CHAPTER I

1. Introduction

1.1 Background

Ramsar Convention on wetlands, defined that wetlands are "areas of marsh, fen, peat land 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 wetlands " 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 amongst the most productive ecosystems in the world (Halls 1997).

1.1.2 Wetlands in Nepal and Bird Diversity

The Nepali term for wetland is Simsar. The informal group in Nepal at the first informal meeting on wetlands management in Nepal attempted to define wetlands as "Wetlands represent landmass saturated with water due to high water table through ground water, atmospheric precipitation or inundation and it may be natural or artificial, permanent or temporary, static or flowing and fresh water or brackish" (Shrestha & Bhandari, 1992).

Table 1.1: Wetland Types in Nepal

S.N.	**Wetland type**	**Estimated area (ha)**	**Percent**
1	Rivers	395000	48.35
2	Lakes	5000	0.61
3	Reservoirs	1500	0.18
4	Village Ponds	5954	0.73
5	Marginal/Swamps/Gholes	11500	1.41
6	Irrigated Paddy Fields	398000	48.72
	Total	**816954**	**100**

Source: DoFD (2003)

There are 242 wetland sites in Nepal of which 163 sites lie in the Terai Region and the rest 79 in Hill and Mountainous Regions. According to the Development Region, 64 wetland sites lie in mid-western region, 52 in central region, 50 in western region, 42 in eastern region and 34 in mid-western region (IUCN-Nepal, 1996).

Table 1.2: Wetland sites in the Terai that Merit Legal Protection

Site	District (VDC)	Size (Ha)	Reasons for Listing
Bishazar Lake	Chitwan (Gitanagar)	180	Large complex of oxbow lakes set in a very scenic environment. Of major importance as a particularly good representative of an oxbow ecosystem, supporting an appreciable assemblage of rare, vulnerable and endangered wildlife species.
Gaindahawa Lake	Rupandehi (Bisnupura)	11	Oxbow lake supporting small resident and wintering populations of several species of waterfowl.
Jagadishpur Reservoir	Kapilbastu (Niglihawa)	157	Large irrigation reservoir supporting > 4% of the Asian population of Ferruginuous Duck (*Aythya nyroca*), (whose 1% criterion = 100) with 405 recorded. The same site almost reached the 1% criterion for the Lesser Whistling Duck (*Dendrocygna javanica)*.
Badahiya	Bardia (Chailahi)	100	Large marshy natural depression supporting a large number of resident and wintering populations of several species of waterfowl.
Ghodaghodi Lake	Kailali (Darkh Nidi)	150	Large complex of oxbow lakes set in a very scenic environment, surrounded by dense Sal forest. Of major importance as a particularly good example of an oxbow ecosystem supporting an appreciable assemblage of rare, vulnerable and endangered wildlife species. Important site for transient migratory species moving between Dudwa National Park (India), Royal Suklaphanta Wildlife Reserve and Royal Bardia National Park. The resident population of *Nettapus coromaindelianus* makes up nearly 1% of the total Asian population.

Nacrodi Lake	Kailali (Sandempani)	100	Large complex of oxbow lake surrounded by dense Sal forest. Of major importance as a good example of an oxbow ecosystem supporting an appreciable assemblage of rare, vulnerable and endangered wildlife species.
Rampur Lake	Kailali (Ruma)	20	Medium-sized complex of oxbow lakes set in a very scenic environment, surrounded by dense Sal forest. Of major importance as a particularly good representative of an oxbow ecosystem supporting an appreciable assemblage of rare, vulnerable and endangered wildlife species.
Deukhuria	Kailali (Dhangadi Municipality)	22	Large lake set in a very scenic environment. Of major importance as a particularly good example of an oxbow ecosystem supporting an appreciable assemblage of rare (*Sarkidiornis melanotos*), vulnerable and endangered wildlife species.
Patriyani	Kanchanpur (Krishnapur)	35	Large oxbow take of major importance as a particularly good representative of an oxbow ecosystem supporting an appreciable assemblage of rare, vulnerable and endangered wildlife species.
Belkot	Kanchanpur (Daiji)	4	Very scenic lake of special value for maintaining genetic and ecological diversity.

Source: BPP (1995a)

Only four wetland sites are enlisted in "Lists of Wetlands of International Importance."

Table 1.3: Ramsar sites of Nepal

S.N.	**Site Name**	**Designated Date**	**Area in ha**
1	Koshi Tappu	17/12/1987	17,500
2	Beeshazar and Associated Lakes	13/08/2003	3,200
3	Ghodaghodi Lake Area	13/08/2003	2,563
4	***Jagadispur Reservoir***	**13/08/2003**	**225**

Fig. 1.1: Map showing Ramsar sites of Nepal

Source:Ramsar, 2004.

Nepal is globally renowned for its high bird diversity and considered as a paradise for birds. The total of 861 species have been recorded, occupying 8% of the world's known birds (Baral & Inskipp 2004). The topography, rainfall, altitudinal variation together with the bio-geographical location of Nepal at the meeting point of the Oriental and Palaerctic 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 the western Nepal (Inskipp & Inspkipp 1991). Of the 861 bird species, an alarming number of 133 (15%) of Nepal's birds are considered nationally threatened and as many as 72 of these are thought to be critically threatened or endangered at a national level (Baral and Inskipp 2004).

A total of 44 nationally threatened birds are wetland species (Baral Inskipp 2004). Nearly half of the country's globally threatened birds (14 species) and 10 near threatened species regularly inhabit wetlands (Baral & Inskipp 2005). The Nepal terai, composed of flat lowlands below 300m, and has rich species diversity with more than 500 bird species (Inskipp and Inskipp 1991).

Important Bird Areas (IBAs) in Nepal

The IBA programme in Nepal was coordinated by Bird Conservation Nepal (BCN), the BirdLife International Affiliate for the Kingdom of Nepal with support from the Royal Society for the protection of Birds (RSPB), UK. A report entitled 'Important Bird Areas (IBAs) in Nepal' was published in 2001 which identifies 27 IBAs (Annex 1) and four potential IBAs in Nepal. *Jagadispur Reservoir* is one of the IBAs in Nepal.

1.2 Literature Review

Wetland-Dependent Birds

Of the 862 (the latest is Greater White-Fronted Goose) bird species found in Nepal, 193 (22.5 percent) are known to be dependent on wetlands. The IUCN Red List of 2003 list 12 globally threatened species that are wetland dependent, including the critically endangered Pink-Headed Duck (*Rhodonessa caryophllacea*), endangered Greater Adjutant (*Leptoptilos dubius*) and Lesser Florican (*Sypheotides indica*), and vulnerable Baikal Teal (*Anas Formosa*), Swamp Francolin (*Francolinus gularis*), Baer's Pochard (*Aythya baeri*), Grey Pelican (*Pelecanus phillippensis*), Sarus Crane (*Grus antigone*), Indian Skimmer (*Rynchops albicollis*), Black-Necked Crane (*Grus nigricollis*), Lesser Adjutant (*Leptoptilos javanicus*) and Band-Tailed Fish Eagle (*Haliaeetus leucoryphus).*

Gunawardena (1999) has studied on bird diversity at Keralakele wetland Srilanka and indicated this lake as an important feeding and breeding site for large number of resident and migratory water birds. He reported the reduction of number of purple gallinules in Keralakele wetland of Srilanka due to destruction of habitats.

Policy, Legal and Institutional Context of Wetland Management in Nepal

Nepal is signatory to several Multilateral Environment Agreements (MEAs) of which three can be considered the most important for wetland biodiversity conservation - Convention on Wetlands (Ramsar (1971), Convention on Biodiversity Conservation (CBD 1992) and Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES 1973). The Nepal Biodiversity Strategy (NBS) 2002 lays down Nepal's strategy for biodiversity conservation and has clearly identified the need for conservation and sustainable use of wetlands and specifically the need for the following key actions:

- Formulation of comprehensive national wetland policy and wetland legislation;
- Review of institutional arrangements to ensure clarity in tenure wise-use and conservation;
- Research on wetland resources to provide scientific data and information;
- Identification of critical wetland habitats and their protection and directory and database on wetlands;
- Promotion of collaborative management of wetland resources;
- Implementation of demonstration projects to apply and promote wise use of wetlands and their resources and
- Promotion of awareness and capacity programmes on the important, use, function and management of wetlands and their resources.

Nepal became signatory to the Convention on Wetlands of International Importance especially as habitat of waterfowls (Ramsar 1971) in 1987. In order to meet its obligations under Article 3 of the Ramsar Convention, to develop a national wetland policy and under Recommendation 6.3 of the Conference of the Parties 1996, to manage wetlands in participation with local people and communities, Nepal Wetland Policy (2003) was recently formulated. The policy addresses the need for a coordinated approach to wetland management and includes the following objectives:

- To conserve, manage and promote wise use of national wetlands particularly through the collaboration of communities;
- To recognize the importance of the knowledge, innovations and practices of indigenous people and local communities in relation to wetlands and to promote the wider use of such for conservation and sustainable use of wetlands;
- To manage wetlands in an ecologically sustainable way;

- To achieve community participation in the management and decision-making processes of wetlands;
- To raise public awareness, especially of women, about the conservation values and benefits and wise use of wetlands; and
- To ensure a sound scientific and technological basis for conservation, management and wise use.

Legal Protection for Wetland Species

The main legal instruments that protect some of the wetland dependent species across the country inside and outside protected areas are the National Parks and Wildlife Conservation Act, 1973 (amended five times) for fauna, the Forest Act 1993 for flora and the Aquatic Life Protection Act 1961 for some specific aquatic species. Out of the nine nationally protected species of birds under the National Parks and Wildlife Conservation Act 1973, White Stork (*Ciconia ciconia*), Black Stork (*Ciconia nigra*) and Sarus Crane (*Grus antigone*) are wetland dependent birds.

Threats to Wetland Birds

Gopal (1987) found that water hyacinth plants have a tremendous growth and reproductive rate and the free-floating mats cause great problems for wetland biodiversity. Because of its higher growth rate, it rapidly expanded its coverage in most parts of the Koshi habitat resulting in heavy loss in biodiversity primarily for avian biodiversity. The aggressive expansion of water hyacinth significantly reduced open water area and caused sharp decline in number of pure water dwelling bird species especially darters, cormorant, and grebes. The substantial coverage of water hyacinth can lead low dissolved oxygen levels which might influence the community dynamics of the benthic community and ultimately to bird species that are dependent on insects and fish.

Bird species that are sensitive to even small changes in the ecosystem decline because of their specific habitat requirements (Baral *et al.* 1996).

Sah (1997) reported that fishing is one of the most destrctive activities, a common practice in Koshitappu Wildlife Reserve that greatly affects water birds in their feeding and nesting behaviour.

Nepal's wetlands face threats from drainage, diversion, abstraction, siltation, over-enrichment, pollution and poisons used to kill fish. Many observers have noted a decline in wetland birds, although data are currently lacking to illustrate trends on a national level. Figures available over a ten-year period from 1989 to 1999 for three wetlands in Royal Chitwan National Park reveal a decline in wetland dependent birds (Baral, 1999).

In Nepal, many lakes, ponds, pools have become overgrown by exotic plant species, water Hyacinth *Eichhornia crassipes* making it less suitable for many water birds (Grimett et al. 2000). However, the occurrence of an alien weed species as a narrow fringe of vegetation in contrast to a blanket over the water supporting certain types of bird species.

