

# 1. INTRODUCTION

## 1.1 General Background

Geographically, Nepal is a landlocked country with a total area of 1,47,181 sq.km.(56,846 sq.mile). The kingdom of Nepal is bounded on the North by china and on the South, East and West by India. Its geographic position lies between 26<sup>0</sup>22' to 30<sup>0</sup>27' North latitudes and 80<sup>0</sup>4' to 88<sup>0</sup>12' East longitude. It is roughly rectangular and elongated in shape averaging about 885Km in length (east-west) and 193km in width (north to south). The altitude ranges from 70m above sea level in the Terai region to 8,848m at the peak of the world; Mount Everest (Sagarmatha) in the north.

Topographically, Nepal can be divided in to three distinct geographical regions namely the Himalayan region, the Sub-Himalayan region and the Terai region. The Himalayan region lies above the altitudinal range of 16000ft from the sea level (Amatya and Shrestha 1967) and contributes about 15% of the total area of Nepal and is always covered with snow. The Sub-Himalayan region or mountainous region is located between the south of the Himalayas and the north of Terai region with a chain of massive mountains running from west to east. It occupies about 68% of the total area of Nepal lying in between 2000ft to 16000ft. The Terai region includes inner Terai and represents about 17% of the total area of Nepal.

## 1.2 Water Resources

A fundamental feature of the earth is an abundance of water, which covers 71% of its surface. Of the total water, about 97% remains in the seas as salt water and remaining 3% exists as freshwater in Rivers, lakes, streams, reservoirs, underground water, polar and permanent glaciers etc (Wetzel 1983).

Nepal has a total of 8,17,100 hectares of inland water resources, which is about 5.5% of Nepal's total area (DOFD 2007). It is a small land locked country which possesses 2.27% of the water resources in the world has great potential for hydropower generation (Rai 2008 and Gubhaju 2012).The inland water resources are in the form of Rivers, rivulets, streams, lakes, reservoirs, ponds, swamps, wetlands and paddy fields. Wetlands are important for their economical, socio-economic, cultural, scientific, aesthetic and recreational values. They support to provide tremendous socio-economic benefits to mankind through agricultural production, aquaculture, wood and timber production.

### **1.3 Natural water resources**

The natural water resources of Nepal consist of Rivers, lakes, and reservoirs comprising of approximately 49.13% of the total existing water area of Nepal (Appendix 1). The Rivers are of major importance with regard to percentage coverage (48.34%) of the total area. Lake and reservoirs are of less significance, as they comprise only 0.79% of the total water area.

#### **1.3.1 Rivers**

The Rivers are the major constituents of water resources in regard to coverage (Appendix 1). There are more than 6,000 Rivers in Nepal with a total length of 45,000 km. There are three major River systems and each River system has seven main tributaries. They are i) Sapta Koshi in the east ii) Sapta Gandaki in the mid region and iii) The Sapta Karnali in the west. Besides these, Kankai, Kamala, Mechi, Babai, Rapti, Tinau, Mahakali Rivers are also equally important Rivers. All these River systems constitute the 48.34% of the total water area of Nepal. All these Rivers and their tributaries drain into the Ganges system in India. The combined run off from all Rivers of Nepal contributes 40% of the annual flow of the Ganges River and 71% of the dry season flow (Shrestha 1992). Hydrologically, the Rivers of Nepal can be divided into i) purely rain fed Rivers and ii) Snow plus rain fed. The Rivers of shorter lengths are seasonal and dry up from time to time. But in snow fed Rivers, the melting of the snow of the Himalayas in dry season maintains certain water flow. The Rivers of Nepal lose their speed as they reach the southern plain or Terai region and deposit silt in the fertile flood plains.

#### **1.3.2 Lakes**

There are several lakes scattered all over the country. The estimated area of lake is about 5,000 ha that is 0.61% of the total existing water areas. The lakes can be categorized into 3 types on the basis of their origin viz. 1) Glacial, ii) oxbow and iii) tectonic. There are 17 major glacial lakes in the northern Himalayan region which are located above 4000 m altitude. Tectonic lakes occur in the hill region. Most of lake of Nepal are tectonic origin which when drained out were replaced by flat basins. The Kathmandu valley, Banepa, Panchkhal, Mariphant (Palpa), Dang, Surkhet, valleys are the good examples of such basins. Oxbow lakes are mainly confined to the southern part of the country.

### **1.3.3 Reservoir**

There are few reservoirs with a total area of 1500 ha comprising 0.18% of the total existing water area of Nepal. These reservoirs are mainly constructed for hydroelectric and irrigation purposes. Among the existing reservoirs Kulekhani is newly impounded reservoir for producing hydroelectric power by damming Kulekhani River in the mid hill of Nepal. Other existing reservoirs are Trisuli (16 ha.), Marsyangdi (62 ha.), Panauti, Sunkoshi for irrigation & generating hydroelectric power.

### **1.4 Fish Diversity of Nepal**

Shrestha (2001, 2003) had reported 184 fish species belonging to 93 genera, 31 families and 11 orders in the water bodies of Nepal. According to Rajbanshi (2005), there were altogether 187 species of fishes belonging to 10 orders, 30 families and 194 genera. The current status of fish shows there are 232 fish species in Nepal (Shrestha 2008). These 232 species belonging to 114 genera, 37 families and 11 orders. On the basis of taxonomic status, there are 2 endangered species (EN), 9 vulnerable species (VU), 23 rare and threatened species (R), 32 Data deficient Pristine Rare Ornamental species (PRO), 27 Conservation Dependent and Rare species (CDR), 53 uncommon or Lower Risk Least Concern species (UN), 71 Common species (C) and 15 Exotic species (\*). No particular fish species is identified as Critically Endangered (CE) and extinct (EX) in Nepal yet. The conservation status of fishes in Nepal is given in Appendix 1.

### **1.5 Ghodaghodi Lake complex**

Ghodaghodi Lake complex is the largest interconnected natural lake system, situated in Kailali District of Far-Western Development Region of Nepal, at an altitude of 205 m. It lies between 28°41'03" N, 80°56'43"E (DNPWC 2005). It is positioned in a very strategic location between Bardia National Park and Suklaphanta Wildlife Reserve and alongside of the east- west highway. Ghodaghodi lake complex includes about 13 associated lakes and ponds and covers an area of 2563 hectares (Anon 2002), with associated marshes, swamps, streams, springs, seasonal marshy grasslands, and artificial wetlands (canals, irrigated fields, ponds, etc.) surrounded by tropical deciduous mixed forest in the lower slopes of Siwalik hills. The Ghodaghodi Lake complex encompasses three Village Development Committees (VDCs) of Kailali district namely Darakh, Sandepani and Ram Shi-

khar Jhala. The area is bordered by Sandepani VDC in the east and north, Ram Shikar Jhala VDC in the west and Mahendra Highway in the south. It was designated as Ramsar Site on 13 August 2003. The area is remarkable for its rich biodiversity and connectivity between the Terai plains and the Siwalik of Nepal (Kafle 2006). It provides habitat for 34 species of mammals, around 29 species of fish including threatened (*Puntius chola*) and endemic species (*Notopterus notopterus* and *Oxygaster bacaila*), around 140 species of birds (migratory & resident) representing 16% of the national avifauna, and 9 species of herpeto fauna including three species of turtle (DNPWC and WWF Nepal 2003). Major lakes of the complex include Ghodaghodi (138 ha), Nakharodi (70 ha), and Baishawa (10 ha) (Siwakoti and Karki 2009). Out of 13 lakes Ghodaghodi and Nakharodi are only perennial lakes while others are seasonal.

Ghodaghodi Lake (138 ha) is the largest ox-bow lake of Nepal with 28<sup>o</sup> 41.06' latitude and 80<sup>o</sup>56.44' longitude and have topography roughly palm shaped with many ramifications. Hydrology of lake is fed by atmospheric inputs, surface flows, springs. It has no inlet with two outlets along the Mahendra highway. It has sub tropical monsoonal type of climate with dry winter and rainy summer.

