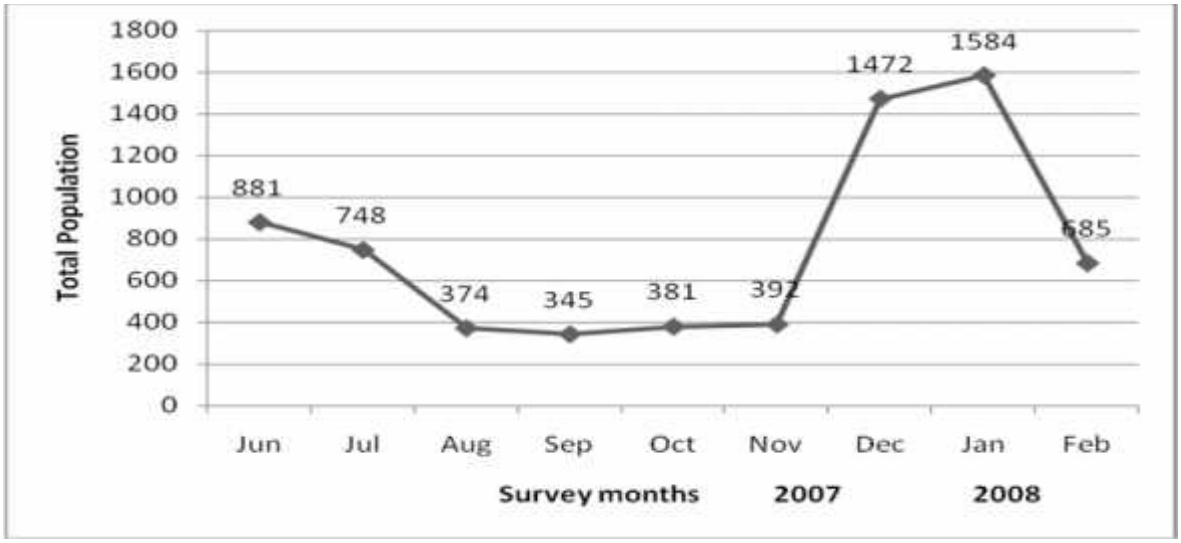


Fig.12: Total number of individuals counted in different months.

But some species had covered major portion of the total population in different periods. During the months of June, 69.92% (616 individuals) of the total population (881) was covered by Cattle Egret only and same case in the successive months till November i.e. 66.44% (497 individuals out of 748) in July, 47.06% (176 out of 374) in August, 48.41% (167 out of 345) in September, 44.88% (171 out of 381 in October and 35.46% (139 out of 392) in November. But in the months of December, January and February, Common Coot had the highest population. The species like Ruddy Shelduck, Common Teal, Common Pochard, Little Grebe and Cattle Egret had comparatively higher population (Appendix: 2).

Higher species density was found in the months of winter season (4 species per sq. km during December and January) than in summer and autumn. The month of July and September had less (1 species per sq. km) species density (Fig: 13).

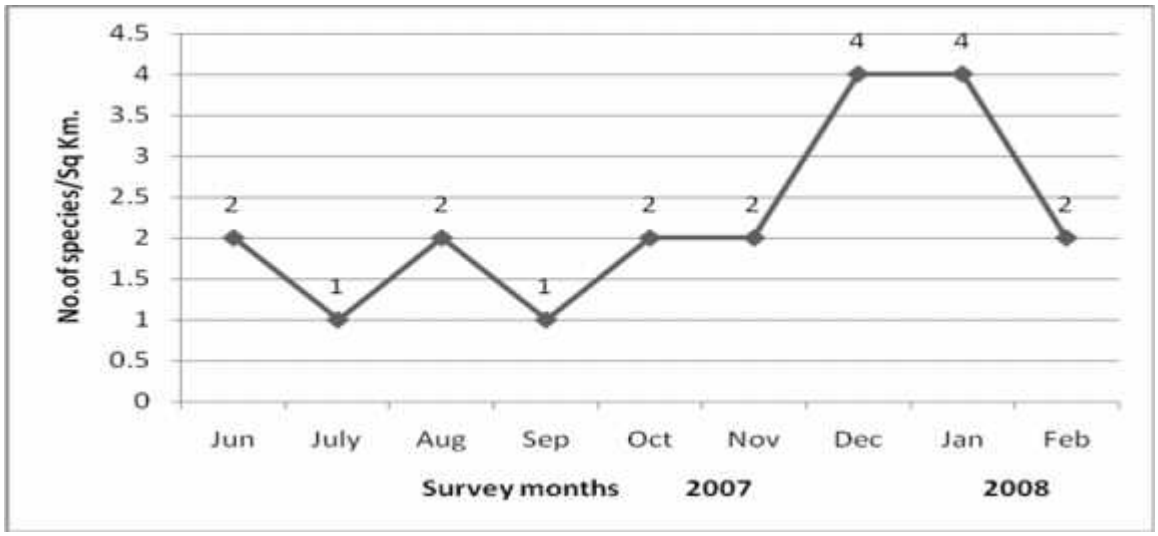


Fig.13: Number of species per square km in different months

The population density was also found to follow the same trend like the species density (Fig: 14). The months of December (173 individuals/sq. km) and January (183 individuals/sq. km) had the higher population density. September had the lowest population density (40 individuals/sq. km). August, October and November also had low population density comparatively (Fig: 14).

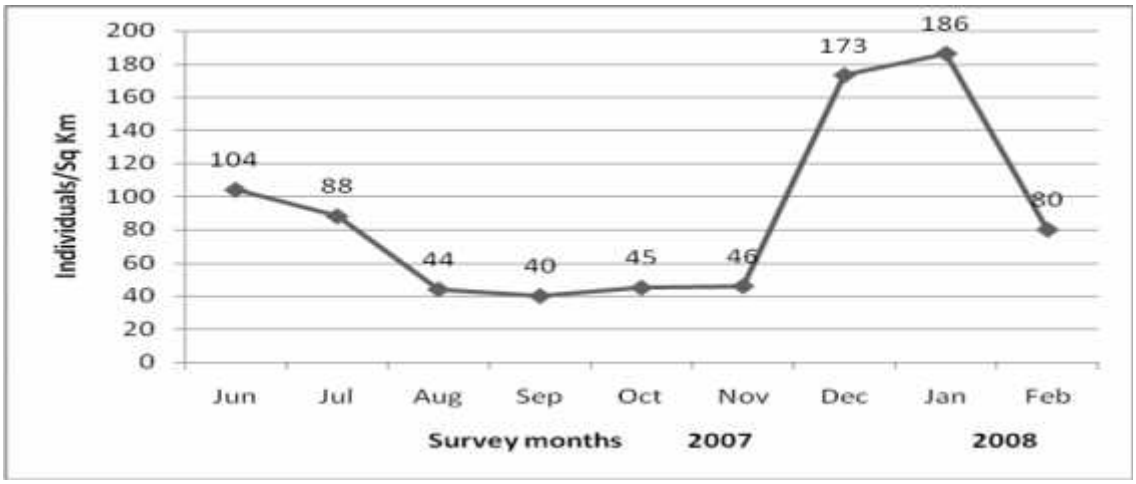


Fig.14: Density of birds in different survey months

4.3 Local Status of Wetland Birds

For the category of the birds according to abundance of individuals, field hours for the number of individuals of each species observed were recorded. Encounter rates were calculated for each species by dividing the number of birds recorded by the number of hours spent searching giving figure of birds per hour for each species (Bibby *et al*., 2000b). These were categorized in crude ordinal scales of abundance (Table: 2).

Table: 2 Categorization of birds in crude ordinal scales of abundance

Abundance category (No. of individuals per 10 field hours	Abundance Score	Ordinal Scale
<0.1	1	Rare
0.1-2.0	2	Uncommon
2.1-10.0	3	Frequent
10.1-40.0	4	Common
40.0+	5	Abundant

From the study carried out during June 2007 to February 2008, out of the 39 species recorded, 13 species were frequent, 6 species common, 17 species uncommon and 3 species were abundant (Fig:15 and Appendix: 1).

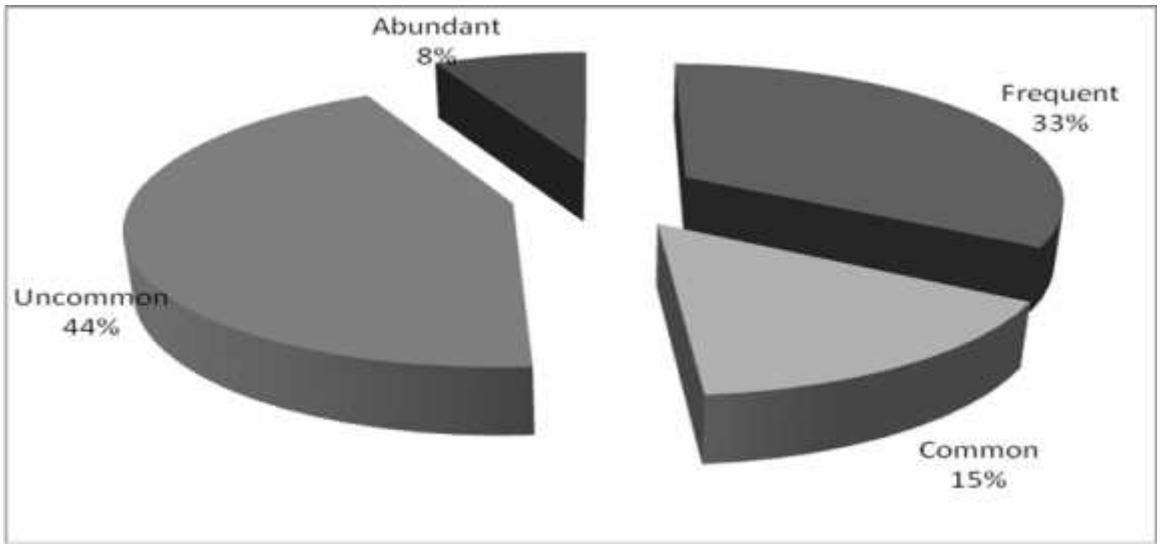


Fig.15: Status of the waterbirds according to population abundance

Likewise out of the 39 species, 10 species were resident, 15 species were winter visitors, 10 species were occasional visitor and 4 species were rare winter visitor (Fig: 16 and Appendix: 1).