Wetlands are more vulnerable to accidental and intentional human interference than any other habitat because both water levels and quality can very easily be altered to spoil the life support of the wetland (Kler, 2002).

Many large water birds, whether solitary or flocking by nature, are edging very close to extinction through the disturbance or conversion of their habitats, as well as, through intense hunting pressure in many areas (Bird Life International 2002).

Habitat loss or damage is the major threat to 89% of the bird species considered at risk nationally. Over fishing, which has led to a marked decline in prey is a serious threat to many fish-eating bird species, for example terns, gulls, Indian Skimmer and fish-eating raptors and owls such as Grey-headed Fish Eagle *Lchthyophaga ichthyaetus,* Lesser Fish Eagle *I. humilis* and Tawny Fish Owl *Ketupa flavipes* (Baral and Inskipp 2004).

Haag et al. (1987) reported that Common Moorhens along with Boat-tail Grackles *Quiscalus major* L. and Red-winged Blackbirds *Agelaius phoeniceus* L. were frequently observed birds on mats of water hyacinth augmented the available nesting for moorhens.

McEachern (1993) investigated 3 lakes: Devi Tal, Lami Tal and Tamor Tal belonging to Chitawon National Park of inner Terai area of Nepal and reported impact of Water Hyacinth mat on improving trophical status from eutrophic to mesotrophic level in the Devi Tal.

WMI (1994) investigated limnological features and aquatic/wetland biodiversity of fishes, waterflows and aquatic macrophytes of Koshi Tappu Wildlife Reserve, the only Ramsar site of Nepal.

BPP (1995) investigated water quality, aquatic and wetland biodiversity of 51 wetland sites comprising lakes and ponds and river floodplains of Terai area occupying more than 5 hectare in area.

Lakes such as Devi Tal and *Jagadishpur Reservoir*, with ground water resources, have low nitrogen concentration, and behave as mesotrophic lakes. Low nitrogen condition in the lakes of the Terai is usually a result of loading from rivers or groundwater with low N: P, the mean value of which was recorded 7 in other seasons and 4 in monsoon by Bhandari (1996).

IUCN (1996) surveyed diversity of 163 wetland sites belonging to lacustrine, riverine and palustrine habitat types of Terai area.

Mc Eachern (1996) studied the regional and seasonal characteristics of water chemistry, algal biomass and nutrient limitation in different lakes of Nepal including Jagadispur Reservoir (present study area), Gaindahawa Lake, Ghodaghodi Lake, Rani Tal, Bishazar Lake and Koshitappu during the period (1993-1995). On the basis of TN and TP, he categorized the reservoir as oligotrophic in nature comparing with trophic state criteria proposed by Forsberg and Ryding (1980). (Annex 4)

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 (Bhandari 1998).

DNPWC/IUCN from a single survey made on July, 1997 listed a total of 42 bird species (Annex 2) in *Jagadishpur Reservoir* (DNPWC/IUCN, 2002).

1.3 Objectives

1.3.1 Broad Objective

The broad objective of the study was to study the avifaunal diversity at *Jagadishpur Reservoir.*

1.3.2 Specific Objectives

The specific objectives of the study were

1) To enumerate the bird species diversity in *Jagadishpur reservoir*.
2) To assess the water quality of the reservoir
3) To identify the threats to the birds at the reservoir area.

1.4Justification

Very little research works have been done in the wetland in the field of freshwater ecology. DNPWC/ IUCN (2002) from a single survey made in July 1997, has reported that the reservoir supports 42 bird species. Birds are good bio-indicators and useful models for studying a variety of environmental problem because they potentially detect aspects of wetland landscape conditions that are not detected by the other groups commonly used as indicators.

1.5 Limitations

Resource and time constraints narrowed the study duration to a one year period involving only three field visits.

The increasing conflict and insurgency in the country affected the schedule of study.

CHAPTER II

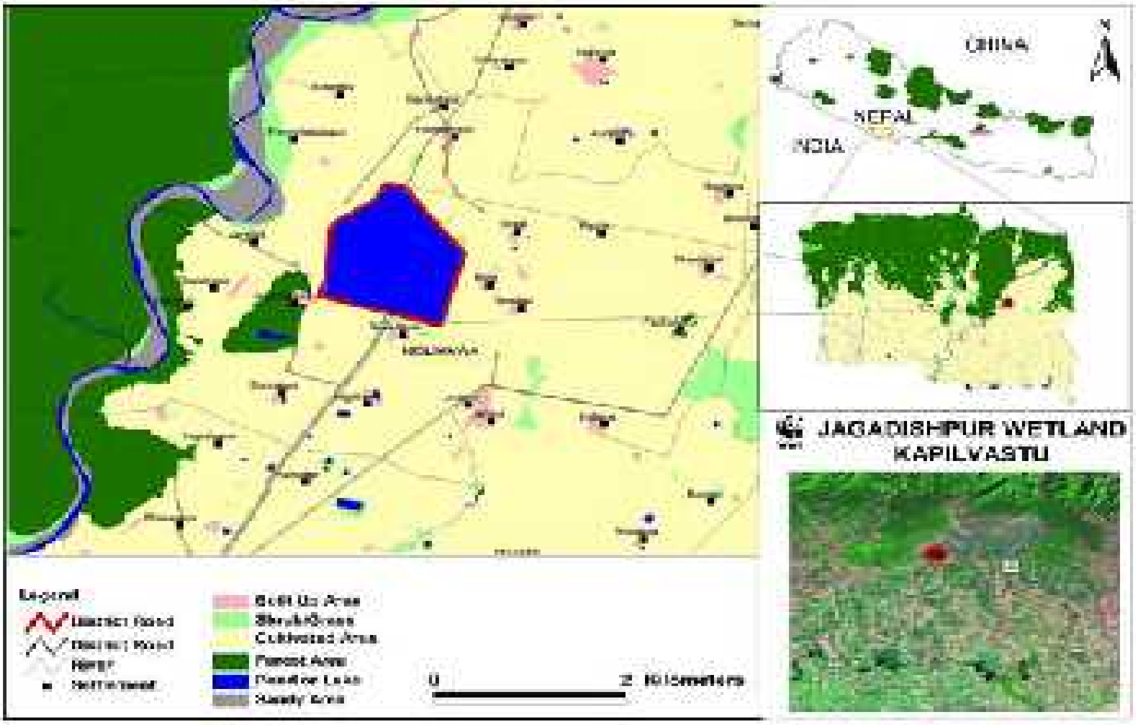
2.1 Study Area

2.1 The *Jagdishpur Reservoir* is situated approximately 4.8 kilometers east of Banganga River 10 km north of Taulihawa, district head quarter of Kapilbastu and 8 km south of Banganga Bridge along the eastern embankment road, Niglihawa VDC, Kapilbastu District,Lumbini zone, at geographical coordinates of $27^0$35'00.0" N, $83^0$05'00.0" E (DNPWC-IUCN, 2002).

The reservoir is constructed for irrigation purpose and it is harnessed by rock fill dike. The reservoir surface area is approximately 157 hectares at full storage level with a total shoreline perimeter of approximately 5 km.At FSL (EL 110m) the storage capacity is 45×10^6 m^3 with a maximum depth to the dam wall and average depth 3m (Shrivastav, 2006). The dam has a selective depth discharge system ensuring the best quality is released through the withdrawal outlet to meet farmland irrigation and downstream needs. An earthen dike runs north to south from the centre of the reservoir. The eastern part has shallow water body whereas the western part of the reservoir is deeper and completely covered by water.

The reservoir is surrounded by the agricultural land. The terrestrial vegetation is dominated by plantation of *Dalbergia sisoo* and *Acacia catechu* along the dike. The wetland vegetation consists of Morning glory (*Ipomea carnea ssp. fistulosa*) cattail (*Typha angustifolia*). The aquatic vegetation is represented by extensive coverage of floating leaved species mainly lotus (*Nelumbo nucifera*), wild rice (*Hygrorhiza aristata*) and pondweed (*Potamogeton nodosus*). The free floating species include water valvet (*Azolla imbricate*) and Duckweed (*Lemna* spp.) The abundant submerged species include water nymph *(Naja minor*), Hydrilla(*Hydrilla verticillata*) and Hornwort (*Ceratophyllum demersum*).

Fig. 1.2 Map showing *Jagadispur Reservoir*



Source: WWF, 2002

CHAPTER III

3.1 Materials and Methods

3.1.1 Reconnaissance Survey

The site was visited from 10th to 14th December, 2005 with the purpose of collecting baseline information about the research area. Additional information was collected by consulting the related experts, local people, literatures and maps of the research area.

3.1.2 Research design

The present investigation was conducted from January, 2006 to January, 2007 consisting of a period of 1 year. It consisted of three field visits in the month - winter, monsoon and autumn season.

3.1.2.1 Sampling sites

For the present investigation, 4 sampling sites were fixed on the basis of lentic bodies i.e. open water, marshland and Island to identify the habitat preference of birds and were designated as Site A, (Site B + Site C) and site D respectively as shown in figure.

Fig. 3.1 Sampling Sites in the study area

(*Source: Toposheet No. 098-13*)

General description of the sampling sites:

Site A: Inlet region of the reservoir dominated by Marsh and Swamp land.

Site B + C: The site consists of major portion of Island formation as a result of siltation.

Site D: Main body and outlet region of the reservoir containing open water with aquatic weeds.

3.1.2.2 Water sampling and analysis

Rubber tubes were used to reach the sampling sites and water samples (surface water) were collected from the sites with the help of sterilized sampling bottles. All the physico-chemical parameters (except total nitrogen) were determined according to the methods prescribed APHA, AWWA, WPCF (1995). The total nitrogen was determined according to the methods described in Trivedy and Goel (1984).

Surface Water Temperature

Water temperature was measured with the help of a mercury thermometer of -10 ^{o}C to 50^{o}C range with 0.2^{o}C least count. The bulb of the thermometer was dipped in a beaker filled with water sample for about 2 minutes and the reading was noted.

Transparency

The transparency of water was measured by using a Secchi Disc of 20cm diameter, divided into black and white quadrants. The disc was lowered in the water and the point where it just disappeared was noted. The disc was further lowered and began to rise and the point where it just reappeared was again noted. The distance was calculated with the help of those marked points and the transparency was calculated as

Secchi disc Transparency (cm) = (A+B)/2

Where, A = depth at which Secchi disc disappears (cm)

B = depth at which Secchi disc reappears (cm)

Hydrogen Ion Concentration (pH)

pH of the water sample was measured by an automatic digital pH meter (HI 8314 portable pH meter, HANNA instrument with an accuracy of ± 0.01 at $20^oC/68^oF$). Before measuring, the pH meter was first calibrated with standard buffer solution of pH 4.0 and 9.2. The glass electrode was washed with distilled water and dipped in a beaker containing fresh sample until the reading stabilized at a certain point. Then the pH reading was noted.

Free Carbondioxide

Principle: The amount of free Carbondioxide can be determined by the titration of the water sample using a strong alkali (such as NaOH) to pH 8.3. At this pH all the Free Carbondioxide is converted into bicarbonates. The completion of the reaction is indicated potentiometrically or by the development of the pink color characteristic of phenopthalein indicator at the equivalence pH of 8.3.