## **1.6 Objectives**

### **General objectives**

The general objective of this study is to explore the fish diversity of Ghodaghodi Lake.

### **Specific objectives**

- To investigate seasonal diversity of fishes.
- To analyze the seasonal physiochemical parameters of water.

## **1.7 Statement of the problem and justification of the study**

The wetlands of Terai region are well known for biological diversity with many habitats. The Ghodaghodi Lake is one of the important lake of Terai region. It is the main source of water for many wildlife fauna of Ghodaghodi Lake Complex. Studies so far conducted in Ghodaghodi Lake Complex show the existence of numerous fish species including the endemic fishes.

The degradation of freshwater ecosystem is severe in many parts of the world and fish species are among the most endangered species. Particularly, the wetlands of Terai region are victims of human activities and human pressure by overfishing. There is a possibility of the disappearance of fish species, even before they are discovered. Despite their importance, Ghodaghodi Lake has not yet been largely investigated and its biodiversity is still unknown by the scientific world. Little is known on fishes from Ghodaghodi Lake. Therefore there is a need to investigate fish diversity in this Lake and eventual threats for their survival.

## **1.8 Limitation of the study**

This study was focused on the fish diversity of Ghodaghodi Lake only. Due to limited time, limited financial resources and technical facilities the study could not cover whole wetland area. Fish sampling was not done in the centre of the lake due to technical problem.

## 2 LITERATURE REVIEW

The oldest documented report on fishes of world dates back from the time of Aristotle. Aristotle incorporated ichthyology into formal scientific study. Between 335 BC–322 BC, he provided the earliest taxonomic classification of fish, accurately describing 117 species of Mediterranean fish. Furthermore, Aristotle documented anatomical and behavioral differences between fish and marine mammals. John Ray and Francis Willughby (1686) collaboratively published *Historia Piscium*, a scientific manuscript containing 420 species of fish, 178 of these newly discovered. The fish contained within this informative literature were arranged in a provisional system of classification. Piso (1611 - 78 AD) was a one of the noteworthy scholars of ichthyology. His notable contributions were arrangement of various species of fishes in proper systematic manner. He also gave fishes independent and proper scientific names. He and his colleagues catalogued about 420 fish species including these which were already recorded (Wikipedia 2015). Close to the dawn of the “19th century”, Marcus Elieser Bloch of Berlin and Georges Cuvier of Paris made attempts to consolidate the knowledge of ichthyology. Cuvier (1828-1849) summarized all of the available information in his monumental *Histoire Naturelle des Poissons*. This manuscript was published between 1828 and 1849 in a 22 volume series. This document describes 4,514 species of fish, 2,311 of these new to science. It remains one of the most ambitious treatises of the modern world. Scientific exploration of the Americas advanced our knowledge of the remarkable diversity of fishes. Gunther (1859) published catalogue of the fishes of British Museum, London in eight volumes. The work contained an account of 6847 species together with the description of another 1682 doubtful species. According to FishBase (2015), 34,300 species of fish had been described by October 2015.

Hamilton (1822) had provided the first valuable authentic information concerned to the fishes of Nepal in his book entitled “An account of the fishes found in River ranges and its tributaries”. Further, he had reported 24 fish species from the Koshi River and 2 fish species from the Rapti River of Nepal. But he collected these fish species across the border within the territory of India.

Gunther (1861) reported some cold-blooded vertebrates including fishes, collected by Hodgson in Nepal. Altogether 35 fish species were included in his checklist. Beavan (1872) described two imperfectly known species of cyprinid fishes from Punjab and had mentioned some of the fishes of Nepal. Day (1878-1889) performed his classical work

“fishes of India, Burma and Ceylon” in which he referred a number of fresh water fishes of Nepal. Boulenger (1907) reported a collection of Nepalese fishes and western Himalayan fishes. Regan (1907) reported five species from Nepal. Hora (1921-1940) published many papers regarding his fish collection and the collection was included 158 specimens of which 22 species are from Nepal comprising 15 different genera. He gave an excellent account of the *Tor putitora* in the series of journal of Bombay Natural History Society and indicated the distribution of the species all along the Himalayas.. He also included a full description of *Glyptothorax* collected from Pharping. Hora (1940) reported the Nepalese "Katile" (*Neolissocheilus Hexagonolepis*). Menon (1949) collected 11 families of fishing comprising 26 genera and 52 species from Koshi River and also prepared a checklist of fishes of Koshi River. Taft (1955) submitted a report on his survey "Fishes of Nepal" and described 94 species of fishes reported from Kathmandu and adjoining areas. De Witt (1960) reported 102 species of fishes belonging to 21 families contributing ichthyology of Nepal. Dibbs (1965) reported various aspects on the development of fisheries of Nepal. His report was based on the work of Zwelling, who undertook the assignment of studying fisheries in Nepal under the Food and Agriculture Organization (FAO) of United Nation. Shrivastava (1968) published a book entitled “Fishes of Eastern Uttar Pradesh” in which he mentioned a number of Nepalese fishes. Thapa and Rajbanshi (1968) studied the ecology of hill stream fishes of Nepal. Majupuria and Shrestha (1968) published a paper on "Fresh water fishes and fisheries of Nepal". Majupuria (1969) contributed a paper on socio-economic condition of fisherman of Kathmandu valley. Bhatta (1970) had listed about 57 species of fishes in his book “Natural History and Economic Botany of Nepal”. Bhatta and Shrestha (1973) had listed 27 species of fishes from the Mahakali River. Ferro and Swar (1978) surveyed the biological and limnological conditions of lakes and natural waters in Pokhara valley with reference to existing fish population and feeding habits and biology. Shrestha (1978) studied the fish fauna of Nepal and reported 118 fish species out of which she described two new species and one sub species. Shrestha (1979) studied the resource biology and aquatic ecology of fresh waters in Kathmandu valley with particular reference to fish population, marketing management and conservation. Shrestha et.al (1979) studied the aquatic ecology and fishing potential of Bagmati River and have reported 82 fish species from downstream of the River Bagmati.

Ferro and Badagami (1980) reported 22 fish species from lakes Begnas and Rupa in Pokhara valley. Shrestha (1980) studied fishing gear and methods used in Narayani River and reported 103 species of fishes. Shrestha (1981) describes 120 fish species in the book entitled "Fish of Nepal." Terashima (1984) reported three endemic species of genus *Schizothorax macropthalmus*, *S. nepalensis*, and *S. raraensis*. Edds (1986) studied the fishes of Kaligandaki/Narayani River and Chitwan National Park reporting 111 and 107 species respectively. Jha and Shrestha (1986) highlighted the prospects of fishery resources of Karnali River and recorded 51 species of fishes. Joshi (1988) studied fishery resources of Sunkoshi River with particular reference to dam and its impact on fishery. Shrestha (1991) reported 59 species of coldwater fishes from the natural water bodies of mountains and Himalayan region of Nepal. Sapkota (1992) studied fishery ecology of swamplands of Koshi River. Shrestha (1994) described 66 genera and 123 species of fish in her book 'fishes fishing implements and methods of Nepal'. Shrestha (1995) made enumerations of 185 indigenous fish species representing 79 genera, 31 families and 11 orders. In 1998, she has reported 186 fish species with the finding of *Puntius phuntunio*. Smith et al (1996) reported 121 and 135 fish species in the Karnali and Narayani River respectively. Karki (2000) studied on biodiversity and fishery resources of lower Karnali, Nepal and recorded 50 species of fish belonging to 29 genera under 15 families and 8 orders.