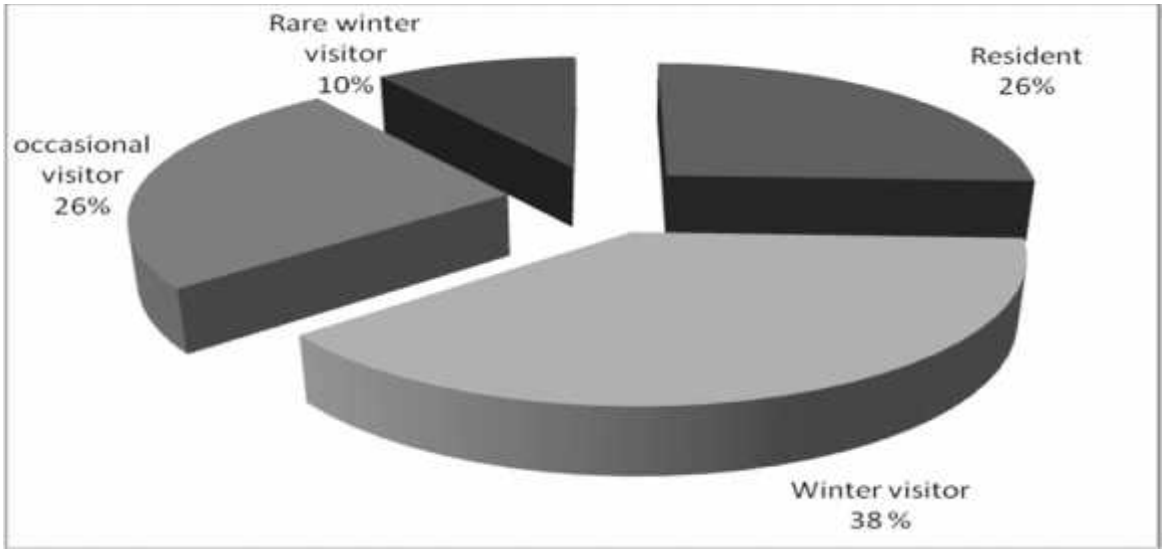


Fig.16: Status of the waterbirds according to time spent in the study area

4.4 Diversity of Wetland Birds

The value of Shannon's index of diversity was found highest ($\overline{H}$ = 2.6228) in February and lowest ($\overline{H}$ = 1.2014) in June (Fig: 17 and Appendix: 5). The value of diversity index

gradually increased with the increment of number species. The value of evenness (Jacob's coefficient) (Fig: 18 and Appendix: 5) also followed the same rule i.e. highest value (0.8485) in February and lowest (0.4555) in June. The value of Simpson's index of dominance was highest in June (C = 0.5058) and lowest in February (C = 0.1020) (Fig: 19). Here, the value of Shannon's index of diversity and evenness were higher when the value of Simpson's index of dominance was lower and vice-versa (Appendix: 5).

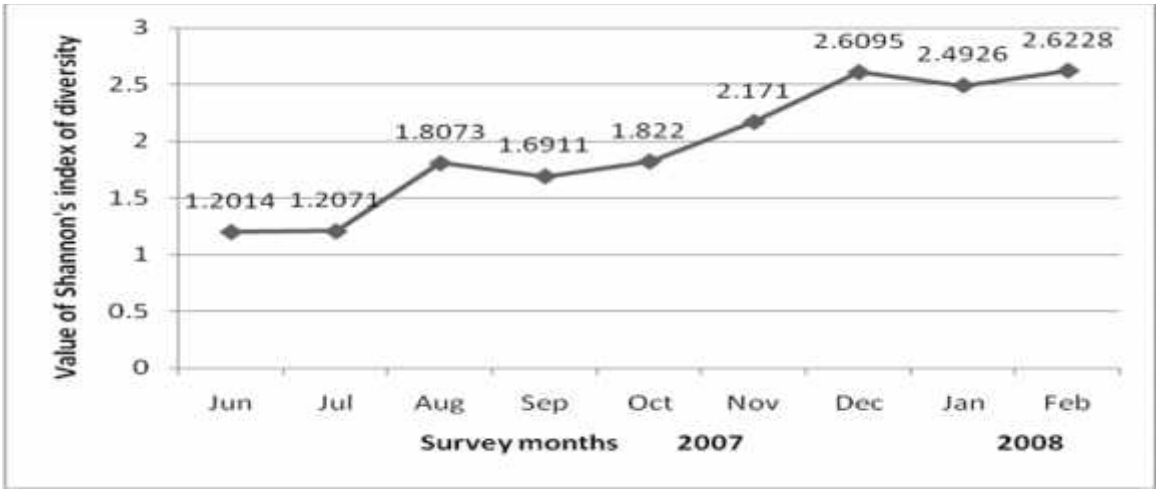


Fig.17: Values of Shannon's index of diversity in different survey periods

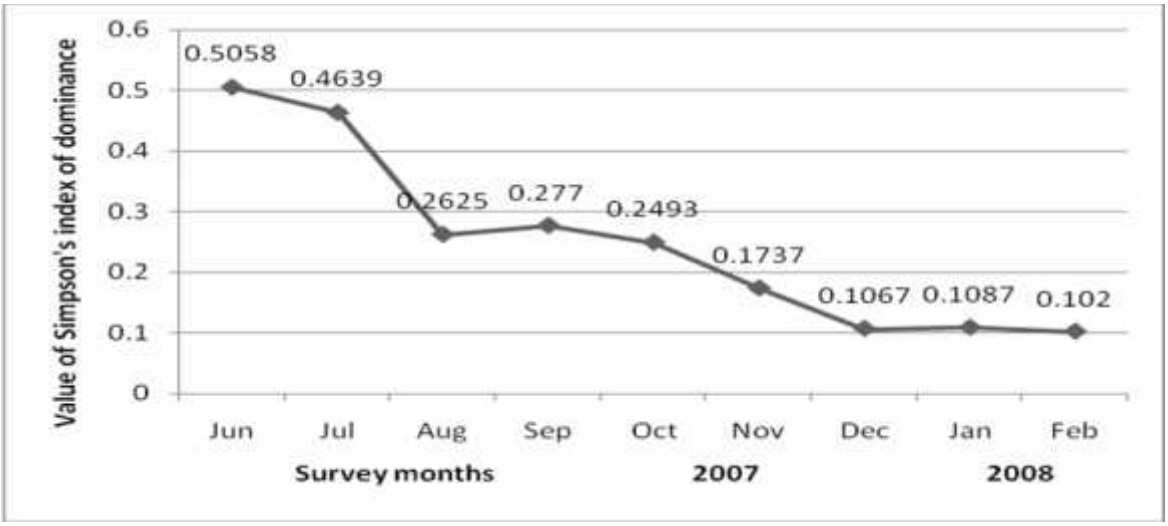


Fig. 18: Values of evenness (Jacob's coefficient) in different survey periods

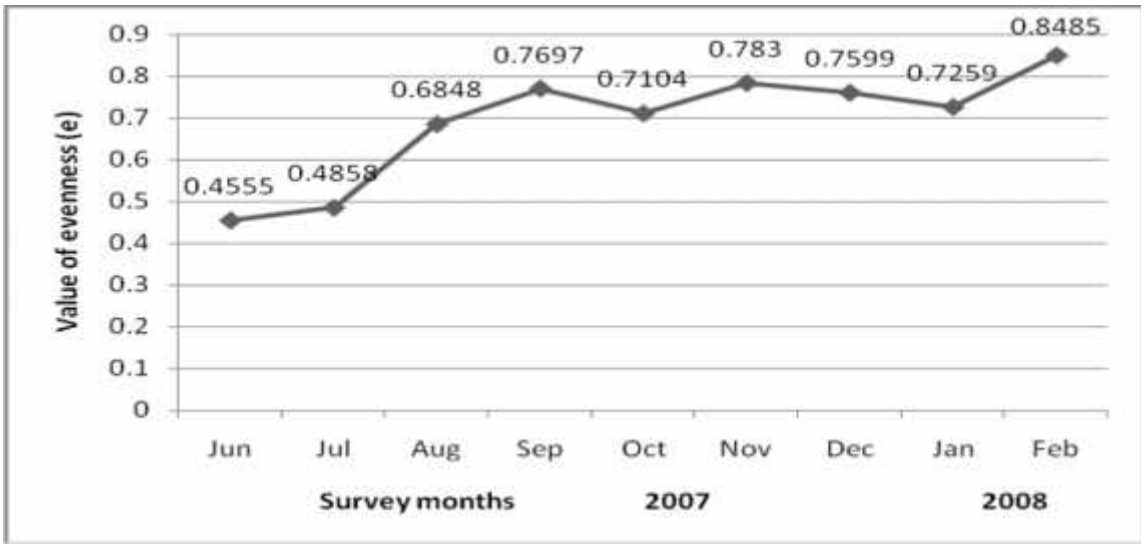


Fig.19: Values of Simpson's index of dominance in different survey months

4.5 Correlation between number of Birds and number of Cattle

The cattle were considered as disturbance factor, so that relationship between numbers of cattle and total number of birds in different survey periods was tested by simple correlation (Table: 3). The value of correlation coefficient (+ 0.3636) showed positive correlation between number of cattle and birds. The value of correlation coefficient was found very close to zero.

Table: 3 No. of cattle and total bird population recorded during different survey periods

	Jun	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb
Cattle	7	12	9	21	20	66	301	394	176
Birds	881	748	374	345	381	392	1472	1584	685

4.6 Test of significance of correlation coefficient

The calculated value of t (1.1086) was found less than the table value of t (t = 6) at 5% level of significance and df 7. The null hypothesis (Ho: There was no relationship of statistical significance between two variables) was accepted.