Procedure: 50ml of water sample was taken in a conical flask and a few drops of phenopthalein indicator were added. Then it was titrated against 0.05N NaOH.

Calculation:

$$\text{Free } CO_2 \text{ (mg/l)} = \frac{(ml \times N) \text{ of } NaOH \times 1000 \times 44}{\text{Volume of sample taken}}$$

Dissolved Oxygen

Principle(Winkler's Method): The basic concept of this Iodometric method is to bind the oxygen in the water with Iodine which is released as a result of chemical reaction. This chemically bound dissolved oxygen is quantitatively measured by titration with Sodium Thiosulphate ($Na_2S_2O_3$). The Manganous Sulphate reacts with the alkaline potassium hydroxide to form a white precipitate of manganous hydroxide which in the presence of oxygen gets oxidized to a brown coloured compound. In a strong acidic medium, manganic ions are reduced by iodide ions which get converted into iodine equivalent to the original concentration of oxygen in the sample. The Iodine can be titrated against Sodium Thiosulphate using Starch as an indicator.

Procedure: The water sample was collected in a 300ml BOD bottle avoiding any kind of bubbling and trapping of air bubbles in the bottle after placing the stopper. To the sample, 2ml of $MnSO_4$ and 2ml of alkaline KI solutions were added. Then the stopper was placed tightly and the bottle was shaken well. Then the bottle was left for a while to allow the precipitate to settle. 2ml of conc.H_2SO_4 was added to dissolve the precipitate by shaking the content well. Then 50ml of the content of BOD bottle was titrated with standard sodium thiosulphate (0.025 N) using starch as an indicator. At the end point, initial blue color changed to colorless.

Calculation:

$$\text{DO as } O_2 \text{ (mg/l)} = \frac{(ml \mid N)\, of\ titrant \mid 8 \mid 1000}{V_2 \mid \frac{V_1\, Z V}{V_1}}$$

Where, N = Strength of sodium thiosulphate

V_2 = Volume of content titrated

V_1 = Volume of sample bottle (BOD bottle)

V = Volume of $MnSO_4$ and KI added

Chloride

Principle: Silver Nitrate reacts with chloride to form very slightly soluble white precipitate of Silver Chloride. At the end point when all the Chlorides get precipitated, free Silver ions react with Potassium Chromate to form Silver Chromate of reddish brown colour.

Procedure: 50ml of water sample was taken in a conical flask and 2ml of potassium chromate was added to it as an indicator. Then it was titrated against 0.02 N $AgNO_3$ until persistent red tinge appear. This red tinge color is due to the formation of silver chromate of reddish brown color.

Calculation:

$$\text{Chloride (mg/l)} = \frac{(ml \times N)\ of\ AgNO_3 \times 1000 \times 35.5}{Volume\ of\ sample\ taken}$$

Total Alkalinity

Principle: Total alkalinity is the measure of the capacity of the water to neutralize the strong acid. Total alkalinity can be estimated by titrating the sample with a strong acid (HCl or H_2SO4), first to pH 8.3 using phenopthalein as indicator and further to pH 4.2 and 5.4 using methyl orange or mixed indicator.

Procedure: 100ml of water sample was taken in a conical flask and a few drops of phenopthalein indicator were added to it. The sample remained colourless. Then the content was added with 2-3 drops of methyl orange and titrated against Hydrochloric Acid. At the end point, yellow color changed to pink.

Calculation:

$$\text{Total Alkalinity as } HCaCO_3 \text{ (mg/l)} = \frac{A \times N \times 1000 \times 50}{\textit{Volume of sample taken}}$$

Where, A = Volume of standard H_2SO_4 used in titration.

N = Normality of H_2SO_4 used.

Orthophosphate

Principle: The Phosphates in the water react with Ammonium Molybdate and form complex and heteropoly Acid (Molybdophosphoric Acid), which gets reduced to a complex of blue color in the presence of Stannous Chloride. The absorbance of light by this blue color at 690nm can be used to calculate the concentration of Phosphates in water.

Procedure: 50ml of water sample was taken in a clean conical flask. The colloidal impurities and colour content were removed by adding a spoonful of activated charcoal prior to filtration. Then, 2ml of Ammonium Molybdate was added to the filtrate followed by the addition of five drops of stannous chloride. The absorbance was noted within 5 to 12 minutes after the addition of the last reagent. Then the orthophosphate concentration of the water sample was obtained by using standard curve.

Preparation of Standard Phosphate Solution

4.388 grams of dried anhydrous potassium Hydrogen Phosphate (KH_2PO_4) was dissolved in distilled water to make up a volume of 1 litter. 10ml of this solution was diluted to 1000ml (i.e. 100 times) to make the standard phosphate solution of concentration 10 mg/l.

Preparation of Standard Curve

A standard curve for the absorbance of phosphate at different concentrations was made by diluting the stock solution at different strengths. To 50ml of each dilution, 2ml Ammonium Molybdate and 4 drops of Stannous Chloride solution were added. The absorbance of each solution, after the development of blue color, was measured within 5 to 12 minutes after the addition of the last reagent at 690nm in the spectrophotometer.

Total Nitrogen

Principle: The digestion of the sample with H_2SO4 and Potassium Sulphate, converts all the organic Nitrogen and Ammonia into Ammonium Sulphate. However, most of the other forms remain unaffected. NaCl is added to prevent the partial reduction of Nitrate to Ammonia which converts the NO_2 into NOCl. The Nitrogen in the form of Ammonium Sulphate can be determined by distillation at higher pH.

Procedure: 40ml of water sample was taken in a 100ml Kjeldahl Flask. To the sample, 4ml H_2SO_4, 0.3ml $CuSO_4$ solution, 6gm of solid Potassium Sulphate and 1ml of 10 percent NaCl solution were added. The flask was heated on a heater to avoid loss through foaming. When the color of the content turned pale green, the heating process was continued for additional 30 minutes. The flask was cooled and the volume was diluted to 100ml. 25ml of the content was kept for distillation after the addition of 10ml of 10N NaOH. The distillate was titrated (in Boric Acid + Mixed Indicator) with 0.01N HCl until the color changed from blue to brown or faint pink.

Calculation:

$$\text{Total Nitrogen (mg/l)} = \frac{(a\text{-}b)\times 0.01\times 1000\times 14\times D}{\text{Volume of sample distilled}}$$

Where,

a = ml of HCI used with sample

b = ml of HCI used with blank

D = dilution factor (2.5)

3.1.2.3 Waterfowl Survey

In order to find the most appropriate time of day to survey water birds, a preliminary field survey was conducted to each of three zones at different times (hours) of the day from early morning to the late evening. The survey was started at 0600hrs and ended at 1800hrs for four consecutives days.

Birds were counted with a direct counting method which was generally used if the congregation was no more than 3000 birds (Bibby *et al.* 2000). This method was considered most appropriate since study zones were small and also there were small number of birds. Bird could be easily spotted so that it was assumed all birds within wetlands were counted. 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.

Each wetland zone was surveyed in the morning on foot at a constant pace to ensure that each zone was covered within same speedhey were observed from suitable observation points from where all the individual birds were counted directly using binoculars (8×30 magnifications) and telescope (20×magnifications). We spent 15 minutes to each of the survey points and counting was facilitated by dividing the area using natural features to avoid double counting.

Waterfowl survey was conducted in summer (September - October), 2006 and in winter (January - February), 2007. A popular field guide to the bird of Nepal (Grimmett et al. 1999, Inskipp and Inskipp 1991) was used for identification of birds.

Shannon-Wiener Diversity Index (H):

Species diversity of birds was calculated by using Shannon-Wiener function (Stiling, 1999)

$$H \text{ XZ } \quad pi \ln pi$$

where,

H = index of species diversity

pi = proportion of individuals found in the i^{th} species

3.1.2.4 Threat Identification

The day to day activities of the local people (women, indigenous Tharus, religious persons, children, herders, etc.) were observed and recorded. Each activity was related to its impact on the waterfowls and wetland ecosystem condition. The details of the identified threats are presented in 4.1.2.3 section.

3.2 Data Analysis

Microsoft Excel 2003 was used for statistical analysis to determine the species diversity of birds and to obtain the correlation results between different water quality variables.

CHAPTER IV

4.1 Results

4.1.1 Water Quality

Water quality parameter of Jagadishpur reservoir varied seasonally in different sites Annex (3a, 3b and 3c).

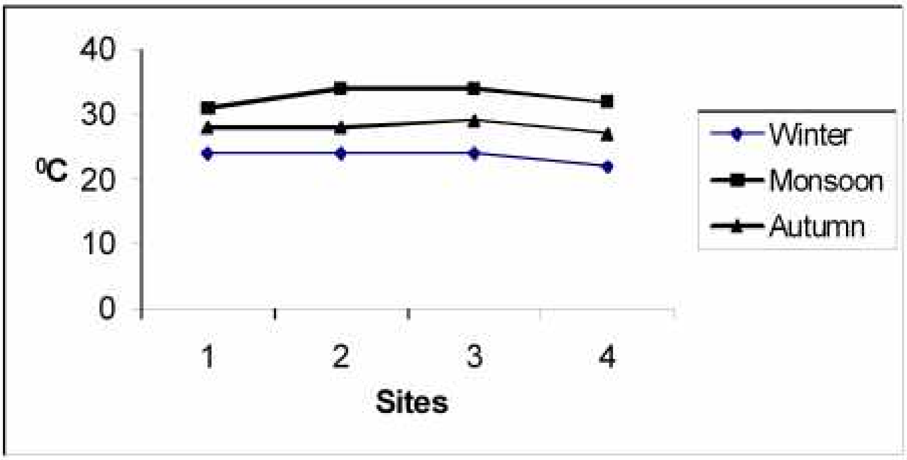


Fig: 4.1 Seasonal changes of surface water temperature in different sites.

The value of water temperature was higher in monsoon 32.75^{0}C followed by autumn 28^{0}C and was observed least in winter 23.5^{0}C. Fig. 4.1.

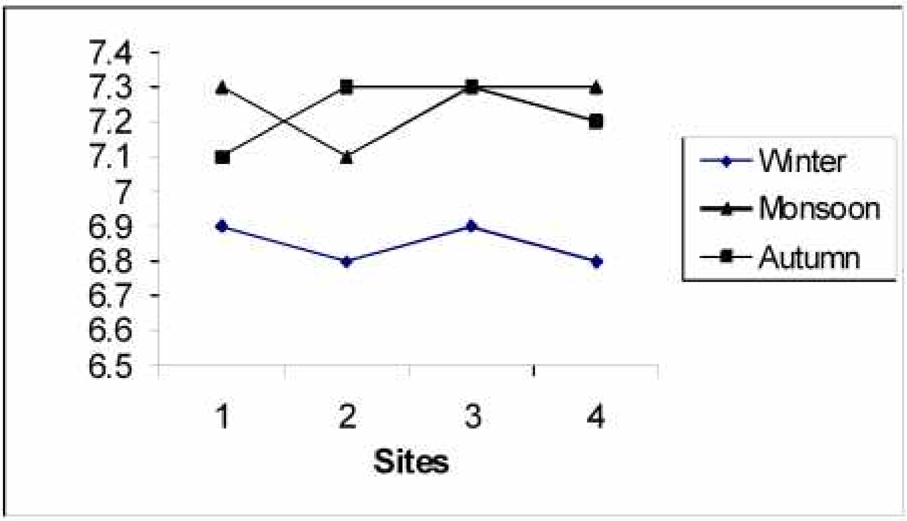


Fig: 4.2 Seasonal changes of pH in different sites.