Shrestha (2001) published a paper entitled "Taxonomic Revision of Fishes of Nepal" reporting a total of 182 species belonging to 93 genera, 31 families and 11 orders. Later, she again revised her work in 2002/2003 and reported the total number of fishes of Nepal is 184 species with the inclusion of *Dipticus maculatus* and *Bagarius bagarius*. Bajracharya (2001) studied fish and fishery resources of the Bhotekoshi and Sunkoshi and recorded 16 species of fish under 3 families and 2 orders. Gurung et.al. (2003) had reported 186 fish species, out of which 176 are indigenous and 10 are exotic fish species. Gautam (2003) studied on the fish diversity of aquatic life resource of Lake Rupa and recorded 23 species of fish belonging to 5 orders, 6 families and 18 genera. Malla (2004) studied diversity, distributional patterns and frequency occurrence of fish and invertebrate species in Dharam Khola, Baglung. A total of 21 fishes belonging to 16 genera, 8 families and 4 orders were reported. Rajbanshi (2005) reviewed on current taxonomic status and diversity of fishes in Nepal” based on the current work of Menon (1999) and recorded a total number of 187 fish species representing 94 genera, 30 families and 10 orders. Shah

(2005) studied on the fish diversity of Budhiganga River and recorded 18 species of fish belonging to 2 orders, 4 families and 13 genera. Prajoo (2007) studied on fish diversity of Harpan Khola and recorded 22 species of fishes belonging to 5 orders, 6 families and 16 genera. Shrestha (2008) studied different water bodies of Nepal and reported 75 species of fish from Karnali River, 108 species from Koshi River, 34 species from Trishuli River, 102 species from Narayani River, 69 species from River Mahakali River, 82 species from Bagmati River, 69 species From Kaligandaki River and 29 species from Kulekhani reservoir in his book entitled “Ichthyology of Nepal”.

Giri (2010) studied distribution pattern of fishes and the socio-economic condition of fisher community, recorded 21 species of fish belonging to 5 order, 6 families, 16 genera. Pokheral (2011) studied fish diversity of west Rapti, recorded 24 species belonging to 4 order, 6 families and 16 genera. Mandal and Jha (2013) conducted a study on impacts of damming on Ichthyo-faunal diversity of Marshyangdi River in Lamjung District, Nepal and reported 26 species of fishes belonging to 5 orders, 6 families and 18 genera. K.C. (2015) reported 15 species of fishes from Sharada River representing 3 orders, 4 families and 10 genera. IUCN (1998) identified 27 species of fish fauna from Ghodaghodi Lake Complex. DNPWC and WWF Nepal (2003) reported 29 fish species from Ghodaghodi Lake Complex. Kafle (2007) identified 25 species from same area. Recently Lamsal et al. (2014) recorded 9 fish species from Ghodaghodi Lake complex. Many literatures are available regarding the fish diversity of different Lakes of Nepal. But there are very few literatures which represents the diversity of Ghodaghodi Lake.

## **3. MATERIALS AND METHODS**

### **3.1 Study period**

For the present study, the field work was conducted from October 2014 to July 2015, to cover four different seasons. Each sampling site was visited in the month of October, January, April and July.

### **3.2 Study Area**

The present study was carried out in the Ghodaghodi Lake. It is one of the largest and most diverse perennial ox-bow lake of Ghodaghodi lake complex. It is protected area and prohibited for fishing and other activities in the lake. The lake does not contain inlet but has two outlets near the Mahendra highway. The lake is surrounded by dense forest in three sides and one side is near the Mahendra Highway.

### **3.3 Selection of sampling stations**

A preliminary survey was done prior to the selection of sampling stations. Four sampling stations were selected on the basis of human disturbance, habitat and outlet.

#### **Station I:-**

The sampling station first was selected on south, near the Mahendra highway, which consists of two outlets. Water passes out from these two outlets. One outlet was disturbed by human activities such as bathing, throwing stones and other waste materials.

#### **Station II:-**

The sampling station second was selected on west, near the temple, which is highly human disturbed area. In this area three boats are also kept for boating. View tower is also located near this site.

#### **Station III:-**

The sampling station third was selected on east. This site was surrounded by tall trees and also by small herbs near the edges. It is not disturbed by human activities but disturbed by illegal fishing.

#### Station IV:-

The sampling station fourth was selected on north side of lake. This site was also surrounded by tall trees and also by small herb near the edges. It is not disturbed by human activities but disturbed by illegal fisherman. It is wider than station third.

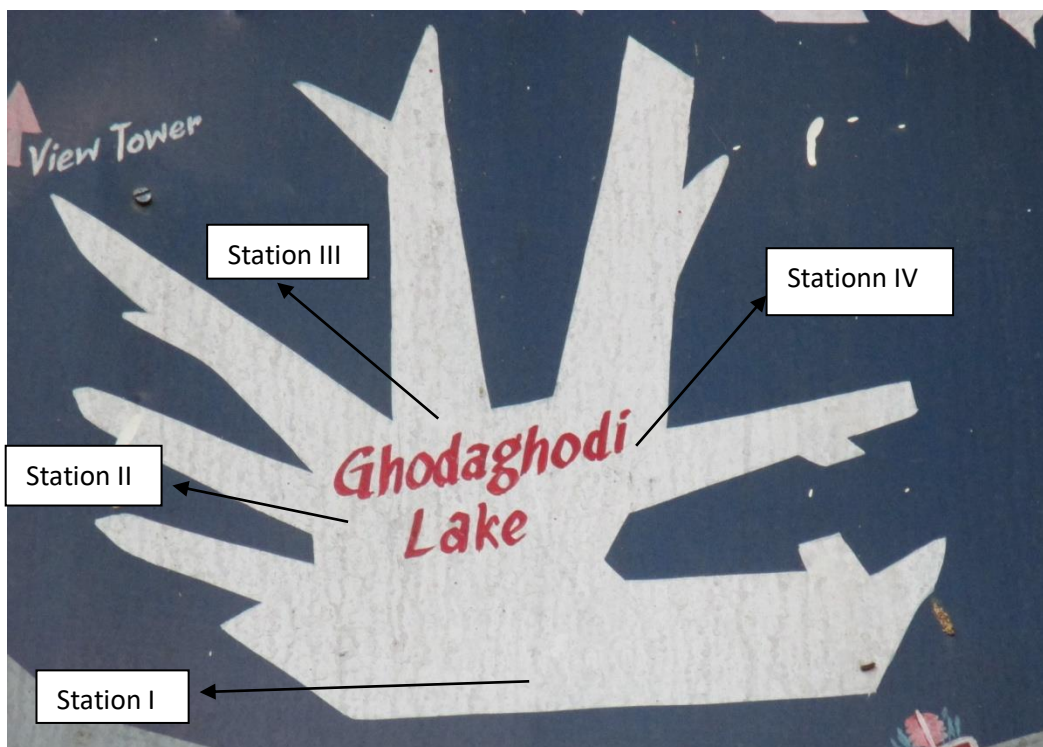
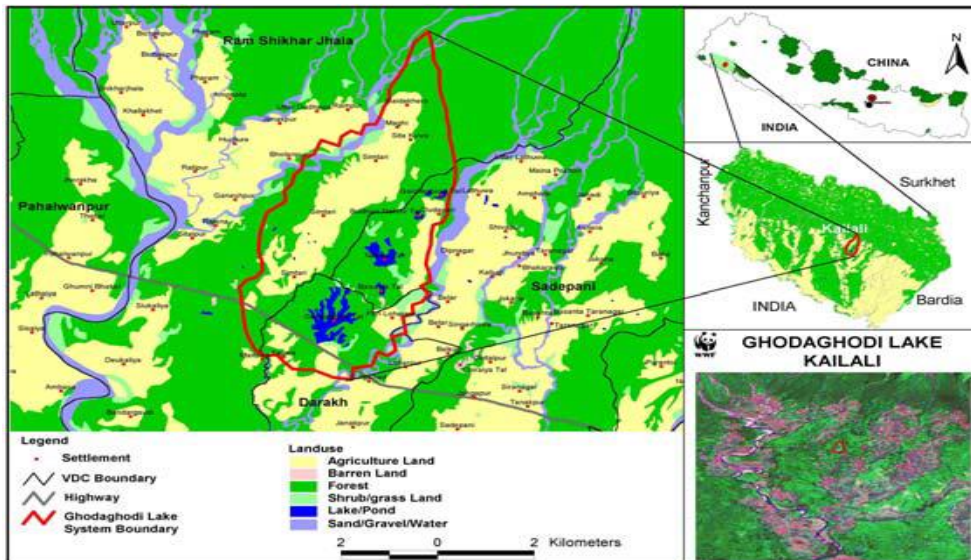


Figure 1: Study area

### **3.4 Analysis of physical parameters of water**

Some of the physical parameters of Ghodaghodi Lake were analyzed during the present study. This was done seasonally with the help of APHA (1998), Adoni (1985) and Trevedy and Goal (1986). The important parameters studied are:-

#### **3.4.1 Water Temperature:**

The temperature of water was recorded by using a standard mercury thermometer by dipping directly on the surface water.