4.7 Community Similarity

The value of Similarity index (S) was higher (0.7059) between the summer and autumn and lower between summer and winter seasons (S = 0.5000) (Table: 4). The similarity of summer bird community (S = 0.5000) was found lower than the autumn season (S = 0.6154) with winter season. The value of similarity index of bird communities between the months of a particular season was found higher than the months belonging to different seasons (Appendix: 6).

Table: 4 Values of similarity index of bird communities between different seasons

Between months	Similarity index value(S)	% similarity
Summer/Autumn	0.7059	70.5882
Summer/Winter	0.5000	50.0000
Autumn/Winter	0.6154	61.5385

4.8 Seasonality in number of individuals of bird species

The calculated value of F (F = 1.7120) was less than the table value of F (F = 1.94), at 5% level of significance at df 8,342. The null hypothesis was accepted i.e. the number of individuals of the bird species were not affected by seasons (months).

4.9 Seasonality in Species richness

The calculated value of Chi-square (¡ ^{2} = 29.34) at 5% level of significance and 8 df was higher than tabulated value (¡ ^{2} = 15.5). The null hypothesis was rejected i.e. prevalence of seasonality in the species richness.

4.10. Major Conservation Threats for Waterbirds and Phewa Lake

Solid Waste

Solid waste problem was found to be one of the causes of pollution in Phewa Lake. Bottles, glasses, cans, plastics, etc were the main solid waste materials. If this problem went on increasing the lake may become a dumping site. Such unnatural dumping may greatly affect the tourism. It was found associate with uncontrolled human flow and lacking of certain rules and regulations implementation for short term visitors.

Thriving of Water hyacinth

An invasive weed Water hyacinth *Eichhornia crassipes* was found as an increasing problem. During rainy season, it was found to cover large area of the lake giving a greenish look to the lake. It is being removed generally twice a year by the involvements of locals, social organizations, tourism related organization, Phewa conservation committee and volunteers. This species may become a major conservation problem in the future. The removal of the weed was unmanaged because the removed weeds were dumped in the shore areas of the lake. This might have been being a problem for birds because birds like Bronze Winged jacana, Egrets, Common Moorhens, Indian Pond Heron, etc. were found to use shore areas for foraging and hiding. The nutrients can again go to the water body after decaying the dump.

Agricultural Seepage

The dense mat of Water hyacinth was recorded throughout the study period in the close proximity to the agricultural lands. High nutritional load through the agricultural seepage probably is the major cause of thriving of the water hyacinth in the water body of the Phewa Lake.

Hunting of Birds and Collecting Eggs

Hunting of birds and collecting of eggs by the children was found as a major problem in the Phewa Lake. Common coot was found as one of the major victims of this problem (witnessed during survey period personally). From the questionnaire survey, it was found

that mainly school children are involved in collecting eggs. And these eggs are neither used for selling nor eaten but destroyed by them in curiosity. The wintering ducks are also being killed annually.

Tourism and tourist activities

Human flow to the Phewa Lake was found increasing during recent years. Paragliding and boating were found unmanaged. Landing of glider very near to the shore area during winter season and rush of boating in the wintering bird area were found as driving factor for birds from place to place. Gliding was found as a cause of gathering of children near the shore area of the lake also. These were mainly found disturbing factor for feeding of the wintering birds.

Siltation and Sedimentation

Lots of river edge cuttings and landslides were recorded during monsoon season in the surrounding landscapes. Lake Phewa becomes the collecting site of all the eroded soils and other waste materials. So siltation and sedimentation was found as cause of the size decrease (it was found from the information of officials of Fishery Research Center, other organization and people living there for many decades that the size of the lake was about 20,000 ropanies (approx. 1000 ha) previously 30-40 years back now becoming the size approximately 12000 ropanies).

Domestic sewage and Drainages

Sewage disposal and diversion of drains toward the lake were causing pollution and increment of nutrition in the lake. These activities were found to associate with over human load due to uncontrolled urbanization and unmanaged tourism. Though these activities are prohibited, the problems arose due to less effective implementation of the rules and regulations.

Grazing of Cattle

Cattle were always found concentrated toward the shore area and marshes around the lake. Very large numbers of cattle were found to graze during the winter months when

most migratory birds arrive there (Photo Plate: 3 D). This is damaging the hiding places, eggs, young birds, etc.

Infrastructure Expansion

Many hotels and large buildings are being constructed in the close proximity of lake. The road has been constructed along the northern shore of the lake to connect surrounding villages with Pokhara city. Due to the easy access, there is increasing urbanization. This is bitter fact that human related problems are going to become more severe in the future if effective managements are not implemented. The natural areas are being disturbed with the increment of construction of infrastructure and human settlements which ultimately is causing pollution in the water bird habitat.

CHAPTER-5: DISCUSSION

5.1 Population and Diversity

Lake Phewa is one of the popular fresh water wetlands of Nepal. It is in the grip of huge human pressure. It is suffering from poor environmental conditions though the lake is still supporting a good diversity of waterbirds. During the present study, a total of 39 species were recorded (Photo plate: 1 most common birds around Phewa Lake). Comparatively large numbers of Cattle Egret were found to breed in lake area. In total, 42 nests (5 with two nestlings in each) and 430 individuals of the Cattle Egret were recorded in bamboo groove near Barahi Boat Station. 17 Intermediate Egrets and 8 Little Egrets were also recorded from the same nesting site. During the present study there was no species which were spending summer in the Phewa Lake. But Gautam and Kafle (2007) had mentioned two species, Cotton Pigmy-goose (*Nettapus coromandelianus*) and Garganey (*Anas querquedula*) as summer visitors. This loss probably was due to deteriorating environmental condition of the Phewa Lake and increasing disturbances.

Gautam and Kafle (2007) had presented records of water bird species combining two survey results conducted by the first and second authors independently in August 2003 to July 2004 and 1-5 January 2004 respectively. They recorded a total of 43 species of water birds belonging to 14 families. The eight species such as Bear's Pochard (*Aythya baeri*), Bar-headed Goose (*Anser indicus*), Comb Duck (*Sarkidiornis melanotos*), Common Golden-eye (*Bucephala clangula*), Common Shelduck (*Tadorna tadorna*), Cotton Pygmy-goose (*Nettapus coromandelians*), Falcated Duck (*Anas flacata*) and Gargancy (*Anas querquedula*) of the family Anatidae were not recorded during this study period. Other six species which were not recorded by Gautam and Kafle (2007) were Darter (*Anhinga melanogaster*), Little Cormorant (*Phalacrocorax niger*), Purple Suamphen (*Porphyrio porphyrio*), White-browed Wagtail (*Motacilla maderaspatensis*), Greater Painted Snipe (*Rostratula benghalensis*) and Marsh Sandpiper (*Trianga stagnatilis*). Nine species such as Lesser Whistling Duck (*Dendrocygna javanica*), Common Snipe (*Gallingo gallingo*), Small Pratincole (*Glareola lacteo*), Black-headed Gull (*Larus ridibundus*), Little Heron (*Butorides striatus*), Black-crowned Night Heron (*Nycticorax*

nycticorax), Wooly-necked Stork (*Ciconia episcopus*), Plumbeous Water Redstart (*Rhyacornis fuliginosus*) and Grey Wagtail (*Motacilla cinerea*) were the additional records during present study which were not recorded in the study by Gautam and Kafle (2007). Comparing these two results in the Phewa Lake, it indicates that the habitat is becoming unfavorable to the water birds. Improving the habitat conditions may increase the water birds diversity as shown in earlier surveys by Gautam and Kafle. The species like Bronze Winged Jacana (*Metopidius indicus*) and Little Ringed Plover (*Charadrius dubius*) were recorded as occasional visitor but these were resident in the past (Gautam and Kafle, 2007). This situation probably was because of the prevalence of overgrazing along the shore area which provides feeding as well as hiding site for them.

Avifauna are very active during the morning and evening with little activities during the rest of the day there by giving highest opportunity for maximum capturing of the bird species and total individuals (Robbins, 1981; Lay, 1938). Thus the survey was mainly focused on the dawn and dusk. According to Robbins (1981) and Lay (1938), the activity and song output are greatest near dawn, low during the middle of the day, and increase again close to dusk. But it might not be valid to consider this timing of day equally to all the bird species (Dahal, 2006), because species like Black-crowned Night Heron, Black Bittern (*Dupetor flavicollis*) and Cinnamon Bittern (*Ixobrychus cinnamomeus*) were hardly recorded in morning during his study. This may be because, they feed mostly nocturnally and crepuscularly (Zeiner *et al*. 1990: cited in Dahal, 2006) although they sometimes also feed diurnally (Terres, 1980). Black-crowned Night Heron (7 individuals) recorded in resting stage during morning (in January). Gautam and Kafle (2007) had recorded some globally threatened species like Comb Duck *Sarkidiornis melanotos* (Critically Endangered), Bear's Pochard *Aythya baeri* (Vulnerable) and Ferruginous Duck *Athya nyroca* (Near-threatened) (Birdlife International, 2002). But during the present study, only Ferruginous Duck (Pochard) was recorded in December (5 individuals) and January (7 individuals). The Ferruginous Duck is a little studied, partial migrant, widely distributed in Europe, Asia and Africa. During the first quarter of this century, it was described as one of the most plentiful Antidae species over a great part of

its range. Since then, it has undergone a large, long-term decline globally (Robinson and Hughes, 2003).