The pH value was found higher in monsoon season 7.25 whereas lowest 6.85 in winter. Fig. 4.2

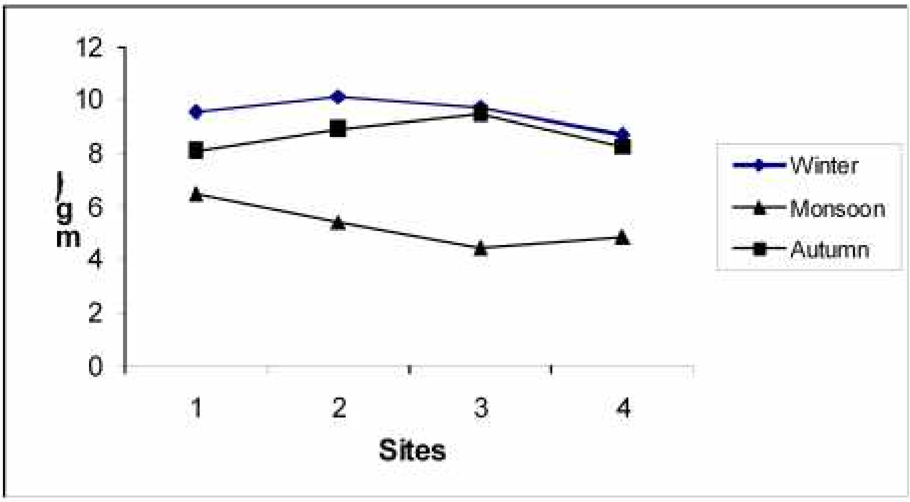


Fig: 4.3 Seasonal changes of DO in different sites

The dissolved oxygen as O_2 was 9.54mg/l in winter, 8.71 in autumn and 5.30mg/l in monsoon. Fig. 4.3.

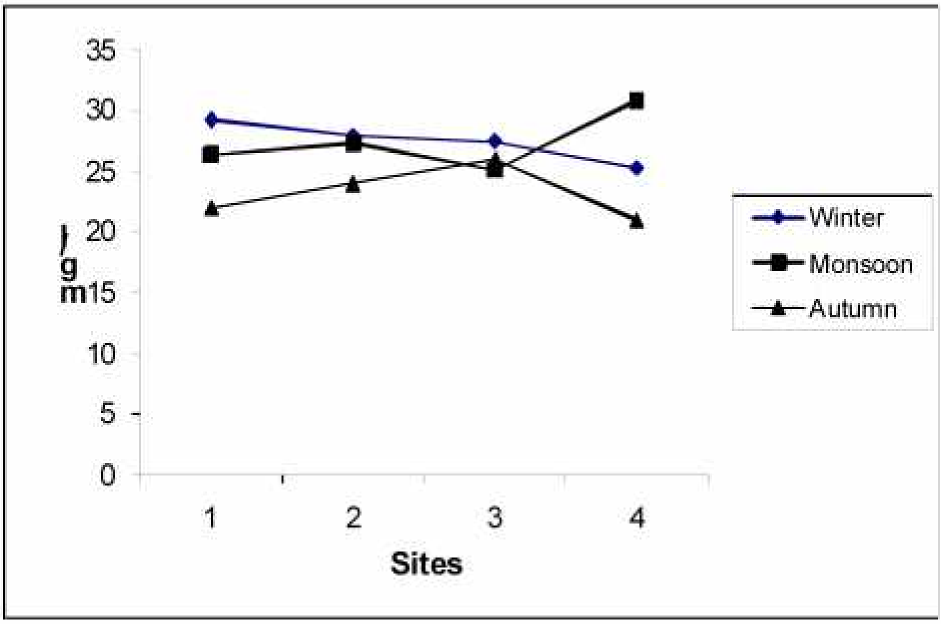


Fig. 4.4: Seasonal changes of free CO_2 in different sites.

The average value of free CO_2 was 27.5mg/l in winter, 27.40mg/l in monsoon and 23.25mg/l in autumn. Fig. 4.4.

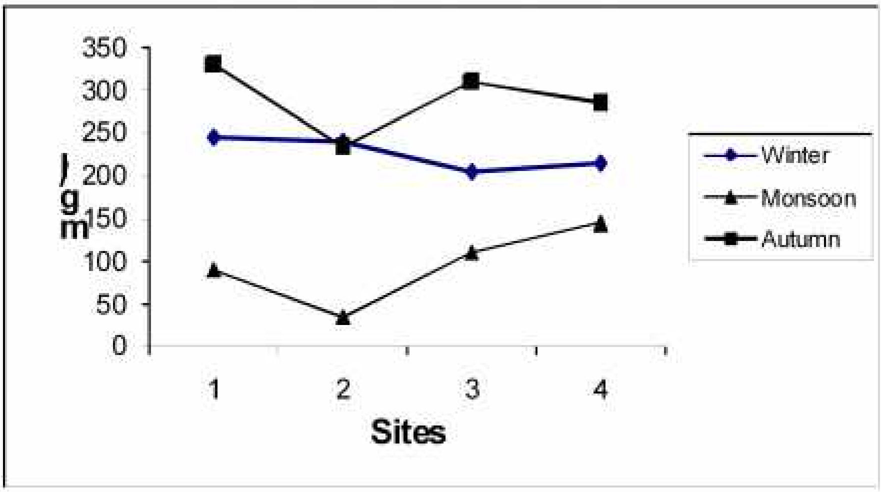


Fig. 4.5 Seasonal changes of total alkalinity in different sites.

The total alkalinity value as $CaCo_3$ was 290mg/l in autumn, 226.25mg/l in winter and 95mg/l in monsoon. Fig. 4.5

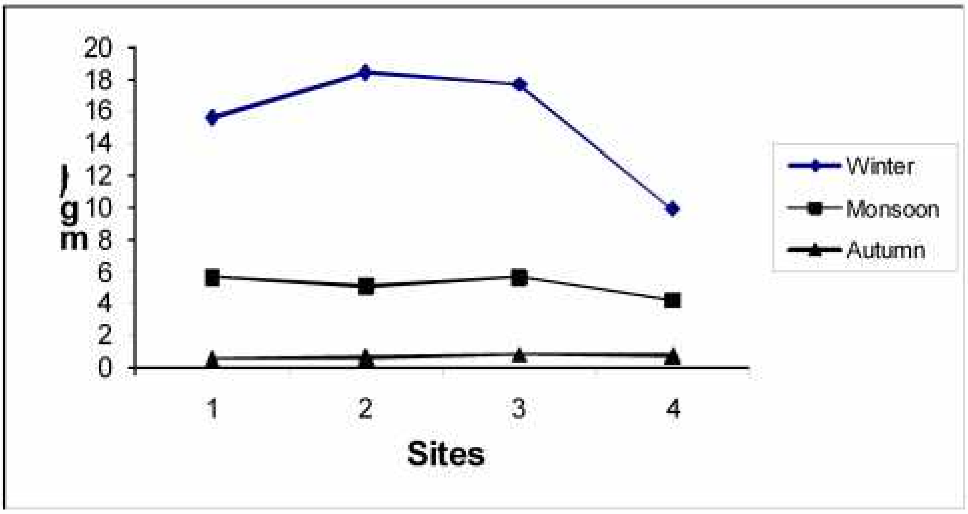


Fig. 4.6 Seasonal changes of chloride in different sites

The highest value of chloride was observed in winter 15.41mg/l followed by 5.17mg/l in monsoon and minimum 0.7mg/l in autumn. Fig. 4.6

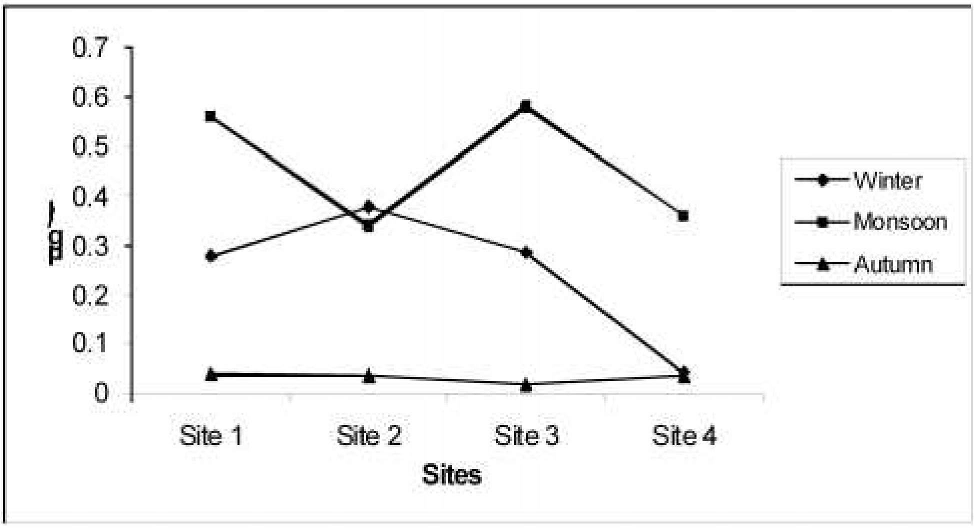


Fig.4.7. Seasonal changes of PO_4-P in different sites.

The concentration of Po_4-P was 0.46µg/l in monsoon and least in Autumn season i.e. 0.03µg/l. Fig. 4.7.

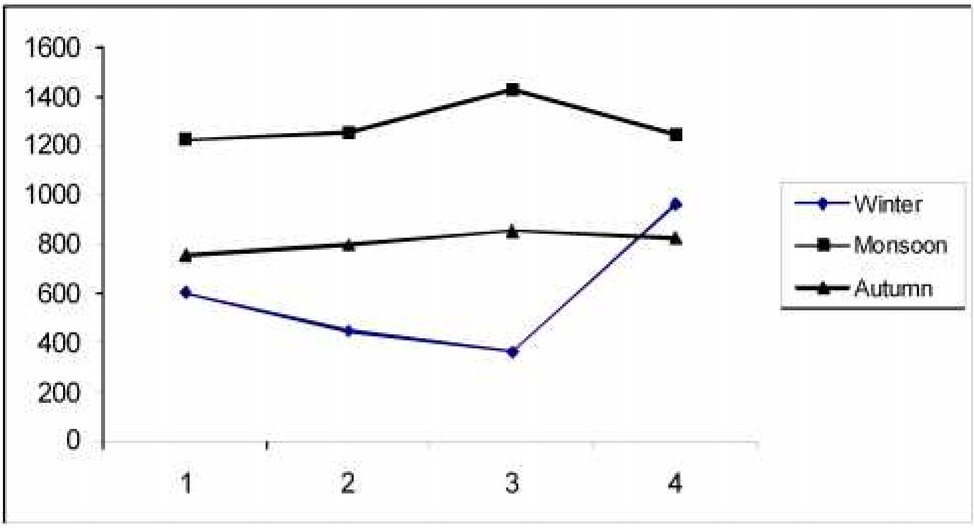


Fig. 4.8 Seasonal changes of total nitrogen in different sites.