#### **3.4.2 Depth:**

The depth was measured using nylon rope with weight and a measuring tape was used to record the depth in centimeters (cm).

#### **3.4.3 Transparency:**

Transparency of the water was recorded with the help of Secchi disc (APHP 1979). The Secchi disc was lowered in the water until it becomes invisible and a measuring tape was used to record the depth in centimeters (cm). Then the disc was gradually pulled up and the reading was noted at which it reappeared.

The transparency was calculated by applying the following formula,

$$\text{Transparency (cm)} = \frac{A+B}{2} \quad \text{Where, A - Depth at which Secchi Disc disappears}$$

B - Depth at which Secchi Disc reappears

#### **3.4.4 Turbidity:**

To measure the turbidity, water was collected in a bottle and taken to the District Drinking Water Supply Corporation at Dhangadhi. It was measured by a turbidity meter (Turb 430 IR).

#### **3.4.5 Conductivity:**

To measure the conductivity, water was collected in a bottle and taken to the District Drinking Water Supply Corporation at Dhangadhi. It was measured by a conductivity meter (Orion 3 star conductivity bench top).

### 3.5 Analysis of Chemical Parameters of water

Water sample was collected from every stations of Ghodaghodi Lake during the study period. The chemical parameters were analyzed by using the standard methods of Adoni (1985), Trivedy and Goel (1986) and APHA (1998).

#### 3.5.1 Hydrogen ion concentration (pH):

A pH meter was used to record the hydrogen ion concentration of water during the study period at every station of Ghodaghodi Lake.

#### 3.5.2 Dissolved Oxygen (DO):

The dissolved oxygen of water was calculated using Winkler's method. The sample of water from every station was collected in a BOD bottle without bubbling. 2ml of manganese sulphate and similar quantity of alkaline- iodide- azide solution were added and shaken. Brown precipitation was obtained which was again dissolved by adding 2ml of concentrate Sulphuric acid. Then this solution was titrated against standard sodium thio sulphate solution (0.025N) and the calculation was carried out using formula

$$\text{D.O. (mg/l)} = \frac{\text{ml} \times \text{normality of titrant} \times 8 \times 1000}{V_2 \left\{ \frac{V_1 - V}{V_1} \right\}}$$

Where, V = Volume of MnSO<sub>4</sub> and KI added.

V<sub>1</sub>= Volume of BOD bottle

V<sub>2</sub>= Volume of the part of the content titrated.

#### 3.5.3 Free Carbon dioxide

Free carbon dioxide present in water was analyzed by titrating water sample against a strong alkali (NaOH). Phenolphthalein indicator was used in titration and calculation was done by using following formula of Trebedi and Goal (1986).

$$\text{Free CO}_2 = \frac{(\text{ml} * \text{Normality}) \text{ of NaOH} * 1000 * 44}{V}$$

Where, V = Volume of water sample taken (ml)

#### 3.5.4 Total Hardness:

It is the total amounts of salts present in the water (i.e. salts like chlorides and sulphates of calcium and magnesium). The total hardness of water was measured by EDTA titrimetric method. 50ml of sample water was taken in a conical flask and then KOH powder

(8 molar) was added. Sample turned into red if hardness is very high but remains violet if hardness is very low. Then the solution was titrated with EDTA (0.01M), up to violet colour was seen. Volume of EDTA consumed was noted. Then calculation was done by using following formula-

$$\text{Amount of Calcium} = \frac{\text{Volume of EDTA consumed} * \text{molarity of EDTA}(0.01) * 40.0785 * 1000}{\text{Total Volume of sample taken}}$$

$$\text{Hardness} = \frac{\text{Ca} * 50}{20}$$

### 3.6 Collection and identification of fishes

The fishes were collected from each sampling sites by employing local fisherman to find out the systematic position, average abundance and distribution pattern. The habitat conditions like spawning ground and shelter and characteristic features of Lake were observed during the field trips. Fishes were collected by using locally prepared fishing gear like cast net, hookline etc. The measurement and photography was taken in the field of all the collected fishes. The collected specimens were fixed in 10 percent formalin and preserved in 5% formalin. The preserved Specimens were brought to the laboratory of Central Department of Zoology (CDZ) for identification. These collected fish samples were identified using standard literatures of fish taxonomy after Shrivastava (1968), Day (1878), Shrestha (1981), Jayram (1981), Talwar and Jhingran (1999), Shrestha (2001) and Shrestha (2008).

### 3.7 Statistical Analysis

The relation of fish with temperature, depth, transparency, turbidity, conductivity of water, pH, DO, free CO<sub>2</sub>, and hardness of water was calculated by using correlation coefficient formula given by Karl Pearson (Gupta 1988).

$$\text{Correlation Coefficient (r)} = \frac{N \cdot \sum xy - \sum x \sum y}{\sqrt{N \cdot \sum x^2 - (\sum x)^2} \sqrt{N \cdot \sum y^2 - (\sum y)^2}}$$

$$\text{Probability Error (PEr)} = \frac{1-r^2}{\sqrt{N}} \times 0.6745$$

### **3.8 Diversity Status**

#### **3.8.1 Species Diversity Index**

The diversity of species was calculated by using Shannon-Weiner diversity index (Shannon and Weaver 1949).

Shannon Weiner diversity index is designated as  $H'$ , which is calculated as:

$$H' = -\sum (P_i) * \ln (P_i)$$

Where,

$$P_i = n_i/N$$

$n_i$  = Number of individuals of species  $i$ .

$N$  = Total number of all individuals in the sample.

$\ln$  = Logarithm of base  $e$ .

#### **3.8.2 Species richness index (d)**

The species richness is calculated by using Margalef Species richness (Margalef's 1968).

Margalef richness index is designated as  $d$ , which is calculated as:

$$\text{Margalef species richness } (d) = S-1/ \log N$$

Where,

$S$  = Total number of species

$N$  = Total number of individuals in the sample

#### **3.8.3 Evenness index**

To calculate whether species are distributed evenly across seasons and across landscapes elements, evenness index was determined by the following equation (Pieleu 1966).

$$E = H' / \log S$$

Where,

$H'$  = Shannon-Wiener's diversity index.

$S$  = Total number of species in the sample.

## 4. RESULTS

### 4.1 Physical Parameters

#### 4.1.1 Water temperature

The temperature of water plays an important role in the distribution of flora and fauna in the lake. The water temperature was found to be highest at station I, which was 29.1 °C where as it was recorded lowest at station III and IV, which was 12 °C. The variation in temperature at different station during the study period is presented in figure 3.