Accurate censuring of wetlandbirds requires a variety of techniques, including nocturnal surveys, nest counts, intensive effects involving or canoeing through marshes, and the use of recorded calls to elicit responses (Weller, 1986: Cited in Dahal, 2006). As only direct count method was used in the study, probably, some species which were in less number as common Snipe, were not recorded. The number of bird species increased when the winter started. The highest numbers of species were found in December and January. The population also increased with the onset of winter. During the months of June and July, Cattle Egret covered 70% and 66% of the total population respectively. It was because the Phewa Lake was used as breeding site by large numbers of Cattle Egret. It is still dominating species in the months of August to November though the number was very low compared to June and July. This decrease in number probably was due to migration of Cattle Egret for other better habitat because the Phewa area could not support that much population. Due to the migration of comparatively larger number during the months of December, January and February, species like Common Coot, Common Teal and Common Pochard had large populations (Appendix: 1).

The values of index of diversity were higher in winter months. Likewise value of evenness also followed the same trend. But the value of index of Dominance was higher in the months other than months of winter season and lesser in June and July. This result shows that diversity and dominancy has inverse relation. The June and July months showed lesser values of index of dominance, because Cattle Egret had significant dominant position in these months. The winter months showed less similarity in community composition with other months. This dissimilarity probably was due to higher movement of birds in this area in winter season. The higher diversity and population of birds in the winter was probably because of the high mobility of birds during this season. Waterfowl tend to be highly mobile in winter, moving to other areas in response to factors such as cold weather and changes in water levels and in food resources (Kershaw and Cranswick, 2003). In comparison to the population of resident and other birds, Phewa

Lake was found supporting large population of wintering birds. Here wintering started from November reaching arrival of birds highest in January and started decreasing bird species and population from February.

All the habitats studied must have their own significance in the biological sciences. Subedi (2006) studied wetland avifauna in Rupa Lake of Pokhara valley and recorded 30 species of wetland birds including 4 associated or partially wetland dependent birds of 16 families belonging to 5 orders. Of them, 16 species were resident, 12 species winter visitor, one species summer visitor and one vagrant.

Shah (2000) studied the bird diversity in and around the Taudaha lake of Kathmandu and recorded 55 species of birds belonging to 23 families, of which 23 species were water birds. Among them, winter migratory, summer migratory and residential were 22, 11 and 22 species respectively. She also focused on the importance of Taudaha Lake for migratory bird species. Basnet (2001) studied the status and diversity of avian fauna in Siwalik of Morang and recorded 114 bird species belonging to 13 orders and 40 families. Among the total bird species, 86 (75.4%) were resident, 22 (19.3%) winter visitors, 3 (2.63%) summer visitors, 2 (1.75%) local migratory and 1 species uncertain in status.

Chalise (1998) recorded 75 species of birds in Ghodaghodi Tal most of them were winter migratory wetland birds and also residential. Since it was observed in winter season, the species like Common Moorhen (*Gallinula chhoropus*), Purple Swamphen (*Porphyrio porphyrio*) were recorded in highest number. Others were migratory bird species like Gadwall (*Anas strepera*), Common Coot (*Fulica atra*), Common Teal (*Dendrolygna javania*), Common Pochard (*Aythya ferina*), etc. Similar types of species were the major species in the Phewa Lake as winter visitors suggesting this wetland is important for water birds.

Baral and Buckton (1997) studied the distribution and ecology of river birds in the Langtang National Park in 1995 and 1996. They recorded altogether 12 bird species, of which 10 were passerine. Of the 10 Passerine river bird species, 7 were typical of mid-

high altitude streams, 2 were found in low altitude and only 1 found at the highest altitude in the spring and at low altitude in winter. They suggested that Himalayan waterbirds can serve as biological indicators.

In the context of being mid hill and high altitude regions less studied in Nepal, Karki, Shrestha and Khanal (2003) studied the faunal diversity and conservation issues at Badimalika region (Achham, Bajura and Kalikot districts) of Western Nepal. They recorded 114 species of bird and suggested that the Badimalika and Rama-Roshan areas have high potential for biodiversity conservation and creating conservation area or national park in the upper reaches and buffer zone area around it to conserve biodiversity of that area. Subedi (2003) studied the mid-winter waterfowl diversity in Pokhara valley and total of 20 species of waterfowls belonging to 9 families were recorded during the two-year waterfowl survey. Suwal (2003) surveyed the Upper Mustang area and suggested that the Kaligandaki River is one of the most important migratory corriders for the aquatic birds visiting Nepal. Danga (2006) studied in Mahakali Watershed area near Darchula where he recorded 80 bird species belonging to 13 orders and 32 families. Such studies concentrated in hilly and high altitudinal regions will probably be very useful to find the important area for biodiversity of unique compositions and find relationship of low land-high land migration and resting sites.

Studies of Subedi (2003), Gautam and Kafle (2007), Subedi (2006) and the present study show that the improvement of the wetland habitat in Phewa Lake will certainly help to establish whole valley as a mid-hilly region's important area for ornithology and other species diversity. Sharma (2004) studied the diversity of threatened birds and their conservation threats in Barandabhar corridor forest (BCF), Chitwan and recorded 160 bird species in BCF. 12 of them were nationally threatened. The species diversity index was highest in April (0.779). The bird diversity and size of population was found relatively larger in buffer zone. The major conservation threat to bird conservation was considered from Padampur settlement. Malla (2006) in Nagarjun Forest recorded a total of 117 bird species belonging to 12 orders and 37 families. Seventy seven (65. 81%) species of the birds were of the order Passeriformes along with 22 families. 76 species

(64.95%) were resident, 18 species (15.38%) were winter visitors and 19 species (16.23%) were summer visitor. He has mentioned that because of lacking of wetland habitat very few wetland dependent birds were found. Basnet (2006) recorded 161 species belonging to 11 orders and 36 families, in Godawari and its adjacent regions. Paudel (2005) recorded 73 bird species belonging to 13 orders and 30 families in the study in Kirtipur. Of the total, 27% of the recorded birds were found associated with water. He recorded direct evidences of human disturbances to birds in Taudaha which were encroachment of pond, remaining of feathers and body parts of Pintail in two places, washing clothes, introduction of domestic sewage on pond.

In a study conducted by Rai (2003) in Beeshazari Tal, wetland listed on Ramsar Site, and on its suburbs, Chitwan recorded 270 species of birds representing 61 families. Among them, 60 wetland species were found. With comparison to this result, the Phewa Lake also shows the possibility of becoming important area for birds at least of national level. Likewise Shah (2000) and Paudel (2005) had focused on the importance of Taudaha, a middle hill wetland, for the migratory bird species.

Thakuri, (2007), in Satikhel Community Forest and Dallu Community Forest in Seshanarayan VDC, recorded 118 species of birds belonging to 10 orders and 29 families. Of them, 85 species were resident, 16 species summer migratory, 16 species winter migratory and one was of unknown status. Reissen (2007) discussed about the need of comprehensive study of the birds in his through study in Saibu, Bagmati and Taudaha area. He mentioned that this comprehensive study was necessary for the contribution to the study of birds for Kathmandu valley and the rest of the country. The study was done in the period between 18 December 2003 and 11 June 2006 during 75 trips of between four and five hours. The two years bird inventory has found a total of 194 different species, of which 39 were residents, 22 passage migrants, 24 summer visitors, 16 stragglers from other parts of Nepal, while 87 were winter visitors

5.2 Threats and Conservation:

Birds are suffering at the hands of human in different ways. They hunt them, take their eggs and graze domestic animals or introduce exotic predators into their habitats. Habitat alteration, destruction or loss is the major threat to survival of birds (Baral *et al*., 1996).

Habitat loss is major threat to 89% of nationally threatened birds of Nepal (Baral *et al*., 1996). Birds, like all other animals, are dependent for food and shelter on the kinds of environment to which each species is adapted by evolution. Most birds have little tolerance to environmental change. Today, powers of modern technology, massive change to environments are being made in less than a decade. Millions of hectares of wetlands are being drained; major rivers are being diverted or dammed and polluted and the tropical forests are being felled or burnt for construction of highways, airports and cities almost at an incredible rate. As human numbers and power of technology expand, the changes of survival for wildlife diminish. The root cause of loss and damage to habitats are complex, interlinked and often controversial. Most of Nepal's environmental problems have been attributed to poverty and a rapidly growing population, but other factors, including national dept, insecurity of land tenure, and tourism are also important (Dahal, 2006).

According to Baral *et al*. (1996), tourism is a major industry and source of foreign exchange in Nepal, and the number of tourists coming to Nepal will rise day by day. There are indications that tourism based industries may cause some damage of wildlife if not planned carefully. New lodges are built almost every year in several trekking areas. This involves clearing patches of dense forests and subsequently leads to forest thinning and degradation. As a consequence bird species, which are sensitive to even small changes in the ecosystem, decline because of their specific habitat requirements (Baral *et al*., 1996). Adequate knowledge is necessary while running such industries to minimize the impact of tourism on birds and other wildlife. These days, tourism also has become one of the major problems to the bird species in Phewa Lake because of the high flow of tourists for recreational activities (both internal as well as external tourists). The wintering birds were found highly affected because of the tourist activity like paragliding.

The paraglide was found to land near the shore area of the lakes and on the paddy field vacant after harvesting of rice. Birds were found to driven here and there when glider come near to the lake while landing. This was also causing large human mass gathering near the shore areas so that it is also becoming a problem.

Wetlands comprise some of the most valuable and important natural environments for living creatures, including man. And yet, like tropical forests, they are one of the most threatened habitats in the world, under pressure from human activities and development (Sonobe and Usui, 1993). The wetlands are fast disappearing ecosystems of Nepal. The wetland habitats in Nepal face various problems from siltation, eutrophication, vegetation succession, encroachment, agricultural conversion, urbanization, pollution, fish poisoning and infrastructure development. These problems are creating threats to water birds of Nepal. Study on wetland birds from 1989 to 1999 has shown to decline some wetland birds such as Lesser Whistling Duck (*Dendrocygna javanica*), Oriental Darter (*Anhinga melanogaster*), Ruddy Shelduck (*Tadona ferruginea*), Great Cormorant (*Phalacrocorax carbo*) and Storks (Baral, 1999).