The concentration of TN was found highest in Monsoon i.e. 1288.75µg/l and least in winter season i.e. 594.5µg/l. Fig. 4.8.

Table 4.1: Correlation Coefficient (r) within different variable

	water temp	pH	Conductivity	Transparency	DO	Free Carbon dioxide	alkalinity	chloride	PO4-P	TN
water temp	1									
pH	0.787112	1								
Conductivity	0.81279	0.8975	1							
Transparency	-0.83223	-0.78273	-0.98113	1						
DO	-0.86618	-0.57252	-0.60263	0.783256	1					
Free Carbon dioxide	0.041887	-0.21239	-0.36453	0.075414	-0.12903	1				
Total alkalinity	-0.61287	-0.19475	-0.16364	0.561737	0.741441	-0.43604	1			
chloride	-0.57741	-0.80749	-0.90946	0.660707	0.408603	0.567543	-0.08868	1		
PO4-P	0.466795	0.108495	-0.02488	-0.31860	-0.56885	0.520871	-0.76437	0.364445	1	
TN	0.822815	0.63384	0.63948	-0.58927	-0.91871	0.02470	-0.6728	-0.54572	0.42313	1

4.1.2 Avifaunal Resources

4.1.2.1 Preliminary results

4.1.2.2 Presence of bird over the day

The initial study revealed that early morning was the best time to survey wetland birds at *Jagadishpur reservoir*. Comparing the results throughout the day, the number of bird species and total individuals were found to be relatively high in the early morning, compared to the rest of the day. The highest number of bird species (n=9) and total individuals (N = 226) were recorded in the early morning compared in the late morning (n = 5, N = 182) and in the afternoon (n = 3, N = 57) number decreased. A small increase in both bird species and total individuals was found in the early evening (n = 7, N = 190) Fig. 4.9 and 4.10.

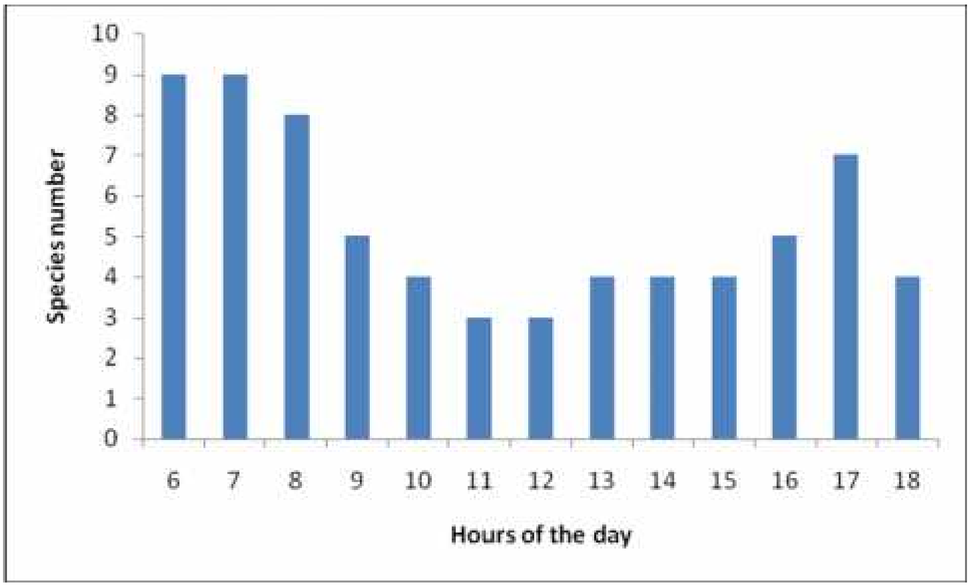


Fig. 4.9: The number of bird species recorded at different times (hours) of the day.

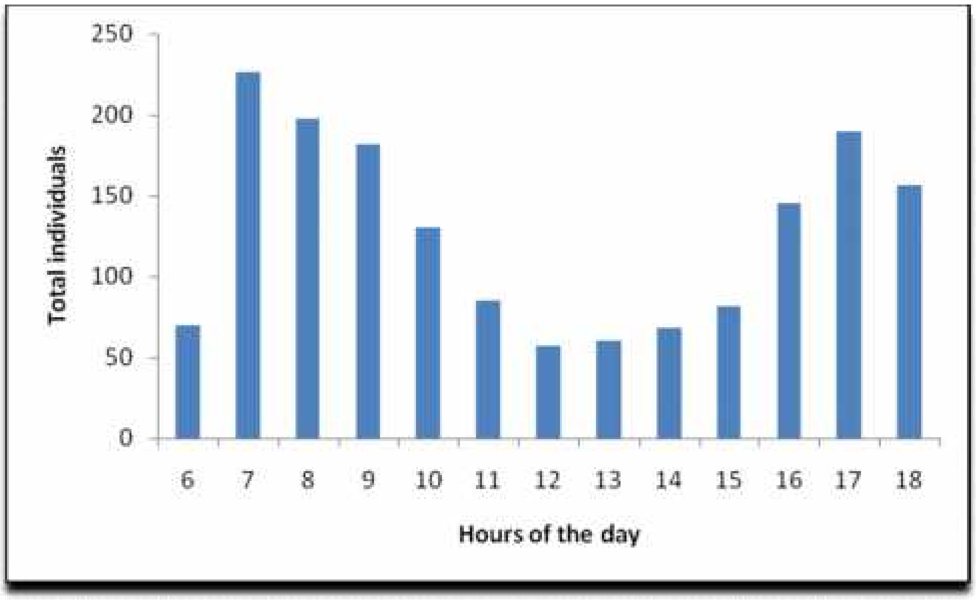


Fig. 4.10: The total individuals of bird species recorded at different times (hours) of the day.

4.1.2.3 Species richness (Species number)

A total of 35 species belonging to 7 orders, 10 families and 22 genera were recorded from all three study zones of the study area (Table 4.2). The highest number of bird species (n=25) was recorded from site D. The second highest number of species was recorded from site B & C (n=17) followed by site A (n=12) Fig. 4.11.

Fig. 4.11: The number of bird species recorded at different study zones.

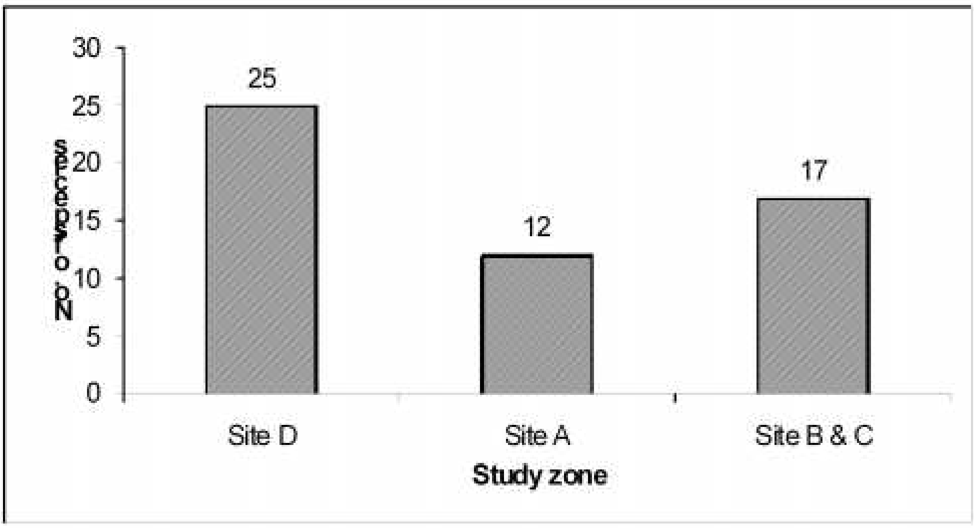


Table 4.2 Check List of Avifauna recorded from Jagadishpur Reservoir

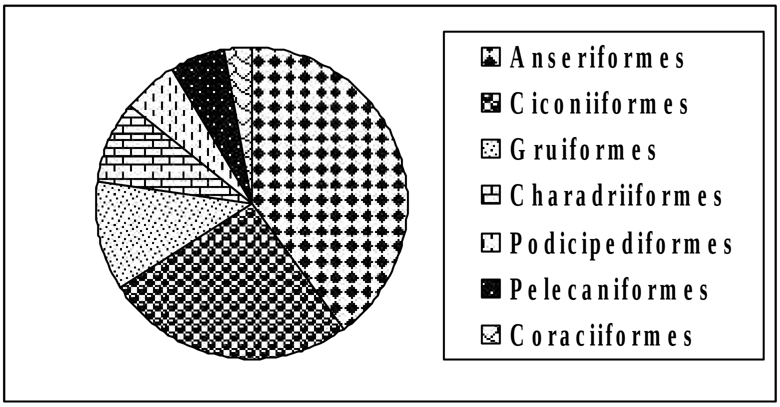
Order	**Family**	**Genus**	**Species**	**Common name**
Anseriformes	Anatidae	*Anas*	*Anas penelope*	Eurasian Wigeon
			Anas strepera	Gadwall
			Anas crecca	Common Teal
			Anas platyrhynchos	Mallard
			Anas flacata	Falcated Duck
			Anas acuta	Northern Pintail
			Anas clypeata	Northern Shoveler
			Anas querquedala	Gargeny
		Nettapus	*Nettapus coromandelianus*	Cotton Pigmy Goose
		Aythya	*Aythya ferina*	Common Pochard
			Aythya nyroca	Ferruginous Pochard
			Aythya fuligula	Tufted Duck
		Rhodonessa	*Rhodonessa rufina*	Red Crested Pochard
		Dendrocygna	*Dendrocygna javanica*	Lesser Whistling Duck
Ciconiiformes	Ardeidae	*Bubulcus*	*Bubulcus ibis*	Cattle Egret
		Egretta	*Egretta garzetta*	Little Egret
			Egretta intermedia	Intermediate Egret
		Casmerodius	*Casmerodius albus*	Great Egret
		Ardea	*Ardea cinerea*	Grey Heron
			Ardea purpurea	Purple Heron
		Ardeola	*Ardeola grayii*	Indian Pond Heron
	Ciconidae	*Anastomus*	*Anastomus oscitans*	Asian Openbill Stork

		Ciconia	*Ciconia episcopus*	Woolly-necked Stork
Podicipediformes	Podicipedidae	*Podiceps*	*Podiceps cristatus*	Great Crested Grebe
		Tachybaptu	*Tachybaptus ruficollis*	Little Grebe
Pelecaniformes	Phalacrocoracidae	*Phalacrocorax*	*Phalacrocorax niger*	Little Cormorant
			Phalacrocorax carbo	Great Cormorant
Gruiformes	Rallidae	*Fulica*	*Fulica atra*	Common Coot
		Porphyrio	*Porphyrio porphyrio*	Purple Swamphen
		Gallinula	*Gallinula chloropus*	Common Moorhen
	Gruidae	*Grus*	*Grus antigone*	Sarus Crane
Charadriiformes	Jacanidae	*Metopidius*	*Metopidius indicus*	Bronze-winged Jacana
		Hydrophasianus	*Hydrophasianus chirurgus*	Pheasant-tailed Jacana
	Charadriidae	*Vanellus*	*Vanellus indicus*	Red-wattled Lapwing
Coraciiformes	Alcedinidae	*Halcyon*	*Halcyon Smyrnensis*	White throated Kingfisher
7 orders	10 families	22 Genera	35 species	

Species composition by order and family:

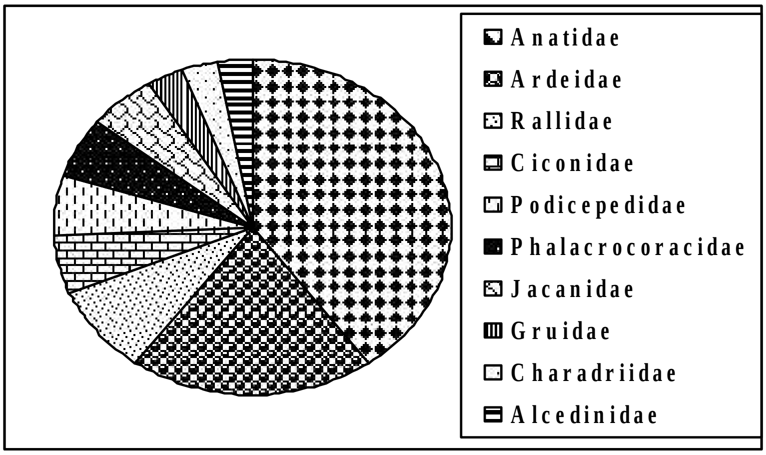
Order Anseriformes represented the highest bird species composition (14 species i.e. 40%) followed by Ciconiformes (9 species i.e. 25%) and Charadiiformes (3 species i.e. 8%) Fig. 4.12.