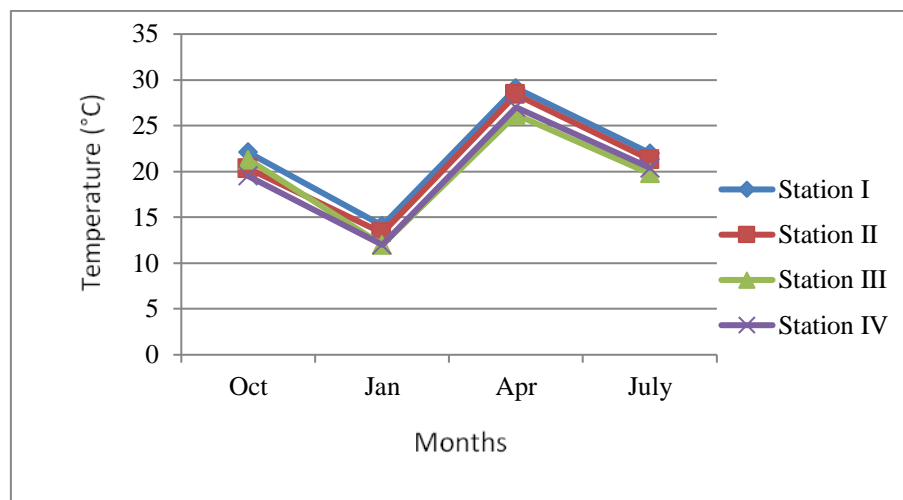


Figure 2 variations in temperature at different stations of GL.

#### 4.1.2 Water Depth

The depth of Lake varied during study period and ranged from 98 to 302 cm. The depth was found to be highest at station IV (302) and the lowest was recorded at station II (98).

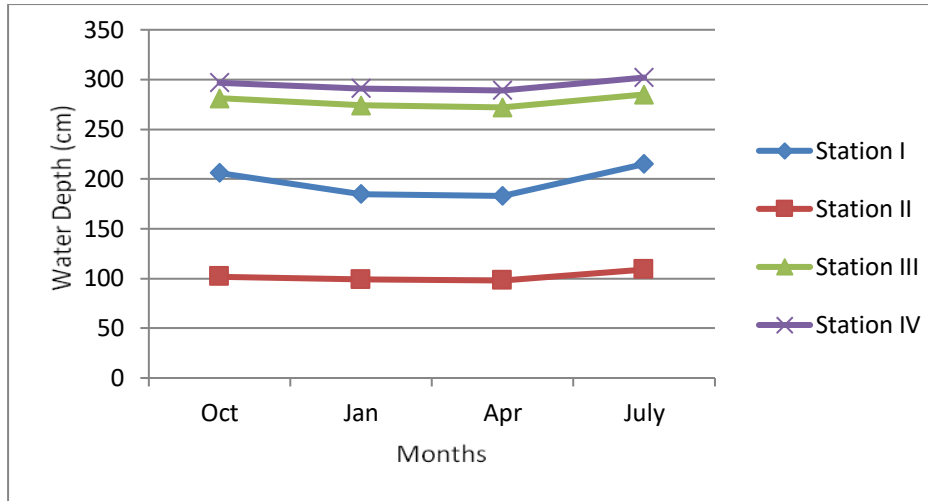


Figure 3 Water depth at different stations of GL.

#### 4.1.3 Transparency

The transparency of the Lake water was found to be high throughout the study period, except during monsoon. The transparency was found to be highest (83cm) at station I, which was 83cm and the lowest was recorded at station II (60cm).

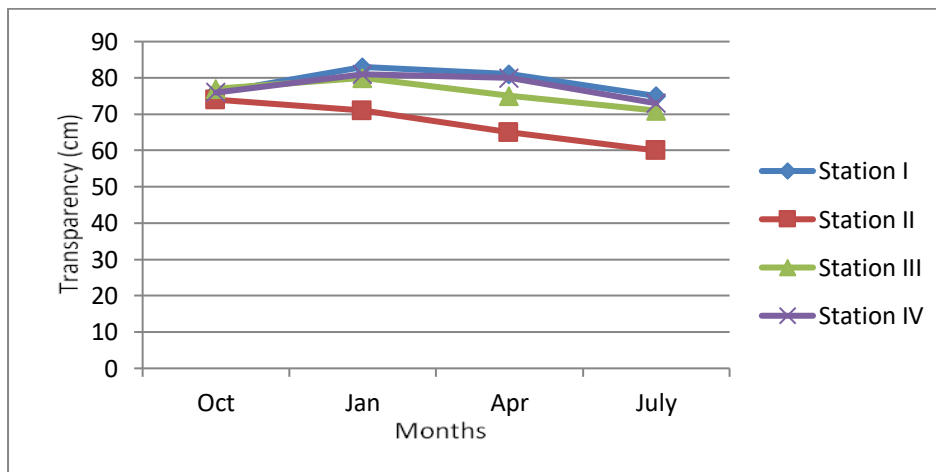


Figure 4 Transparency at different stations of GL

#### 4.1.4 Turbidity

Turbidity plays an important role in distribution of fish fauna. The turbidity of water ranged from 0.35 to 0.86 FNU. The turbidity was found to be highest (0.86FNU) at station III and the lowest was recorded at station I (0.35 FNU).

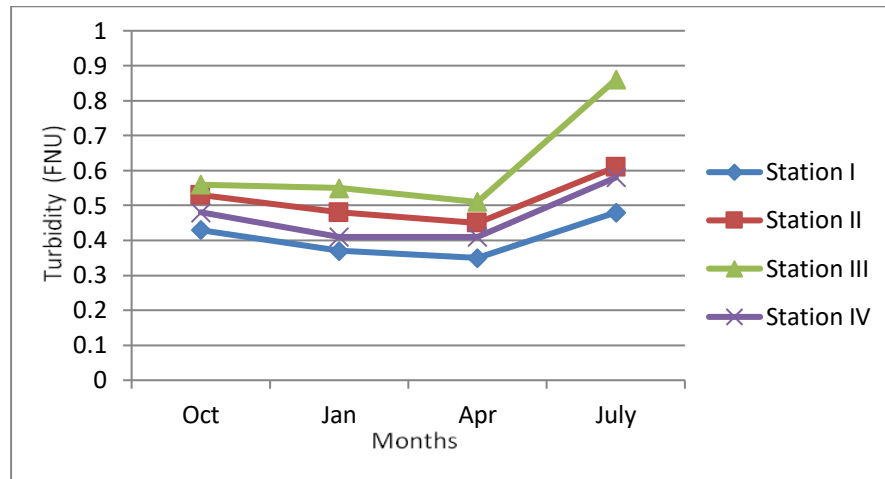


Figure 5 variations in turbidity at different stations of GL

#### 4.1.5 Conductivity

The conductivity was maximum at station I (161  $\mu\text{s}/\text{cm}$ ) and it was recorded minimum at station IV (126  $\mu\text{s}/\text{cm}$ ). The average conductivity was found to be 139.44  $\mu\text{s}/\text{cm}$ .

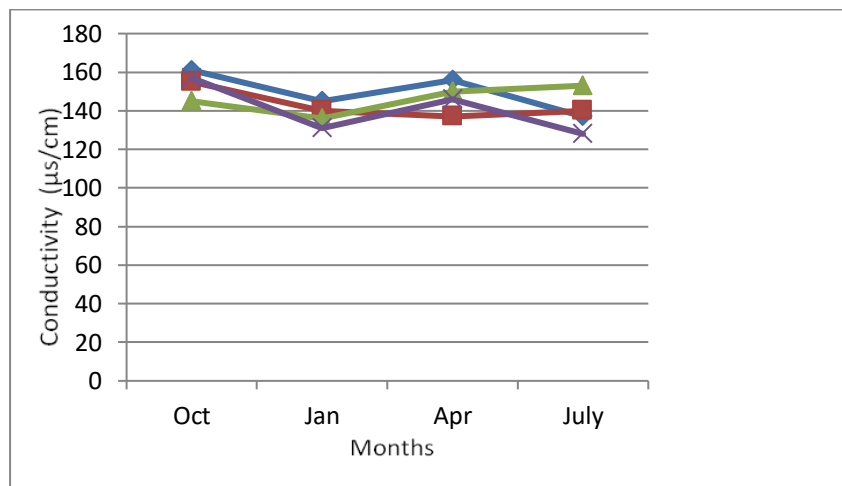


Figure 6 Conductivity at different stations of GL.