Wetlands in the Pokhara Valley which are unprotected are even more at risk: from drainage, diversion, obstruction, siltation, encroachment, infrastructure development, land use changes, pollution and poison to kill fish (Karki *et al*., 1997; Karki and Thapa, 1999; Subedi, 2003) resulting in a marked reduction in bird numbers and species diversity since 1970 (Gautam and Kafle, 2007). The survival of waterbirds cannot be viewed in isolation. The diversity of waterbirds reflects the many ways of life possible for birds in wetlands. Waterbirds exploit a range of different parts of a wetland, or microhabitats. Each of these microhabitats can support a variety of different food types: from fish, crustacean and mud-dwelling invertebrates, to water plants and tiny plankton (Sonobe and Usui, 1993).

Nepal’s wetland birds are declining due to wetland habitat degradation. Wetland habitats are under tremendous pressure due to coverage of invasive weeds and human induced disturbances which causes temporal and spatial displacement of migratory and wintering

waterfowl. The effect of excessive coverage of invasive weeds and human activities on wetland bird community is little known from the Nepalese wetland landscape (Dahal, 2006). Anthropogenic disturbance have been detrimental to birds if causes the birds to stop feeding and seek for the alternative habitat (Marsden, 1997: cited in Dahal, 2006). He found that in 76% of his obstructions, birds stopped feeding due to disturbances and started feeding again within 10 minutes. However high levels of disturbances may affect the number of bird using a site on subsequent days and can seriously affect local habitat quality (Burton *et al*., 2002).

The Phewa Lake area is almost surrounded by human settlements and there is a huge agricultural field in its north-western catchment. This area is visited by lots of local people for the purpose of working in field, collecting grasses and cattle are freed to graze. Many people pass through this area for their daily needs including marketing. The large number of local people was found to use water body as path by their private boats to go to visit the Pokhara city. This movement of the people was found high during dusk and dawn which is also the time of birds' higher activities. Mostly, the people were found to use north-western portion of lake to go across the city by boats. The people involved in fish farming were found to visit every corners of the lake while collecting Hydrilla plant for Grass Carp fish. Though, to some extent it is helping to clean lake, this activity was also found to affect waterbirds sometime. Most of the people who visit lake were found to visit north-western portion of Phewa Lake and tourists were also found to go these site for resting in boat. One very important fact is that almost all of the wintering birds were found concentrated in this area. Sometimes, the birds were recorded to fly here and there throughout the day because of human flow in this area. Such disturbance can be very detrimental to the wintering birds. On some previous studies, Baral (1998), Sah (1997), Dahal (2000, 2001, 2006), also found that the activities associated with hunting, fuel wood collection and fishing reduced to feeding time for birds and compelled them to displace from particular habitats.

Hunting is contributing to the decline of some species, including the globally threatened Greater Adjutant *Leptoptilos dubius*, Lesser Adjutant *L. javanicus*, Sarus Crane *Grus*

antigone, Spot-billed Pelicon *Pelicanus philippensis*, and Cheer Pheasant *Catreus wallichii*. Illegal bird trading goes on near Koshi Barrage all the year round (Inskipp, 1989). Hunting of the birds and collection of eggs were also major problems. During questionnaire survey, it was found that school children are involved in collecting eggs and damage them. It was also found that Coots and Ducks are mostly hunted. One event of killing of Common Coot was recorded during field study (Photo Plate: 2, E and F). Gautam and Kafle (2007) had also mentioned about the hunting of the birds and they had recorded remains of the killed birds. During the present study, mainly teenagers were found involved in this illegal killing of birds. It was found that this activity can be seriously intensive because of the demand of local people for the birds (Personally recorded: just after killing of coot, the boys were requested for killing another one). If these youngsters became deviated towards money making from killing birds, it will reduce their number. Common Coots were found less stressed from the human movements and other disturbing factors resulting their killing.

During migration and winter, the greatest concentrations of waterfowl occur on large relatively undisturbed wetlands which provide suitable feeding and roosting opportunity. However, wetlands are under pressure, not only from physical development and pollution, but also from increasing recreational use (Madsen, 1998). The impact of disturbance on populations of birds depends upon the availability of alternative habitats (Burton *et al*., 2002). In the case of Phewa Lake, there was hardly recorded any undisturbed part that could be alternative site for winter visitors. So, if such situation remains increasing, it will not take longer time to evacuate wintering population from Phewa Lake.

Presently, the lake is facing severe environmental problems as a result of nutrient loading from agriculture, landslides and rapid urbanization in the surrounding area. Sewage from the surrounding settlement is directed into the lake (Lamichhane, 2000), and the volume continues to rise dramatically in response to increased tourism (Oli, 1997). The recent trend is toward rapid eutrophicarion (Oli, 1997; Lamichhane, 2000; Rai, 2000). The lake is now infested with a floating macrophyte, the water hyacinth *Eichhornia crassipes* and

blue green algae indicating enriched nutrient loading into the lake (NARC-FRCP, 2004/05).

The researchers like Gopal (1987), Madson (1997), Grodowitz (1998) found that Water hyacinth plants have a tremendous growth and reproductive rate and the free-floating mats cause great problems for wetland biodiversity. The substantial coverage of Water hyacinth can lead low dissolved oxygen levels which might influence the community dynamics of the benthic community (Gopal, 1987) and ultimately to bird species that are dependent on insects and fish (Schmitz *et al*., 1997: cited in Dahal, 2006). The widespread distribution of invasive weeds has a significant role to decline the number of bird species and total individuals through reduction of the potential foraging ground for water birds (Dahal, 2006). Bird distributions within water bodies are often related to prey densities. The substantial coverage of invasive weeds greatly reduces the invertebrate community due to the reduction of dissolved oxygen concentration (Masfiwa *et al*., 2001). The oxygen concentration regulates the invertebrate distribution since these birds largely feed on a wide range of the invertebrate community and small fishes.

Now Water hyacinth has become a major problem for beauty and healthy environment in Phewa Lake. Since last few years, it is being removed by the involvement of locals, security forces, members of Phewa Conservation Committee and volunteers. The dense mat of this invasive weed recorded mostly near the agricultural lands indicates that this problem probably will be increased in the following years if using of chemical fertilizers are increased in agriculture in the field near the lake. Beside agricultural seepage, other factors like sewage disposal, drainage, washing clothes and bathing, siltation, etc. were also found to increase nutritional load in lake.

Obviously, removal of the Water hyacinth is preserving huge amount of money, otherwise whole environment of Phewa Lake would have become deteriorating for all the species and unfavorable for touristic and recreational activities. But unscientific removal of the weed may affect waterbirds. Comin *et al*. (2001) found that wetland birds prefer wetlands with intermediate plant cover for resting and sleeping activities better than rice

fields and either very open wetlands or very dense ones with tall vegetation, so that complete removal will probably affect the bird species in Phewa Lake. Therefore, the removal of weed should be done leaving breeding and resting sites approximately.

Some species prefer the Water hyacinth since its roots provide a favorable habitat for bird prey in which invertebrate densities amongst roots can range from 3446 to 13800 individuals per square meter (O'Hara, 1967). The species like Common Moorhen, Bronze-winged Jacana, Indian Pond Heron and Cattle Egret are highly adaptable species (Dahal, 2006) and were recorded regardless of the intensity of the invasion. Bartodziej and Weymouth (1995) found Common Moorhen nesting on water hyacinth mats and feeding on them and most often obtained prey that were located near the perimeter of the mats. Removal thus should leave habitat of bird species like Common Moorhen and Bronze-winged Jacana may be threatened in the Phewa area appropriately.

Nepal is very advanced in its approach to conservation. It has long been recognized in the country that conservation cannot be balanced and sustainable without reducing the dependency of local people on resources, and that effective conservation will not be possible without the goodwill and support of local people (Buckton, 2007). Same problem was found in the Phewa Lake also, and same expectations will have been there for the conservation of bio-diversity and Lake Phewa. It is obvious that if we get success in providing sustainable livelihoods, pressure on the Phewa Lake will be reduced. A comprehensive socio-economic survey around the lake to assess the dependency of locals and extent of their pressure on the lake would help design effective livelihood improvement program.

Marsden (2000) studied about impact of disturbance on waterfowl wintering in UK's Dockland Redevelopment Area. He studied on UK's largest flocks of Pochard *Aythya ferina* and Tufted Duck *A. fuligula* which winter in Manchester's busy dockland redevelopment area. He examined the effects of human disturbance on the population, and used this information to recommend minimal land-use restrictions that would help ensure the population's continued use of the site. Birds fed at the ducks every night, but

on 75% of days, the flock flew to suburban or rural refuges in response to disturbance. The common causes of disturbance, particularly pedestrians, did not affect the duck greatly, but redevelopment of the site (e.g., machinery) often made duck evacuate the dock. Birds spent only a small proportion of time feeding, and feeding activity was not heightened following periods of exclusion from the docks due to disturbance. Kanwar *et al.* (2005) studied diversity and relationship of flora and avifauna in Babai River Valley, Bardia, in which they found that composition and diversity of trees have great influence on the occurrence of birds. Habitat loss, deforestation, poaching and trapping, poisoning, grazing and timber smuggling were major threats and being major challenges for conservation of Babai river valley biodiversity. Exactly, the lessening of human disturbance and conserving of diverged habitats can probably increase the wetland bird diversity in Phewa Lake.

The livelihood and culture of large numbers of people, in almost every country of the world, will be endangered if wetland resources become further depleted. A major portion of fisheries production, most hunting, much forest production and a significant part of ecotourism will be lost worldwide, as well as elements of heritage and environmental quality. It is important to stress, however, that it is not sufficient just to protect the populations of plants and animals that are directly exploited: their health and survival, or sustainability. Loss of wetland habitats, which contain so much of the world's plant and animal diversity, thus endangers the genetic resources on which our future prosperity depend (Hails, 1997).