Fig. 4.12 Order-wise bird species composition.



Similarly, family Anatidae represented the highest bird species composition (14 species i.e. 40%) followed by Ardeidae (7 species i.e. 20%) and Rallidae (3 species i.e. 8%). Fig. 4.13.

Fig. 4.13: Family-wise bird species composition



4.1.2.4 Systematic Position of Birds

The birds recorded from Jagadishpur Reservoir are classified to species level after Howard and Moore (1994)

Order: Anseriformes

Family: Anatidae

Genus: *Anas* Linnaeus 1758

Species: *Anas penelope* Linnaeus 1758

Order: Anseriformes

Family: Anatidae

Genus: *Anas* Linnaeus 1758

Species: *Anas strepera* Linnaeus 1758

Order: Anseriformes

Family: Anatidae

Genus: *Anas* Linnaeus 1758

Species: *Anas crecca* Linnaeus 1758

Order: Anseriformes

Family: Anatidae

Genus: *Anas* Linnaeus 1758

Species: *Anas platyrhynchos* Linnaeus 1758

Order: Anseriformes

Family: Anatidae

Genus: *Anas* Linnaeus 1758

Species: *Anas falcata* Georgi 1775

Order: Anseriformes

Family: Anatidae

Genus: *Anas* Linnaeus 1758

Species: *Anas acuta* Linnaeus 1758

Order: Anseriformes

Family: Anatidae

Genus: *Anas* Linnaeus 1758

Species: *Anas clypeata* Linnaeus 1758

Order: Anseriformes

Family: Anatidae

Genus: *Anas* Linnaeus 1758

Species: *Anas querquedula* Linnaeus 1758

Order: Anseriformes

Family: Anatidae

Genus: *Nettapus* Brandt 1836

Species: *Nettapus coromandelianus* Gmelin 1758

Order: Anseriformes

Family: Anatidae

Genus: *Aythya* Boie 1822

Species: *Aythya ferina* Linnaeus 1758

Order: Anseriformes

Family: Anatidae

Genus: *Aythya* Boie 1822

Species: *Aythya nyroca* Guldenstadt 1770

Order: Anseriformes

Family: Anatidae

Genus: *Aythya* Boie 1822

Species: *Aythya fuligula* Linnaeus 1758

Order: Anseriformes

Family: Anatidae

Genus: *Netta* Kaup 1829

Species: *Netta rufina* Pallas 1773

Order: Anseriformes

Family: Anatidae

Genus: *Dendrocygna* Swainson 1837

Species: *Dendrocygna javanica* Horsfield 1821

Order: Ciconiiformes

Family: Ardeidae

Genus: *Bubulcus* Bonaparte 1855

Species: *Bubulcus ibis* Linnaeus 1758

Order: Ciconiiformes

Family: Ardeidae

Genus: *Egretta* Forster 1817

Species: *Egretta garzetta* Linnaeus 1758

Order: Ciconiiformes

Family: Ardeidae

Genus: *Egretta* Forster 1817

Species: *Egretta intermedia* Wagler 1822

Order: Ciconiiformes

Family: Ardeidae

Genus: *Egretta* Forster 1817

Species: *Egretta alba* Linnaeus 1758

Order: Ciconiiformes

Family: Ardeidae

Genus: *Ardea* Linnaeus 1758

Species: *Ardea cinerea* Linnaeus 1758

Order: Ciconiiformes

Family: Ardeidae

Genus: *Ardea* Linnaeus 1758

Species: *Ardea purpurea* Linnaeus 1766

Order: Ciconiiformes

Family: Ardeidae

Genus: *Ardeola* Boie 1822

Species: *Ardeola grayii* Sykes 1832

Order: Ciconiiformes

Family: Ciconidae

Genus: *Anastomus* Bonnaterre 1791

Species: *Anastomus oscitans* Boddaert 1783

Order: Ciconiiformes

Family: Ciconidae

Genus: *Ciconia* Brisson 1760

Species: *Ciconia episcopus* Boddaert 1783

Order: Podicipediformes

Family: Podicepedidae

Genus: *Tachybaptus* Reichenbach 1853

Species: *Tachybaptus ruficollis* Pallas 1764

Order: Podicipediformes

Family: Podicepedidae

Genus: *Podiceps* Latham 1787

Species: *Podiceps cristatus* Linnaeus 1758

Order: Pelecaniformes

Family: Phalacrocoracidae

Genus: *Phalacrocorax* Brisson 1760

Species: *Phalacrocorax niger* Vieillot 1817

Order: Pelecaniformes

Family: Phalacrocoracidae

Genus: *Phalacrocorax* Brisson 1760

Species: *Phalacrocorax carbo* Linnaeus 1758

Order: Gruiformes

Family: Rallidae

Genus: *Fulica* Linnaeus 1758

Species: *Fulica atra* Linnaeus 1758

Order: Gruiformes

Family: Rallidae

Genus: *Porphyrio* Brisson 1760

Species: *Porphyrio porphyrio* Linnaeus 1758

Order: Gruiformes

Family: Rallidae

Genus: *Gallinula* Brisson 1760

Species: *Gallinula chloropus* Linnaeus 1758

Order: Gruiformes

Family: Gruidae

Genus: *Grus* Brisson 1760

Species: *Grus antigone* Linnaeus 1758

Order: Charadriiformes

Family: Jacanidae

Genus: *Metopidius* Brisson 1760

Species: *Metopidius indicus* Linnaeus 1758

Order: Charadriiformes

Family: Jacanidae

Genus: *Hydrophasianus* Wagler 1832

Species: *Hydrophasianus chirurgus* Scopoli 1786

Order: Charadriiformes

Family: Charadriidae

Genus: *Vanellus* Brisson 1760

Species: *Vanellus indicus* Boddaert 1783

Order: Coraciiformes

Family: Alcedinidae

Genus: *Halcyon* Swainson 1821

Species: *Halkyon smyrnensis* Linnaeus 1758

Table 4.3: Number of birds recorded from the reservoir during the investigation period in different sites.

Name of Species	**Sites**	**Summer (2006) (September-October)**	**Winter (2007) (January-February)**
		No. of individual species	No. of individual species
Anatidae (Ducks and geese)			
Eurasian Wigeon (*Anas penelope)*	D, A		272
Gadwall (*Anas strepera*)	D,A		339
Common Teal (*Anas crecca*)	D,A	10	128
Mallard (*Anas platyrhynchos*)	D,A		316
Falcated Duck (*Anas flacata*)	D,A		56
Northern Pintail (*Anas acuta)*	D,A	3	282
Northern Shoveler (*Anas clypeata*)	D,A		156
Gargeny (*Anas querquedala*)	D,A	1	180
Cotton Pigmy Goose (*Nettapus coromandelianus*)	D		38

Common Pochard (*Aythya ferina*)	D		315
Ferruginous Pochard (*Aythya nyroca*)	D		375
Tufted Duck (*Aythya fuligula*)	D		26
Red Crested Pochard (*Rhodonessa rufina*)	D		32
Lesser Whistling Duck (*Dendrocygna javanica*)	B & C, D	4	355
Ardeidae (Herons and Egrets)			
Cattle Egret (*Bubulcus ibis*)	B & C, A, D	8	2
Little Egret (*Egretta garzetta*)	B & C	4	7
Intermediate Egret (*Mesophoyx intermedia*)	B & C		6
Great Egret (*Casmerodius albus*)	B & C		12
Grey Heron (*Ardea cinerea*)	B & C		1
Purple Heron (*Ardea purpurea*)	B & C	8	3
Indian Pond Heron (*Ardeola grayii*)	A, B & C, D	2	14
Ciconidae (Storks)			
Asian Openbill Stork (*Anastomus oscitans*)	B & C	34	24
Woolly-necked Stork (*Ciconia episcopus*)	B & C	2	1
Podicipidae (Grebes)			
Great Crested Grebe (*Podiceps cristatus*)	D		12
Little Grebe (*Tachybaptus ruficollis*)	D	12	43
Phalacrocaracidae (Cormorants)			
Little Cormorant (*Phalacrocorax niger*)	B & C & D	24	15
Great Cormorant (*Phalacrocorax carbo*)	B & C & D		27
Rallidae (Rails, coot and waterhens)			
Common Coot (*Fulica atra*)	D	28	600
Purple Swamphen (*Porphyrio porphyrio*)	D	6	205

Common Moorhen (*Gallinula chloropus*)		A, B & C, D	4	388
Jacanidae (Jacanas)				
Bronze-winged Jacana (*Metopidius indicus*)		A, B & C, D	2	13
Pheasant-tailed Jacana (*Hydrophasianus chirurgus*)		D		8
Gruidae (Cranes)				
Sarus Crane (*Grus antigone*)		B & C	12	4
Alcedinidae (Kingfishers)				
White-throated Kingfisher (*Halcyon Smyrnensis*)		B & C	1	2
Red-wattled Lapwing (*Vanellus indicus*)		B & C		7
Total	35		165	4264

Using Microsoft Excel, 2003

Shannon - H = 2.790 in winter.

H = 2.438 in summer

Hence, the Shannon-Wiener Diversity Index (H) for winter is 2.790 and for summer is 2.438 which shows that the species diversity of birds in winter is more than that in summer.