## 4.2 Chemical parameters

### 4.2.1 Hydrogen ion concentration (pH)

The pH of water at all four stations was found to be alkaline throughout the study period. The highest value of pH was 9.4 at Station I and lowest at Station II, which was 7.5.

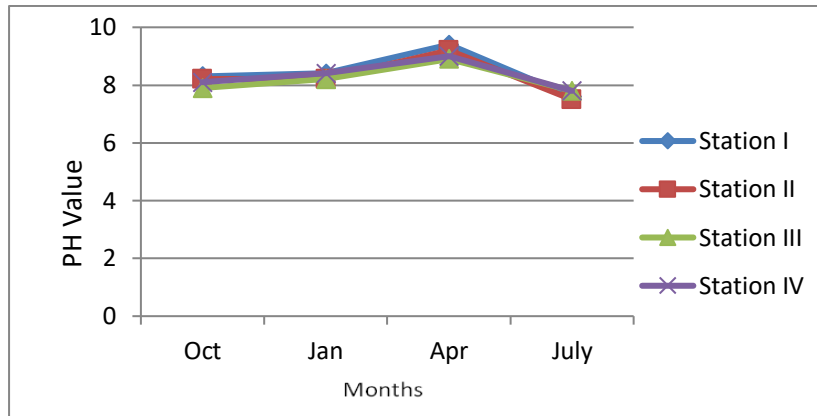


Figure 7 pH values at different stations of GL

### 4.2.2 Dissolved Oxygen (DO)

Dissolved oxygen play vital role in the diversity of fish. The highest dissolved oxygen was found to be 5.6 mg/l at station III and lowest dissolved oxygen was found to be 3.2 mg/l at station II.

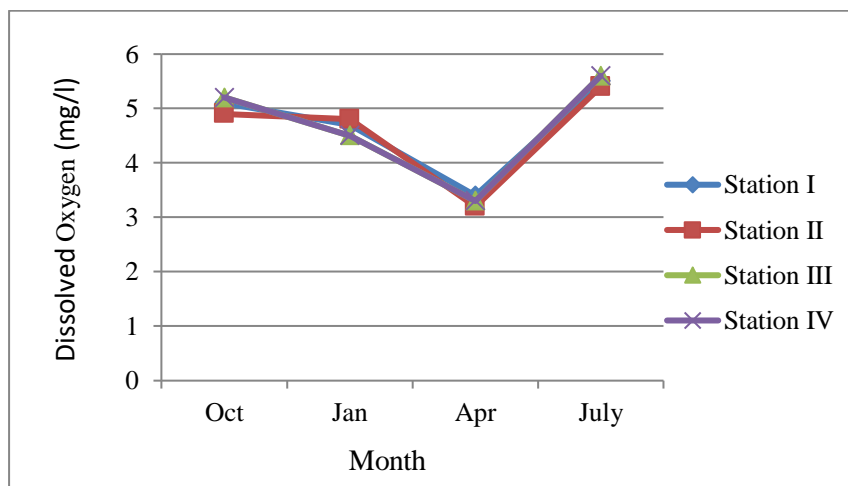


Figure 8 variations in DO at different stations of GL

### 4.2.3 Free Carbon dioxide (CO<sub>2</sub>)

Free CO<sub>2</sub> of water ranged from 3.2 mg/l to 2.01 mg/l. Free CO<sub>2</sub> was found to be highest at station II (3.2mg/l ) and the lowest was recorded at station I ( 2.01).

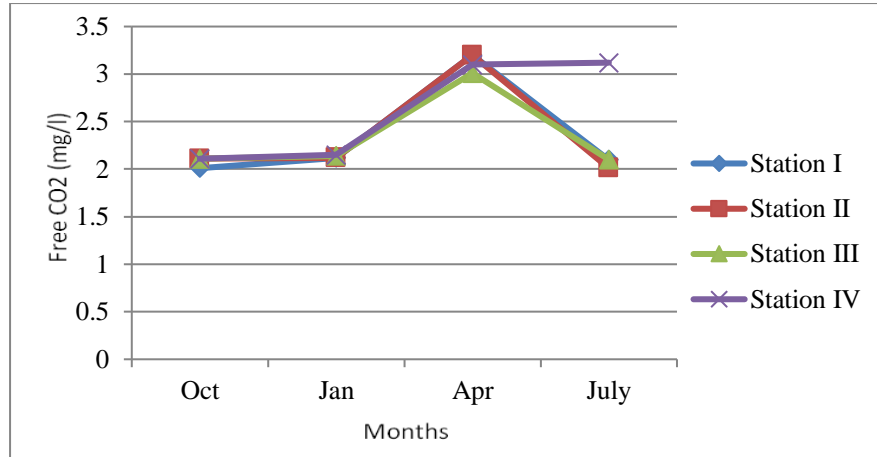


Figure 9 Analysis of free CO<sub>2</sub> at different stations of GL

### 4.2.4 Hardness

Hardness of water ranged from 39.6 ppm to 40.1 ppm. Hardness was found to be highest at station IV, which was 40.1 ppm and the lowest was recorded at station I and station II, which was 39.6 ppm.

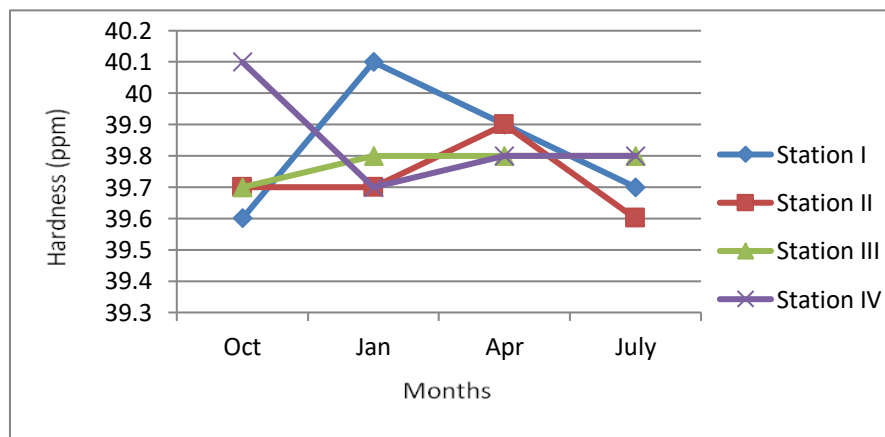


Figure 10 Hardness at different stations of GL

### 4.3 Fish diversity in Ghodaghodi Lake

The Ghodaghodi Lake provides a habitat for freshwater fishes of diverse types. Thirteen different fish species were reported during the present study, which includes five orders, eight families and eleven genera. According to the present study highest diversity was found in station III and lowest in station II. The dominant fish species of Ghodaghodi Lake are *Labeo gonius*, *Mystus tengara*, *Nandus nandus* followed by *Channa striatus*, *Channa punctatus* etc (Table 1). Table 8 explains the species diversity of fish in Ghodaghodi Lake, their local name and abundance.