Kafle *et al*. (2007) suggested the scientific research and monitoring of biodiversity and wetland ecology in the Ghodaghodi lake area and further recommended that the lake area should be declared as 'Conservation Area' with provision of its buffer zone so that its significance for biodiversity conservation and community development will further be explored. For the conservation of the Phewa Lake and its biodiversity, management plans for the minimization of conservation threats should be formed. Programs should be lunched which can minimize the siltation by the direct involvement of locals. For implementing the rules and regulations, provision of punishment and awards should be

started among the locals. This can affect on the activities like hunting, sewage disposal, cattle grazing in the close proximity of lake and solid waste dumping. Tourism related organizations should start the sustainability in tourism. For this, other lakes like Begnas, Rupa and Depang should be promoted which can be alternative for the tourist so that large human flow at a time can be controlled in the Phewa Lake. The formation of the Phewa management committee from the local people may be very effective for the regular monitoring of the conditions of the Phewa Lake.

CHAPTER-6 CONCLUSION

The Phewa Lake, though being inside the grip of human population itself, is supporting good diversity of water birds. The species diversity and population abundance were found higher in the winter season. This shows its importance for the wintering species. There is an urgent need of creating an undisturbed site for the wintering population. And the winter season was found as the time of high human disturbance. It can be concluded that there is great possibility of increment of waterbird species. Major control measures can be well managed sustainable tourism and discouraging urbanization to decrease human pressure. Though statistically, no significant relation was found between the number of cattle and number of birds, over grazing along the shore area of lake can destroy the shore vegetation because of which birds like Bronze Winged Jacana, Moorhen, White-breasted Waterhen, etc. may be affected. Dumping of Water hyacinth during removal is also destroying shore area habitat which is causing destruction of their feeding, hiding and breeding ground. There is a very urgent need of implementing rules and regulation strictly which will discourage certain activities like solid waste problem, domestic sewage, hunting of birds, washing and bathing, overgrazing. Most of the water hyacinth mats were recorded near the agricultural land, which is sharp indication of nutritional seepage from agricultural activities. The control of the load of nutrition probably controls the thriving of the weeds. There is an urgent need of a comprehensive geographical study from the Governmental level which can assess the reasons of siltation and sedimentation and recommend for the management and conservation of wetland Phewa. The lessening of the dependency of the local people in the particular resource is the sustainable use of the resources. There is also a need of large scale socio-economic survey to seek the alternative sources of income generation so that sustainable management and conservation of the Lake Phewa will be effective.

In the context of being less numbers of larger wetlands in Nepal because of its complex geography, Lake Phewa is very important site of wetland birds which provides opportunity for ornithological study and supporting higher biological diversity.

CHAPTER-7 RECOMMENDATIONS

- There should be some informative and awareness related illustrative boards in Lake Phewa which can draw attention of the visitors.
- A comprehensive bird survey should be conducted in and around the lake to conserve the area.
- A detail study of the socio-economic condition around the lake should be done to know dependency of people and to suggest alternatives on lake.
- Effective awareness programs, trainings and seminars should be carried out for possible minimization of hunting of birds. Such programs should be carried out intensively in the school children to discourage upcoming generation in such illegal activities.
- Rules and regulations should be implemented strictly so that unnatural urbanization, over grazing in shore area and other human induced activities will be controlled.
- An undisturbed area in the north-western part of the lake should be declared at least for the wintering season.
- Boating through certain sensitive areas should be restricted so that birds will not be severely disturbed.
- Different groups of the local people (Bird club, etc.) should be formed and train them about the conservation and management of resources and sustainable use.
- A comprehensive geographical study should be done around the lake to know the siltation and soil erosions effect.
- Removal of water hyacinth should be continued. But alternative solutions for the maintenance of the level of vegetations should be seeked (aquatic herbicide, biological control, etc.).
- Bird observation as part of tourism may be initiated.
- School Conservation Education Program, Nature guide training can be initiated.

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APPENDIXES

Appendix: 1 Common name, scientific name, National Status and Local Status of the birds recorded in Phewa Lake

SN	Common Name	Scientific Name	National Status	Local Status	
				S_1	S_2
ORDER: ANSERIFORMES					
Family: Dendrocygnidae					
1.	Lesser Whistling Duck	*Dendrocygna javanica*	Locally common resident, winter visitor and passage migrant below 305m (-1351m)	O	F
Family: Anatidae					
2.	Ruddy Shelduck	*Tadorna ferruginea*	Common and quite widespread winter visitor below 305m, regular on passage up to 4800m; also a rare breeder at 4300m.	W	C
3.	Gadwall	*Anas strepera*	Locally common winter visitor and passage migrant; mainly below 915m (-4750m).	W	F
4.	Eurasian Wigeon	*Anas penelope*	Locally common winter visitor and passage migrant; mainly below 250m (-4570m on passage).	W	F
5.	Mallard	*Anas platyrhynchos*	Locally fairly common winter visitor and passage migrant below 3050m; also resident and breeds at 2620m	W	F
6.	Northern Shoveler	*Anas clypeata*	Locally common passage migrant, also a rare winter visitor; mainly below 1350m (-4570m on passage).	W	UC
7.	Northern Pintail	*Anas acuta*	Locally common winter visitor and passage migrant; mainly below 915m (-4650m on passage).	W	UC
8.	Common Teal	*Anas creeca*	Common and quite wide spread winter visitor and passage migrant; mainly below 915m (-4300m on passage).	W	C
9.	Red-crested Pochard	*Rhodoessa rufina*	Frequent winter visitor and passage migrant; mainly below 915m (-3050m).	W	F
10.	Common Pochard	*Aythya ferina*	Locally fairly common winter visitor and passage migrant; mainly below 915m (-4570m on passage).	W	C
11.	Ferruginous Pochard	*Aythya nyroca*	Common and widespread winter visitor, also a	W	UC

			passage migrant; below 915m (-4575m on passage).		
12.	Tufted Duck	*Aythya fuligula*	Fairly common winter visitor and passage migrant, some present all year; mainly below 915m (-4900m on passage).	W	F
ORDER:CORACIIFORMES					
Family: Alcedinidae					
13.	Common Kingfisher	*Alcedo atthis*	Fairly common and widespread resident below 1000m; frequent up to 1800m (-3050m).	R	UC
Family: Dacelonidae					
14.	White-throated Kingfisher	*Halcyon smyrnensis*	Widespread resident common below 1000m; rarely above 1800m (-3050m).	R	F
Family: Cerylidae					
15.	Crested Kingfisher	*Megaceryle lugubris*	Frequent and widespread resident; 250-1800m (-3000m).	RW	UC
ORDER: GRUIFORMES					
Family: Rallidae					
16.	White-breasted Waterhen	*Amaurornis phoenicurus*	Fairly common and widespread resident; below 1370m (-3800m).	R	F
17.	Common Moorhen	*Gallinula chloropus*	Locally common resident and winter visitor; mainly below 250m (-4575m on passage).	O	UC
18.	Common Coot	*Fulica atra*	Uncommon winter visitor and passage migrant; up to 3500m (-5000m).	W	A
ORDER: CICONIIFORMES					
Family: Scolopacidae					
19.	Common Snipe	*Gallinago gallinago*	Locally fairly common winter visitor and passage migrant; below 1500m (-4700m on passage).	RW	UC
20.	Common Sandpiper	*Actitis hypoleucos*	Wide spread; common winter visitor and passage migrant, possibly breeds; winters below 1370m (-5400m on passage).	RW	UC
Family: Jacanidae					
21.	Bronze-winged Jacana	*Metopidius indicus*	Widespread resident; fairly common in lowlands, uncommon up to 915m.	R	F
Family: Charadriidae					
22.	Little Ringed Plover	*Charadrius dubius*	Common and widespread resident, also winter visitor; below 1500m (-2745m)	O	UC
23.	Red-wattled Lapwing	*Vanellus indicus*	Common and widespread resident; below 1050m (-1340m)	O	F

Family: Glareolidae					
24.	Small Pratincole	*Glareola lacteo*	Locally common resident and local migrant; below 305m	RW	UC
Family: Laridae					
25.	Black-headed Gull	*Larus ridibundus*	Winter visitor and passage migrant, fairly common at Koshi Barrage, Uncommon elsewhere; mainly in lowlands (-5490m on passage).	O	UC
Family: Pedicipedidae					
26.	Little Grebe	*Tachybaptus ruficollis*	Fairly common resident, winter visitor and passage migrant; mainly below 1370m (-3050m).	R	A
27.	Great Crested Grebe	*Podiceps cristatus*	Locally frequent winter visitor, possibly breeds; mainly below 1370m (-4800m).	W	F
Family: Phalacrocoracidae					
28.	Great Cormorant	*Phalacrocorax carbo*	Fairly common and widespread non-breeding resident; mainly below 1000m (-3960m).	W	F
Family: Ardeidae					
29.	Little Egret	*Egretta garzetta*	Fairly common and widespread resident; below 1525m.	R	C
30.	Grey Heron	*Ardea cinerea*	Widespread and frequent resident and winter visitor; below 915m (-3050m)	O	UC
31.	Intermediate Egret	*Mesophoyx intermedia*	Widespread and frequent; mainly resident; below 915m (-1370m).	R	C
32.	Cattle Egret	*Bubulcus ibis*	Widespread and common resident; below 1525m.	R	A
33.	Indian Pond Heron	*Ardeola grayii*	Widespread and common resident; below 1525m.	R	C
34.	Little Heron	*Butorides striatus*	Widespread and frequent resident and summer visitor; below m	W	UC
35.	Black-crowned Night Heron	*Nyctycorax nycticorax*	Resident and summer visitor; locally common and widespread but rather patchily distributed; below 1370m.	O	UC
Family: Ciconiidae					
36.	Wooly-necked Stork	*Ciconia episcopus*	Frequent and widespread resident; mainly below 915m; occasionally up to 1800m.	O	UC
ORDER: PASSERIFORMES					
Family: Muscicapidae					
37.	Plumbeous Water	*Rhyacornis*	Widespread resident; common in summer	RW	UC