4.1.2.5 Major threats to birds

Main threats to the wetland birds in the *Jagadishpur Reservoir* are as follows:

a. Siltation: - Heavy Siltation with more decaying organic materials and some soil was observed in all parts of the reservoir. However, the middle parts of the reservoir still consists crystal water. The representatives of a local NGO, informed me that if the lake was cleaned by removing the deposits, the lake condition improves but the diversity of the birds would decline. If not, diversity of birds would increase at the cost of sedimentation in the reservoir.

b. Dependency on wetland resources: There is a high dependence of local people on wetland resources. The local community extracts fish, snails, firewood, and lotus leaves for use. Fishing was year-round practice of the indigenous Tharu people. They were very poor and they had no alternative living options.

c. Invasive species: *Ipomea carnea ssp. fistulosa* was the major invasive alien species in the area. The species was rapidly colonizing marshes/swamps, canals and ditches. Water Hyacinth (*Eichhornia crassipes*) had been spreading in small lakes and marshes.

d Poaching and poisoning: Egg collection, bird trapping by using poisons e.g. pesticides (particularly Furadon) and other chemicals derived from local plants and hunting of birds using the round stone hit by elastic rubber rope were seen in the wetland area during the field visits.

e. Draining: Draining of entire wetlands to harvest all fish and aquatic products is widely practiced, an unsustainable method since it causes the loss of feeding and breeding sites of other species and causes habitats to undergo ecological succession towards dry land.

CHAPTER V

5.1 Discussion

5.1.1 Water Quality

Water temperature is one important factor in aquatic environment as it affects the organisms, as well as the chemical and physical characteristics of water (Delince, 1992; Abdo, 2005). If temperature goes too far above or below the tolerance range for a given taxon (e.g. fish, insects, zooplankton, phytoplankton, microbes), its ability to survive may be reduced (Hoegh-Guldberg, 1999).

Temperature in the range 20^0 to 32^0C is ideal for majority of freshwater fishes (Boyd, 1990). The water temperature in the *Jagadishpur Reservoir* ranged within this value (Annex 3a-3c). Temperature showed a high degree of negative correlation with DO, Transparency and conductivity. (Table 4.1)

Water transparency is important as it determines the amount of light penetration that occurs in the water column. Low water transparency reflects low photosynthetic activity, as a result of which DO declines and organisms may become stressed (Boyd, 1990)

The transparency was fairly good except in the monsoon season; the low transparency was due to heavy sediment load deposition by flood water. The greater Secchi disc transparency in the winter may be associated with the presence of little aquatic vegetation and the lack of external loading from surrounding areas. The trophic classification given by Forsberg and Ryding (1980) revealed the eutrophic condition of the *Jagadishpur Reservoir* on the basis of Secchi disc transparency (Annex 3a-3c and Annex 4). Transparency showed a high degree of positive correlation with DO and Chloride (Table 4.1).

Transparency is inversely related to turbidity which is caused by planktons and suspended solids in the water column (Boyd, 1990). Inorganic particles can have detrimental effects on the aquatic organisms. Suspended particulate matter in water provides a vast amount of surface area for the growth of bacteria and fungi and could increase the potential for disease in the water system (Cairns, 1967).

The Hydrogen ion concentration of the water body is one of the most important local factors known to influence Fish Community Composition (Appelberg et al., 1993). The value of pH is slightly alkaline in monsoon and autumn and slightly acidic in winter. A pH range of 6.5 to 9 is best for majority of aquatic organisms (Wurts and Durborow, 1992). The pH of the reservoir fluctuated between 6.85 ± 0.05 and 7.25 ± 0.1 (Annex 3a - 3c).

The level of DO present in the water is among the most important factor of water quality. If a sufficient amount of DO is not present, animals will be stressed, becoming vulnerable to diseases and parasite outbreaks or will die (Stickney, 1979).

DO equal to or in excess of 5 mg/lt is considered good for majority of fresh water organisms (Wheaton, 1977). Low DO is often associated with epizootic outbreaks of bacterial and protozoan infections in the aquatic organisms (Spotte, 1970). The seasonal patterns of dissolved oxygen in tropical reservoirs are likely to differ from their temperate counterparts because warm tropical waters are more susceptible to oxygen depletion. This may due to the reduced solubility of oxygen in warm waters coupled with higher rates of microbial metabolism as supported by (Townsend, 1999).

The DO in the reservoir never fell below 5mg/l (Annex 3a-3c) which indicates that the water is well oxygenated so as to support diverse aquatic organism. DO showed a high degree of positive correlation with total alkalinity and chloride and significant negative correlation with Total Nitrogen (Table 4.1).

Free CO_2 is an important water quality parameter as high concentrations depress the affinity of fish blood for O_2 and cause suffocation to the fish (Spotte, 1970).

Carbondioxide rarely causes direct toxicity to aquatic organisms. However, high concentration of free CO_2 lower the pH of the water body and limit the capacity of fish blood to carry oxygen by lowering blood pH at the gills (Wurts and Durborow, 1992). This effect by which high concentrations of free CO_2 depress the affinity of fish blood for O_2 is known as root effect and this may be significant in water systems with low O_2 tensions and weak buffering capacities (Spotte, 1970). High concentrations of free CO_2

in water are associated with epizootic outbreaks of bacterial and protozoan infections (Spotte, 1970).

An optimum level of alkalinity provides a good buffering effect to pH swings that occur in the water body thus preventing extreme diurnal pH fluctuations (Boyd, 1990). A total alkalinity of 20 mg/l or more is necessary for good community production (Wurts and Durborow, 1992).

Total alkalinity showed a negative correlation with chloride, phosphate and Total Nitrogen (Table 4.1).

According to Spence (1964), the water bodies are divided into three categorizes according to total alkalinity value i.e. poor nutrient (1 to 15 mg/l), moderately rich nutrient (16 to 60mg/l) and rich nutrient (760 mg/l). Hence, the total alkalinity value observed in the present study categorized the reservoir as nutrient rich water body according to categorization of Spence (1964).

Chloride is a common ion that has little biological significance in fresh water but still it serves as a useful marker for water movements and dilution (Brock, 1985). The relative decrease in chloride concentration during the hot period especially in autumn may be due to dilution after rainy season. The highest value of it during the winter may be due to reduction of water level in the reservoir. (Annex 3a - 3c)

Chloride showed positive correlation with phosphate and negative correlation with Total Nitrogen.

Phosphorus occurs in natural water almost solely as phosphates. Ortho-phosphates are applied to agricultural or residential cultivated land as fertilizers which are carried into surface waters with storm runoff. Organic phosphates are formed primarily by biological processes. They are contributed to sewage, organic wastes. Phosphates are limiting nutrient which are discharged as a raw or agricultural drainage or certain industrial wastes so that water may stimulate the growth of photosynthetic aquatic micro-and macro-phytes in nuisance quantities.

Phosphate is the mineral compound, which is required for the growth of plant. The concentration of orthophosphate in water is due to agricultural runoffs during the monsoon period. The influx of phosphorus to lake with sewage and runoff from the fertilized land brings disastrous consequences for the ecosystems (eutrophication or algal bloom).

Phosphorus is commonly accepted as the most important controlling nutrient in freshwater lake ecosystems (Schindler, 1975). The tropic classification given by Forsberg and Ryding (1980) revealed the oligotrophic condition of the reservoir on the basis of total phosphorus (Annex 3a-3c and Annex 4)

Nitrate is very important Biogenic salt. It is required for the growth of phytoplankton. The source of nitrogen is the molecular nitrogen on the atmosphere. To a very limited extent, some dissolves in water. Nitrate in water is considered as a final oxidation product of nitrogen. Ammonia-based fertilizers are converted by microbes to nitrate. Nitrate is leached into waterways as pollution from heavy fertilized agricultural land.

Nitrate is the end product of the aerobic stabilization of organic nitrogen. The organic nitrogen is the macronutirents for the plant growth, which are required in large amounts. Organic nitrogen in the water came from soil organic matter. Soil organic matter are broken material of dead and decayed plants and animals parts. The source of nitrate in the lake water are soluble nitrogenous compounds like nitrites, ammonia, etc which are entered to the lake during the monsoon season.

The reservoir is categorized as eutrophic based on trophic state criteria proposed by Forsberg and Ryding (1980) (Annex 3a - 3c, and Annex 4).

5.1.2 Bird Resources

5.1.2.1 Effect of time of day for surveying Avifauna

The number of bird species and total individuals were found vary at different times of day from early morning to late evening. Surveys was conducted in the morning because the highest number of bird species and individuals were recorded compared to the rest of the day in the study area. Avifauna are very active during the morning and evening with little activate during the rest of the day thereby giving highest opportunity for maximum capturing of the bird species and total individuals within the study area. These findings are largely consistent with many bird researches. They found that the activity and song output are greatest near dawn, low during the middle of the day, and increase again close to dust (Robbins 1981, Lay 1938) and thereby giving the best result in the early morning compared to later (Grinnell & Storer 1924, Lay 1938). However wetland birds are not easily monitored by the standard census techniques (Bibby et al. 1992) because of the diversity in their behaviour.

Accurate censuring of wetland birds requires a variety of techniques, including nocturnal surveys, nest counts, intensive efforts involving walking or canoeing through marshes, and the use of recorded calls of elicit responses (Weller 1986). The poorest sighting of the birds were made during the middle of day was probably due to the effects of the time of day, when birds are generally inactive.

5.1.2.2 Effect of seasonality

As expected large number of bird species and individuals were counted in mid winter (January- February) compared to that of summer (September - October) in the study area. It was probably because of the high mobility of birds during these periods. 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 & Cransnick 2003).

Species diversity of bird was found higher in winter (i.e. Shannon-Wiener diversity index: 2.790) in comparison to that of summer (i.e. Shannon-Wiener diversity index: 2.438). Values of Shannon-Wiener are often found to fall between 1.5 and 3.5 (Stiling, 1999).

Species diversity was found higher in winter than in summer. Species perform diverse ecological functions. Some species regulate bio-geo-chemical cycles (Vitousek, 1990). Some species modify the physical environment (Jones et al., 1994). Some species regulate ecological processes through trophic interaction-predation, parasitism etc. (Kitchell and Carpenter, 1993) or through functional interactions such as pollination (Fleming and Sosa, 1994) and seed dispersal (Brown and Heske, 1990) The variety of functions that a sp. can perform is limited, and consequently ecologists frequently have proposed than an increase in species diversity also increases functional diversity, producing and increase in ecological stability (Tilman et. al, 1996).

5.1.2.3 Habitat preference

The results suggest that the open water area is most important for wetland birds.

The large stretch of water and vegetation consisting of reed grasses and water lilies, support an incredible number of ducks, grebes and coot, while the floating vegetation provides an ideal habitat for Bronze-winged Jacana *Metopidius indicus,* Common Moorhen *Gallinula chloropus* and Purple Swamphen *Gallinula chloropus* (Wijeyamohan 2002).

Likewise the Bronze-winged Jacana prefers floating and emergent vegetation habitat and eats small aquatic invertebrates which are gleaned from vegetation at the water surface but they also take small seeds and other plant matter (Butchart 1998).

Some species of birds 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 138000 individuals per square meter (O' Hara 1967). The study found that some water bird species such as Common Moorhen, Bronze-winged Jacana, Indian Pond Heron and Cattle Egret are highly adaptable species and was found in all zones regardless of the intensity of the invasion. The fibrous root system of water hyacinth provides nesting habitat for invertebrates and insects and leaf blades and petioles are occasionally used by them. Common Moorhen was one of the highly abundant species in each zone and contributed significantly include all zones making the difference in community composition. This high population abundance of the Common Moorhen indicates a preferred habitat in the water hyacinth mats. The species was found nesting on water hyacinth mats and feeds on them and most often obtained prey that were located near the perimeter of the mats (Bartodziej & Weymouth 1995).