Table 1 Fish species occurrence and diversity in Ghodaghodi Lake

S.N.	Order	Family	Scientific name of fish	Local name
1	Cypriniformes	Cyprinidae	<i>Labeo gonius</i>	Karsa
			<i>Puntius sophore</i>	Sidhra
			<i>Amblyphryngodon microlepis</i>	Mada
			<i>Amblyphryngodon mola</i>	Mada
			<i>Esomus danricus</i>	Dedhawa
2	Siluriformes	Bagridae	<i>Mystus tengara</i>	Tenger
3	Beloniformes	Belonidae	<i>Xenentodon cancila</i>	Kauwa
4	Synbranchiformes	Mastacembelidae	<i>Macrognathus pancalus</i>	Bami
5	Perciformes	Ambassidae	<i>Pseudambassis baculis</i>	Chanari
		Nandidae	<i>Nandus nandus</i>	Dhoke
			<i>Badis badis</i>	Pasari
		Channidae	<i>Channa punctatus</i>	Helae
			<i>Channa striatus</i>	Helae

### 4.4 Systematic Position of the Fishes

The collected specimens were identified and given proper systematic position as described below after Jayram (1999) and Shrestha (2008).

Order: Cypriniformes

Family: Cyprinidae

Sub-family: Cyprininae

Genus: *Labeo* (Cuvier 1817)

Species: *L. gonius* (Hamilton-Buchanan 1822)



Photo 1 *Labeo gonius*

Genus: *Puntius* (Hamilton-Buchanan 1822)

Species: *P. sophore* (Hamilton-Buchanan 1822)



Photo 2 *Puntius sophore*

Sub-family: Danioninae

Genus: *Amblyphryngodon* (Bleeker 1859)

Species: *A. microlepis* (Day 1878)



Photo 3 *Amblyphryngodon microlepis*

Species: *A.mola* (Hamilton-Buchanan 1822)



Photo 4 *Amblyphryngodon mola*

Genus: *Esomus* (Swainson 1739)

Species: *E. danricus* (Hamilton-Buchanan 1822)



Photo 5 *Esomus danricus*

Order: Siluriformes

Family: Bagridae

Sub-family: Bagrinae

Genus: *Mystus* (Scopoli 1777)

Species: *M. tengara* (Hamilton-Buchanan 1822)



Photo 6 *Mystus tengara*

Order: Beloniformes

Family: Belontiidae

Genus: *Xenentodon* (Hamilton-Buchanan 1822)

Species: *X. cancila* (Hamilton-Buchanan 1822)



Photo 7 *Xenentodon cancila*

Order: Synbranchiformes

Family: Mastacembelidae

Sub-family: Mastacembelinae

Genus: *Macrognathus* (Scopoli 1777)

Species: *M. pancalus* (Hamilton-Buchanan 1822)



Photo 8 *Macrognathus pancalus*

Order: Perciformes

Family: Ambassidae

Genus: *Pseudambassis*

Species: *P. baculis* (Roberts 1994)



Photo 9 *Pseudambassis baculis*

Family: Nandidae

Genus: *Nandus*

Species: *N. nandus* (Hamilton-Buchanan 1822)



Photo 10 *Nandus nandus*

Genus: *Badis*

Species: *B. badis* (Hamilton-Buchanan 1822)



Photo 11 *Badis badis*

Family: Channidae

Genus: *Channa*

Species: *C. punctatus* (Bloch 1793)



Photo 12 *Channa punctatus*

Species: *C. striatus* (Bloch 1793)



Photo 13 *Channa striatus*

#### **4.5 Distributional pattern and frequency occurrence of fishes in GL**

Table 2 explains the distribution pattern and frequency occurrence of different species of fish fauna in Ghodaghodi Lake. *Labeo gonius*, *Mystus tengara*, *Nandus nandus* and *Channa striatus* were reported from all four stations and their frequency order was also found to be high, (17.796, 11.905, 11.376 and 10.053). The lowest frequency (2.116) was of *Macrogathus pancalus* and was recorded only from station II and III. So the dominant species of Ghodaghodi Lake is *Labeo gonius* and other dominant species are *Mystus tengara*, *Nandus nandus* and *Channa striatus*.

Table 2. Distribution and frequency occurrence of fishes in Ghodaghodi Lake.

S.N.	Name of fish	Stations				Total	Frequency
		I	II	III	IV		
1	<i>Labeo gonius</i>	+	+	+	+	65	17.196
2	<i>Puntius sophore</i>	-	+	+	+	14	3.704
3	<i>Amblyphryngodon microlepis</i>	-	-	+	+	18	4.762
4	<i>Amblyphryngodon mola</i>	+	-	+	+	17	4.497
5	<i>Esomus danricus</i>	+	+	+	+	36	9.524
6	<i>Mystus tengara</i>	+	+	+	+	45	11.905
7	<i>Xenentodon cancila</i>	-	-	+	+	28	7.407
8	<i>Macrognathus pancalus</i>	-	+	+	-	8	2.116
9	<i>Pseudambassis baculis</i>	+	-	+	+	11	2.910
10	<i>Nandus nandus</i>	+	+	+	+	43	11.376
11	<i>Badis badis</i>	-	-	+	+	21	5.556
12	<i>Channa punctatus</i>	+	-	+	+	34	8.995
13	<i>Channa striatus</i>	+	+	+	+	38	10.053
	<i>Total</i>					378	

#### 4.6 Statistical analysis of ichthyofauna with different variables

The coefficient of correlation between different physiochemical variables and fish diversity of different station was analyzed by Karl Pearson's correlation coefficient method. The correlation between temperature and fish diversity was found to be positively correlated (0.1755, 0.5374, 0.9771 and 0.5652) in all four station. Station III shows the high degree positive correlation while the station I shows low degree positive correlation. Similarly, fish diversity and water depth are positively correlated in station I (0.2476), II (0.4376) and IV (0.7597) while station III shows negative correlation (-0.2011). Transparency and fish diversity shows positive correlation in station I (0.9724), III (0.3509) and IV (0.6779) but it was negative in station II (-0.4025). Similarly station I, II and IV shows the positive correlation (0.442, 0.6486 and 0.823) between turbidity and fish diversity while in station III (-0.2971) it shows negative correlation.

Fish diversity and conductivity are negatively correlated in station I (-0.1034), II (-0.5913) and IV (-0.786) while it was positively correlated in station III (0.6257). Similarly, positive correlation was observed between pH value and fish diversity (0.7701, 0.8256, 0.5767 and 0.7337). All four stations showed positive correlation (0.8242, 0.8074, 0.9345 and 0.6508) between dissolved oxygen and fish diversity. Station I

(-0.6628) and II (-0.723) shows negative correlation between free carbon dioxide and fish diversity while station III (0.769) and IV (0.3988) shows positive correlation between free CO<sub>2</sub> and fish diversity. Hardness and fish diversity are negatively correlated in station I (-0.889), II (-0.8098) and IV (-0.3512) while it shows low degree positive correlation on station III (0.2148).

Table 3 Correlation coefficient between water quality parameters and fish diversity.