	Redstart	*fuliginosus*	1525-3750m (-600m), uncommon up to 4420m, winters 75-2560m.		
Family: Passeridae					
38.	White Wagtail	*Motacilla alba*	Common and widespread passage migrant, winter visitor and resident; summers 2400-4800m, winters mainly below 1500m (-5000m on passage).	R	F
39.	Grey Wagtail	*Motacilla cinerea*	Common and widespread, resident; breeds mainly 1110-3550m (-4115m), winters below 365m, occasionally up to 1550m.	O	UC

W- Winter Visitor R-Resident RW- Rare Winter Visitor O-Occasional Visitor
F-Frequent C-Common UC-Uncommon A-Abundant
Scientific name and commen name (BCN, Official Checklist, 2006)

Appendix: 2 Numbers of individuals of the Birds recorded during the study period

SN	**Birds**	**2007**							**2008**	
		Jun	**July**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**
1.	Lesser Whistling Duck	-	-	13	40	27	7	-	-	-
2.	Ruddy Shelduck	-	-	-	-	-	-	105	132	15
3.	Gadwall	-	-	-	-	-	-	27	30	15
4.	Eurasian Wigeon	-	-	-	-	-	-	17	24	13
5.	Mallard	-	-	-	-	-	-	35	61	41
6.	Northern Shoveler	-	-	-	-	-	-	11	21	-
7.	Northern Pintail	-	-	-	-	-	-	9	17	-
8.	Common Teal	-	-	-	-	-	-	134	173	51
9.	Red-crested Pochard	-	-	-	-	-	-	44	45	33
10.	Common Pochard	-	-	-	-	-	-	193	236	71
11.	Ferruginous Pochard	-	-	-	-	-	-	5	7	-
12.	Tufted Duck	-	-	-	-	-	-	23	31	25
13.	Common Kingfisher	2	2	5	-	2	-	-	1	3
14.	White-throated Kingfisher	20	15	17	7	14	13	6	6	5
15.	Crested Kingfisher	-	-	-	-	-	2	1	-	-

16.	White-breasted Waterhen	6	5	5	-	1	4	8	6	2
17.	Common Moorhen	3	3	1	-	-	-	2	4	-
18.	Common Coot	-	-	-	-	-	15	319	357	161
19.	Common Snipe	-	-	-	-	-	-	-	2	-
20.	Common Sandpiper	-	-	-	-	-	2	4	-	-
21.	Bronze Winged Jacana	16	13	15	12	11	21	33	19	8
22.	Little Ringed Plover	-	-	-	-	4	7	3	3	-
23.	Red-wattled Lapwing	14	11	-	-	-	19	7	3	-
24.	Small Pratincole	4	-	-	-	-	-	-	-	-
25.	Black-headed Gull	-	-	2	-	-	-	-	-	-
26.	Little Grebe	89	87	38	28	27	35	164	143	52
27.	Great Crested Grebe	-	-	-	-	-	-	18	24	14
28.	Great Cormorant	-	-	-	-	-	-	27	32	31
29.	Little Egret	52	55	45	39	60	41	41	16	18
30.	Grey Heron	1	-	-	-	-	-	-	-	2
31.	Intermediate Egret	32	30	21	24	6	6	12	26	19
32.	Cattle Egret	616	497	176	167	171	139	160	91	68
33.	Indian Pond Heron	25	27	33	17	31	48	45	39	29
34.	Little Heron	-	-	-	-	-	-	9	11	-
35.	Black-crowned Night Heron	-	-	-	-	-	-	-	7	-
36.	Wooly-necked Stork	-	-	2	-	-	-	-	-	-
37.	Plumbeous Water Redstart	-	-	-	-	-	-	2	-	-
38.	White Wagtail	1	3	1	11	24	28	5	15	9
39.	Grey Wagtail	-	-	-	-	3	5	3	2	-
Total Population		881	748	374	345	381	392	1472	1584	685

Appendix: 3 Climatic parameters recorded in Pokhara Valley in the year 2004

Months	Temp max(°C)	Temp min(°C)	RH(%)8:45am	RH(%) 17:45pm	Rainfall(mm)
Jan	19.8	7.5	92.3	56.9	31.2
Feb	23.4	10.3	87.4	49.3	10.9
Mar	29.3	15.9	78.6	45.1	28.4
Apr	28.9	16.6	78.9	61.6	265.7
May	30.6	19.3	78.5	67.2	432.5
Jun	31.0	21.0	84.1	74.8	773.0
Jul	29.9	22.1	91.2	75.0	716.9
Aug	31.4	22.6	86.3	75.8	788.7
Sep	29.4	21.1	91.2	79.9	864.0
Oct	27.3	16.2	86.6	64.8	184.2
Nov	23.5	11.1	87.2	61.3	33.0
Dec	21.1	8.7	91.1	59.3	0.0

Appendix: 4 Climatic parameters recorded of Pokhara Valley in the year 2005

Months	Temp max(°C)	Temp min(°C)	RH(%) 8:45am	RH(%) 17:45pm	Rainfall(mm)
Jan	19.3	7.8	92.6	57.9	58.0
Feb	22.8	9.7	86.4	51.2	11.7
Mar	27.3	13.8	78.9	48.2	85.0
Apr	30.2	15.2	66.8	42.2	104.6
May	30.2	17.6	75.9	67.5	309.5
Jun	31.8	21.0	80.4	66.6	282.2
Jul	31.0	22.3	88.1	71.2	548.8
Aug	30.5	22.2	89.7	79.2	924.5
Sep	30.9	21.5	87.2	71.4	313.5
Oct	26.8	16.9	86.9	72.0	325.7
Nov	23.6	11.8	90.3	67.2	3.6
Dec	21.0	7.2	91.3	57.3	0.0

Appendix: 5 Values of $\overline{H}$ (index of diversity), C (index of dominance) and e (evenness) in different months

Months	Diversity index ($\overline{H}$)	Dominance index(C)	Evenness(e)
Jun	1.2014	0.5058	0.4555
Jul	1.2071	0.4639	0.4858
Aug	1.8073	0.2625	0.6848
Sep	1.6911	0.2770	0.7697
Oct	1.8220	0.2493	0.7104
Nov	2.1710	0.1737	0.7830
Dec	2.6095	0.1067	0.7599
Jan	2.4926	0.1087	0.7259
Feb	2.6228	0.1020	0.8485

Appendix: 6 Values of similarity index and percentage similarities of the bird communities between different survey months

Between months	Similarity index value(S)	Percentage similarity (%)
June/July	0.9231	92.3077
June/August	0.7857	78.5714
June/September	0.6957	69.5652
June/October	0.7407	74.0741
June/November	0.6667	66.6667
June/December	0.4444	44.4444
June/January	0.5333	53.3333
June/February	0.6286	62.8571
July/August	0.8462	84.6154
July/September	0.7619	76.1905
July/October	0.8000	80.0000
July/November	0.7143	71.4286
July/December	0.5116	51.1628

July/January	0.5581	55.8140
July/February	0.6061	60.6061
August/September	0.7826	78.2609
August/October	0.8148	81.4815
August/November	0.6667	66.6667
August/December	0.4444	44.4444
August/January	0.4889	48.8889
August/February	0.5714	57.1429
September/October	0.8182	81.8182
September/November	0.7200	72.0000
September/December	0.4000	40.0000
September/January	0.4000	40.0000
September/February	0.5333	53.3333
October/November	0.8276	82.7586
October/December	0.5000	50.0000
October/January	0.5455	54.5455
October/February	0.5882	58.8235
November/December	0.6383	63.8298
November/January	0.5532	55.3191
November/February	0.5405	54.0541
December/January	0.9032	90.3226
December/February	0.7692	76.9231
January/February	0.8077	80.7692

Appendix: 7 Percentage dominance/Relative densities of bird species on the basis of total population in each survey period.

SN	**Birds**	**2007**							**2008**	
		Jun	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**
1.	Lesser Whistling Duck	-	-	3.48	11.59	7.09	1.79	-	-	-
2.	Ruddy Shelduck	-	-	-	-	-	-	7.13	8.33	2.19
3.	Gadwall	-	-	-	-	-	-	1.83	1.89	2.19
4.	Eurasian wigeon	-	-	-	-	-	-	1.15	1.52	1.90
5.	Mallard	-	-	-	-	-	-	2.38	3.85	5.99
6.	Northern Shoveler	-	-	-	-	-	-	0.75	1.33	-

7.	Northern Pintail	-	-	-	-	-	-	0.61	1.07	-
8.	Common Teal	-	-	-	-	-	-	9.10	10.92	7.45
9.	Red-crested Pochard	-	-	-	-	-	-	2.99	2.84	4.82
10.	Common Pochard	-	-	-	-	-	-	13.11	14.90	10.36
11.	Ferruginous Pochard	-	-	-	-	-	-	0.34	0.44	-
12.	Tufted Duck	-	-	-	-	-	-	1.56	1.96	3.65
13.	Common Kingfisher	0.23	0.27	1.34	-	0.52	-	-	0.06	0.44
14.	White-throated Kingfisher	2.27	2.01	4.55	2.03	3.67	3.32	0.41	0.38	0.73
15.	Crested Kingfisher	-	-	-	-	-	0.51	0.07	-	-
16.	White-breasted Waterhen	0.68	0.67	1.34	-	0.26	1.02	0.54	0.38	0.29
17.	Common Moorhen	0.34	0.40	0.27	-	-	-	0.14	0.25	-
18.	Common Coot	-	-	-	-	-	3.83	21.67	22.54	23.50
19.	Common Snipe	-	-	-	-	-	-	-	0.13	-
20.	Common Sandpiper	-	-	-	-	-	0.51	0.27	-	-
21.	Bronze Winged Jacana	1.82	1.74	4.01	3.48	2.89	5.36	2.24	1.20	1.17
22.	Little Ringed Plover	-	-	-	-	1.05	1.79	0.20	0.19	-
23.	Red-wattled Lapwing	1.59	0.02	-	-	-	4.85	0.48	0.19	-
24.	Small Pratincole	0.45	-	-	-	-	-	-	-	-
25.	Black-headed Gull	-	-	0.53	-	-	-	-	-	-
26.	Little Grebe	10.10	11.63	10.16	8.12	7.09	8.93	11.14	9.03	7.59
27.	Great Crested Grebe	-	-	-	-	-	-	1.22	1.52	2.04
28.	Great Cormorant	-	-	-	-	-	-	1.83	2.02	4.53
29.	Little Egret	5.90	7.35	12.03	11.30	15.75	10.46	2.79	1.01	2.63
30.	Grey Heron	0.11	-	-	-	-	-	-	-	-
31.	Intermediate Egret	3.63	4.01	5.61	6.96	1.57	1.53	0.82	1.64	2.77
32.	Cattle Egret	69.92	66.44	47.06	48.41	44.88	35.46	10.87	5.74	9.93
33.	Indian Pond Heron	2.84	3.61	8.82	4.93	8.14	12.24	3.06	2.46	4.23
34.	Little Heron	-	-	-	-	-	-	0.61	0.69	-
35.	Black-crowned Night	-	-	-	-	-	-	-	0.44	-