5.1.2.4 Effect of disturbances

Anthropogenic disturbances have been detrimental to birds if it causes the birds to stop feeding and seek for the alternative habitat (Marsden 1997). He found that in 76% of his observations, 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.

The study found that the species such as Red wattled lapwing left the site after people activities and did not return to the site in the time of survey period. The species may not have become habituated to the irregular nature and noise of the activities associated with fuel wood collection & fishing at *Jagadishpur reservoir*.

Some previous studies found that the activities associated with hunting, fuel wood collection and fishing reduced the feeding time for birds and compelled them to displace from particular habitats (Dahal, 2000). The hunting is the major threats for waterfowl especially duck because they are large in size and are easy to trap them. Hunting attempt has had significant threats to the water birds which might completely flush out the birds from the site for a longer period. The impact of disturbance on populations of birds depends upon the availability of alternatives habitats (Burton *et al.* 2002).

CHAPTER VI

6.1 Conclusion

A total of 35 wetland bird species belonging to 7 orders 10 families and 22 genera were recorded according to the classification after Howard and Moore (1994) during the investigation period from the reservoir. Anseriformes was the most representative order and Anatidae the most representative family each accounting for 40% of the species composition.

A total of 4264 were enumerated with high species richness from open water habitat. However, the results showed that certain species were found to be dominant in the community associated with water hyacinth. There were a significantly high number of individuals of some species e.g. Common Moorhen and Bronze-winged jacana in the habitat associated with extensive coverage of invasive weeds. Species diversity of bird was found to be greater in winter (i.e. Shannon-Wiener diversity index: 2.790) in comparison to that of summer (i.e. Shannon-Wiener diversity index: 2.438)

Siltation, dependency of local population on wetland resources, invasion by aquatic weeds, poaching and draining of wetland are identified as the major threats to the bird species.

The physico-chemical parameters analyzed i.e surface water temp. transparency, pH, DO, total alkalinity, chloride, free CO_2, orthophosphate and total nitrogen revealed that the reservoir can support diverse aquatic flora and fauna. The trophic status of the reservoir was found to be eutrophic based on classification purposed by Forsberg & Ryding (1980).

6.2 Recommendations

Based on the outcomes of this study recommendations have been made for conservation of wetland birds in *Jagdishpur Reservoir*.

1. Species conservation plan that focuses on population surveys monitoring, protecting key habitats, relocation and restoration of wetland birds is needed.

2. The anthropogenic factors are the root cause of the deterioration and degradation of the reservoir and its resources. So, conservation education programme on wetland conservation for birds among local community and school children are highly recommended. For this purpose, local NGOs, CBOs and school level eco-clubs will be the most effective means to achieve the target.

3. This is now high time to give priority to control enhanced succession, excessive eutrophication several human induced effects including invasion by the alien species in the conservation agenda for safeguarding future of our important biological resources.

4. Long-term studies on reproductive biology and behaviour ecology, population dynamics and movements should be initiated under present scenario of human pressure and habitat degradation.

5. Future survey method should be standardized and modified and survey reports should include detailed description of habitats methods, search effort, environmental conditions and bird sightings so that data can be properly evaluated and future surveys can be designed for comparability.

6. It is most important to effectively conduct the various income generating, alternative energy and community development activities for the sustainable management and conservation of natural resources at *Jagadishpur reservoir*. Strengthening capacity of the community based organization would result the sustainable management of the resources.

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ANNEXES

Annex 1: Important Bird Areas (IBAs) in Nepal

S.N.	International Name	IBA Code	Criteria
1.	Annapurna Conservation Area	NP012	A1, A2, A3
2.	Barandabhar forests and wetlands	NP015	A1, A3, A4i
3.	Dang Deukhuri foothill forests and west Rapti wetlands	NP008	A1, A3
4.	Dharan forests	NP023	A1, A2, A3, A4i
5.	Dhorpatan Hunting Reserve	NP007	A1, A2, A3
6.	Formlands in Lumbini area	NP011	A1, A3, A4i
7.	Ghodaghodi Lake	NP002	A1, A3, A4i
8.	Jagdishpur Reservoir	NP009	A1
9.	Kanchenjungha Conservation Areas	NP026	A1, A2, A3
10	Khaptad National Park	NP004	A1, A2, A3
11	Koshi Tappu Wildlife Reserve and Koshi Barrage	NP024	A1, A3, A4i, A4iii
12	Lagtang National Park	NP017	A1, A2, A3
13	Mai Valley Forests	NP027	A1, A2, A3
14	Makalu Barun National Park	NP021	A1, A2, A3
15	Nawalparasi forests	NP010	A1
16	Parsa Wildlife Reserve	NP014	A1, A3

17	Phulchowki Mountain forests	NP019	A2, A3
18	Rampur Valley	NP013	A1
19	Rara National Park	NP005	A1, A2, A3
20	Royal Bardia National Park	PN003	A1, A3, A4i
21	Royal Chitwan National Park	NP016	A1, A3, A4i
22	Royal Sukla Phanta Wildlife Reserve	NP001	A1, A3, A4i
23	Sagarmatha National Park	NP020	A1, A3
24	Shey-Phoksundo National Park	NP006	A1, A2, A3
25.	Shivapuri National Park	NP018	A2, A3
26	Tamur Valley	NP022	A2, A3
27	Urlabari forest groves	NP025	A1

Annex 2: Important bird species record from *Jagadishpur Reservoir*

Bird Name	**Remarks**
Little Grebe (*Tachybaptus ruficollis)*	Resident
Great Crested Grebe (*Podiceps cristatus)*	Migratory
Little Cormorant (*Phalacrocorax niger)*	Resident
Great Cormorant (*P. carbo)*	Migratory
Indian Pond Heron (Ardeola grayii)	Resident
Cattle Egret (*Bubulcus ibis)*	"
Little Egret (*Egretta garzetta)*	"
Intermediate Egret (*E. intermedia)*	"
Great Egret (*E. alba)*	"

Gray Heron (*Ardea cinerea)*	Migratory
Purple Heron (*A. purpurea)*	Resident
Cinnamon Bittern (*Ixobrychus cinnamomeus)*	Migratory
Yellow Bittern (*I. cinensis)*	" / Vulnerable
Open-bill Stork (*Anastomus oscitans)*	Resident *NRDB (S)
White-necked Stork (*Ciconia episcopus*)	Resident *NRDB (S)
Lesser Whistling Duck (*Dendrocygna javanica)*	Resident
Eurasian Wigeon (*Anas penelope)*	Migratory
Gadwall (*A. strepera)*	"
Common Teal (*A. crecca)*	"
Mallard (*A. platyrhynchops)*	"
Northern Pintail (*A. acuta)*	"
Gargeny (*A. querquedula)*	"
Norther Shoveler (*A. clypeata)*	"
Cotton Teal (*Nettapus coromandelianus)*	Resident NRDB (S)
Red crested Pochard (*Netta rufina)*	Migratory
Common Pochard (*Aythya ferina)*	Migratory
Ferruginous Duck (*A. nyroca)*	Migratory
Tufted Duck (*A. fuligula)*	Migratory
Black bellied Tern (*Sterna acuticauda)*	Migratory
Lesser Spotted Eagle (*Aquila pomarina*)	Resident
Rallidae (Rails, coot and waterhens)	Resident
Common Noorhen (*Gallinula chloropus*)	Resident + breeding
Purple Gallinule (*Porphyro porphyro*)	Resident

Common Coot (*Fulica atra*)	Migratory
Pheasant Tailed Jacana (*Hydrophasianus chirurgus*)	Migratory
Bronze-winged Jacana (*Metopidus indicus)*	Resident
Sarus Crane (*Grus antigone*)	Resident / IUCN Endangered
White breasted Kingfishers (*Halcyon smyrnensis*)	Resident

Annex 3a: Physico-Chemical Parameters in Winter Season

Parameters (unit)	Site 1	Site 2	Site 3	Site 4	St.dev.	mean
Water Temp (^{0}C)	24	24	24	22	0.866025	23.5
pH	6.9	6.8	6.9	6.8	0.05	6.85
Transparency (m)	2.1	2.5	1.9	2	0.227761	2.125
DO (mg/l)	9.58	10.135	9.729	8.716	0.517282	9.54
FCo$_2$ (mg/l)	29.26	27.98	27.48	25.28	1.436732	27.5
Total Alkalinity (mg/l)	245	240	205	215	16.72386	226.25
Chloride (mg/l)	15.59	18.43	17.72	9.92	3.340243	15.415
PO$_4$-P (µg/l)	0.278	0.378	0.286	0.044	0.12334	0.2465
TN (µg/l)	605	448	363	962	229.2493	594.5

Annex 3b: Physico-chemical Parameters in Monsoon Season

Parameters (unit)	Site 1	Site 2	Site 3	Site 4	Std. dv	mean
Water Temp (^{0}C)	31	34	34	32	1.5	32.75
pH	7.3	7.1	7.3	7.3	0.1	7.25
Transparency (m)	0.5	0.9	1.25	0.95	0.308221	0.9
DO (mg/l)	6.48	5.43	4.45	4.86	0.880398	5.305
FCo_2 (mg/l)	26.4	27.28	25.14	30.8	2.427749	27.405
Total Alkalinity (mg/l)	90	35	110	145	46.00725	95
Chloride (mg/l)	5.67	5.1	5.67	4.25	0.671137	5.1725
PO_4-P (µg/l)	0.56	0.34	0.58	0.36	0.127541	0.46
TN (µg/l)	1224	1256	1430	1245	95.09776	1288.75

Annex 3c: Physico-chemical Parameters in Autumn Season

Parameters (unit)	Site 1	Site 2	Site 3	Site 4	Std.dv.	Mean
Water Temp (^{0}C)	28	28	29	27	0.816497	28
pH	7.1	7.3	7.3	7.2	0.095743	7.25
Transparency (m)	1.3	1.4	1.6	1.5	0.29439	1.45
DO (mg/l)	8.13	8.94	9.51	8.26	0.640781	8.71
FCo$_2$ (mg/l)	22	24	26	21	2.217345	23.25
Total Alkalinity (mg/l)	330	235	310	285	41.02845	290
Chloride (mg/l)	0.55	0.65	0.85	0.75	0.129099	0.7
PO$_4$-P (µg/l)	0.04	0.037	0.02	0.038	0.009251	0.03375
TN (µg/l)	754	798	854	824	42.37	807.5

Annex 4: The Forsberg & Ryding (1980) criteria to distinguish trophic status of water bodies

Particulars	Oligotrophic	Mesotrophic	Eutrophic	Hypereutrophic
Water clarity	> 13 feet >3.96m	8 -13 feet 2.44-3.96m	3 – 8 feet 0.91-2.44m	< 3 feet <0.91m
TP	< 15 µg/l	15 - 25 µg/l	25 -100 µg/l	> 100 µg/l
TN	< 400 µg/l	400 - 600 µg/l	600 - 1500 µg/l	> 1500 µg/l

Annex 5: List of Photographs

Result of Eutrophication

Invasion by *Ipomea carnea ssp. fistulosa*

Poaching of *Fulica atra* by local people

Researcher observing *Anas penelope* poisoned by chemical