	Heron									
36.	Wooly-necked Stork	-	-	0.53	-	-	-	-	-	-
37.	Plumbeous Water Redstart	-	-	-	-	-		0.14	-	-
38.	White Wagtail	0.11	0.40	0.27	3.19	6.30	7.14	0.34	0.95	1.31
39.	Grey Wagtail	-	-	-	-	0.73	1.28	0.20	0.13	-

Appendix: 8 Monthly values of diversity indices in different vantage points

Months / Vantages	**2007**						**2008**		
	June	**July**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**
A	1.3851	1.3132	1.3971	0.4703	0.3153	1.7125	1.1436	1.4186	1.5176
B	0.6730	0.6558	1.1531	0.3056	0.3251	1.2770	1.5474	1.4584	1.6308
C	0.3788	0.3550	0.8566	1.5125	1.0042	1.4285	1.2302	1.2054	1.7246
D	1.7302	1.8674	1.7778	1.5711	1.2528	1.8723	1.1519	2.0168	2.0032
E	1.3989	1.7105	1.6725	1.2048	1.6234	1.8422	1.7046	1.9658	2.0504
F	1.0806	1.5248	1.4837	1.2406	0.5776	2.0266	0.9971	1.1024	1.8367
G	1.4017	1.5494	1.8254	1.4320	2.1786	1.0141	1.0932	1.8520	1.7201
H	0.5126	0.4514	1.4906	1.0182	1.4747	0.8510	1.3743	1.3966	1.0829
I	1.7990	1.9047	1.3966	1.6274	1.6274	2.1209	2.1493	2.2103	1.9232
J	1.9767	1.5887	1.5745	1.3124	1.3708	1.0090	2.6422	2.5167	2.4195

Appendix: 9 No. of birds recorded in different vantages in different months

Months / Vantages	**2007**						2008		
	June	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb
A	25	27	29	23	54	26	12	10	17
B	5	50	45	70	10	7	32	13	14
C	471	341	89	15	7	37	119	178	129
D	50	31	29	40	14	26	377	487	133
E	19	48	11	13	31	66	232	204	60
F	75	56	19	11	22	18	30	26	19
G	27	47	29	60	27	79	154	44	25
H	88	23	25	27	63	22	44	49	19
I	55	78	39	39	39	46	50	63	34
J	64	47	64	47	114	65	422	492	237

Appendix: 10 Water parameters recorded in Phewa Lake during the year 2007

Months	**Temperature (° C)**	**PH values**	**Dissolved Oxygen (DO) gm/lit.**
January	16	6.7	5.7
February	18	6.9	8.6
March	25	7.4	8.9
April	25	7.1	8.3
May	29	7.2	8.4
June	31.5	6.9	8.0
July	24	6.8	8.3
August	28	6.8	8.5
September	24	6.7	8.1
October	24	7.3	9.9
November	21	7.0	9.4
December	18	6.9	8.0

Source: Fishery Research Centre, Pokhara

Appendix: 11 Phytoplankton, Zooplanktons and Fish species found in Phewa Lake

Phytoplankton	Zooplankton	Fish species
Merismopedia elegans, Microcystis spp., *Synura petersenii, Dinobryon divergens, Mallomonas* spp., *Navicula rhyncocepala, Navicula* spp., *Cyclotella* spp., *Tabellaria fenestrate, Diatomella* spp., *Stephanodiscus carconensis, Nitzchia acicularis, Melosira granulate, M. italic, M.* spp., *Synedra acus, Surirella robusta, Rhoicosphenia curvata, Botryococcus braunii, Centritractus belonophorus, ceratium hirundinella, Gymnodinium* spp., *Peridinium* spp., *Cryptomonas compressa, C.* spp., *Gonyostumum semsn, G.* spp., *Staurastrum pseudopelagicum, S. dimazum, S. dorsidentiferum, S. curvatum, S.* spp., *Arthrodesmum triangularis, A. ralfsii, Arthrodesmus* spp., *Euastropsis richteri, Cosmarium contractum, C. reniforme, Cosmarium* spp., *Spondirosium* spp., *Closterium* spp., *Oocystis lacustris, O.* spp., *Nephrocytium* spp., *Glaeotaenium loitelsbergerianum, Tetraedron hastatum, Crucigenia tetrapedia, Gelenkinia radiate, Carteria cordiformis, Chlamydomonas moewusii, Dictyospherium ehrenbergianum, D. pulchellum, Gonotozygon pilosum.*	**Rotifera** (*Collotheca* sp., *Conochilus unicornis*, *Hexarthra mira*, *Keratella cochlearis*, *K. tropica*, *Crachionus patulus*, *Tricocera cylindrical*, *T. similis*); **Cladocera** (*Diaphanosoma excisum*, *Daphnia longispina*, *D. lumholtzi*, *Ceriodaphnia reticulate*, *C. cornuta*, *Simocephalus vetulus elisabethae*, *Bosmina longirostris*, *Eubosmina coregoni*, *Moina micrura*); **Copepoda** (*Neodiaptomus strigilipes*, *Phyllodiaptomus blanci*, *Mesocyclops leuckarti*, *Thermocyclops crassus*, *Tropocyclots confinis*, *Chaoborus* sp.)	*Barilius barna*(Poti or Faktar), *B. bendelisis*(Fageta or Guderi or Jho jho), *Cirrhinus reba*(Rewa), *Labeo gonius*(Gardi or Kussa), *Labeo rohita* (Rohu), *Puntius sarana*(Kande or Bada Pothi or Sidhri or Bhitti), *Tor tor* (Sor or Sahar), *T. putitora* (Sunaula or Sahar or Mahaseer), *Xenentodon cancila* (Kauwa), *Mastacembelus armatus* (Bamli), *Cyprinus carpio*(CommonCarp), *Hypophthamothys molitris* (Silver Carp), *Aristichthys nobilis* (Big head Carp), *Channa gachua*(Hile or Chenga), *Ctenopharyngodon idella* (Grass Carp), *Anguilla bengalensis* (Rajbam), *Acrossochielus hexagonolepsis*

Source: Fishery Research Centre, Pokhara

Appendix: 12 Field Data Sheet

"WETLAND AVIFAUNA: DIVERSITY, POPULATION STATUS AND CONSREVATION THREATS IN PHEWA LAKE, POKHARA, KASKI"

Jungle Time: Contact Time: Temperature:
On: On: Weather:
Off: Off: Date:

S.N	**Birds**	**Rest**	**Perch**	**Feed**	**Preen**	**Call/Sing**	**Fly**	**Remark**

Appendix: 13 Questionnaires

Name : Sex : Age:
Education: Occupation: Site:

1. Are you native?
2. (If not), migrated? When?
3. What changes have you seen here since you have come here?
4. What changes have you been noticing during last 5-10 years?
    I. Human increment/encroachment to lake.
    II. Road construction
    III. Land slide
    IV. Others
5. Have you ever noticed the birds found here?
6. How many types of birds have you noticed?
7. Have you seen the water birds like ducks and others?
8. In which season do you see more birds?
    I. Spring
    II. Summer
    III. Autumn
    IV. Winter
9. Can you name some birds which you see regularly and occasionally?
    I. Regularly:
    II. Occasionally:
10. Can you name which you have not seen for 5-10 years?
11. Do you know bird migration? And have you ever seen?
12. Have you ever felt harmful effects from water birds and other birds?
13. What types of problem do they create?
14. Have ever seen people hunting birds?
15. Which birds are generally hunted?
16. Which stage is focused?
    I. Egg
    II. Chicks
    III. Adults
17. Which instrument do they use mostly for hunting?
    I. Catapult
    II. Gun
    III. Net
    IV. Others
18. Do you also involved in hunting birds?
19. What may be the reason of decreasing birds of this area?
    I. Hunting
    II. Loss of habitat
    III. Pollution
    IV. High disturbance

V. Others

20. Have you been noticing pollution increased in the water of Phewa Lake?
    I. Increasing turbidity
    II. Stinking of water
    III. High increment of invasive aquatic plants (Water hyacinth
21. What do you think the reason for the pollution of water?
    I. Sewages disposal from houses and hotels
    II. Washing clothes and taking baths in the lake
    III. Disposal of other materials like bottles, plastics, etc.

22. Since when the water pollution and water hyacinth became as a big problem?
23. Water hyacinth is being removed-
    I. Once a year
    II. Twice a year
    III. More
24. Any awareness program held here for water birds (Birds) conservation?

    I. Yes/No
    II. (if yes) How many times?
25. Do you have any suggestion for the preservation of birds and also Phewa Lake?
26. Do you think the conservation of birds in this area also helps to conserve Phewa Lake?
27. Now, do you think the program like “Awareness for Bird Conservation” is necessary?