S.N.	Variables	Station I		Station II		Station III		Station IV	
		r	PE(r)	r	PE(r)	r	PE(r)	r	PE(r)
1	Temperature and Fish Diversity	0.1755	0.1813	0.5374	0.1331	0.9771	0.0153	0.5652	0.1273
2	Water Depth and Fish Diversity	0.2476	0.3165	0.4376	0.2726	-0.2011	0.32361	0.7597	0.1425
3	Transparency and Fish Diversity	0.9724	0.0183	-0.4025	0.2825	0.3509	0.2957	0.6779	0.1822
4	Turbidity and Fish Diversity	0.442	0.1505	0.6486	0.1953	-0.2971	0.3074	0.823	0.1088
5	Conductivity and Fish Diversity	-0.1034	0.3336	-0.5913	0.2193	0.6257	0.2051	-0.786	0.1288
6	PH Value and Fish Diversity	0.7701	0.1372	0.8256	0.10734	0.5767	0.225	0.7337	0.1556
7	DO and Fish Diversity	0.8242	0.1081	0.8074	0.1173	0.9345	0.0427	0.65082	0.1943
8	Free CO <sub>2</sub> and Fish Diversity	-0.6628	0.189	-0.723	0.1609	0.769	0.1378	0.3988	0.2835
9	Hardness and Fish Diversity	-0.889	0.0706	-0.8098	0.116	0.2148	0.3216	-0.3512	0.2956

#### 4.7 Diversity status of fish fauna of Ghodaghodi Lake

The value of Shannon Wiener diversity index (H'), Evenness (E) and Margalef richness (d) were calculated according to month and stations. Highest Shannon Wiener diversity index (2.46) was found in station III and the lowest (1.75) was found in station II. Similarly, highest Shannon Wiener diversity index value (2.42) was found in January, where as lowest (2.25), was found during October. No significant difference was found in the mean Shannon Wiener diversity index among the stations and months. The maximum Margalef richness value was observed 6.14 at station III, where as minimum value was found to be 3.91 at station I. Similarly, highest Margalef richness value was found to be 6.32 during January, where as lowest value was found to be 5.82 during July. Evenness index was found to be highest (0.96) at station III, and the lowest value (0.90) was found

in station II. Similarly, highest evenness value was found to be 0.95 in January and lowest value was found to be 0.88 in October. No significant difference was found in evenness value among the months and stations. The value of Shannon-weiner diversity, Margalef richness and the evenness in different stations and in different months are presented as-

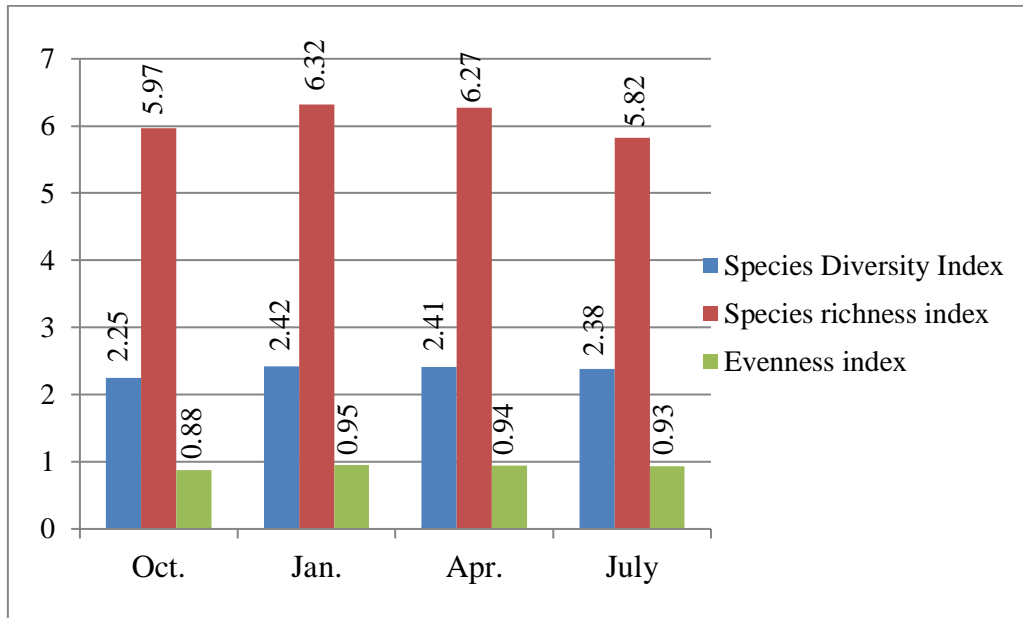


Figure 11 Month wise diversity index, species richness index and evenness index

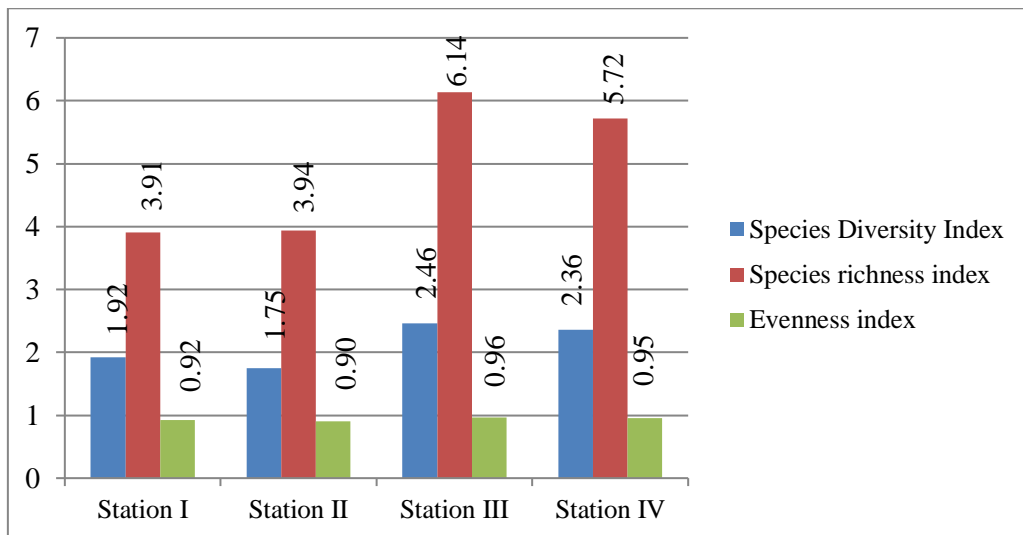


Figure 12 Station wise diversity index, species richness index and evenness index

## 4.8 Community structure of fishes in Ghodaghodi Lake

### 4.8.1 Order wise fish composition

Table 4 shows the order wise fish composition in Ghodaghodi Lake. About 39% of fish species belongs to order Cypriniformes and same was true for order Perciformes. Similarly, Siluriformes, Beloniformes and Synbranchiformes constitute eight percent each of total fish species. Out of 378 fish catch, 150 belongs to order Cypriniformes, which is about 40% of total fish catch. Similarly 147 fish belongs to order Perciformes, which was 39% of total fish catch. The lowest number of fish catch was from order Synbranchiformes, which was only two percent. So the Ghodaghodi Lake was dominated by order Cypriniformes and Perciformes.

Table 4 Order wise fish composition in Ghodaghodi Lake

S.N.	Order	Number Of Fish Species	Frequency	Number Of Fish catch	Frequency
1	Cypriniformes	5	38.462	150	39.683
2	Siluriformes	1	7.692	45	11.905
3	Beloniformes	1	7.692	28	7.407
4	Synbranchiformes	1	7.692	8	2.116
5	Perciformes	5	38.462	147	38.889
	Total	13		378	

### 4.8.2 Family wise fish composition

Table 5 shows family wise fish composition in Ghodaghodi Lake. About 39% of fish species belongs to family Cyprinidae. Nandidae and Channidae constitute 15% each of total fish species. Fish species belongs to Bagridae, Belonidae, Mastacembelidae and Ambassidae was only eight percent each. Out of 378 fish catch, 150 fish belongs to family Cyprinidae, which is 40% of total fish catch. Number of fish catch from family Channidae, Nandidae, Begridai and Belonidae was 19%, 16%, 12% and 7% respectively. Lowest number of fish catch belongs to family Mastacembelidae and Ambassidae, which was 2% and 3% respectively. So the fishes of Cyprinidae family were dominant species in Ghodaghodi Lake.

Table 5 Family wise fish composition in Ghodaghodi Lake

S.N.	Family	Number Of Fish Species	Frequency	Number Of Fish catch	Frequency
1	Cyprinidae	5	38.462	150	39.683
2	Bagridae	1	7.692	45	11.905
3	Belonidae	1	7.692	28	7.407
4	Mastacembelidae	1	7.692	8	2.116
5	Ambassidae	1	7.692	11	2.910
6	Nandidae	2	15.385	64	16.931
7	Channidae	2	15.385	72	19.048
	Total	13		378	

## 5. DISCUSSION

The present study was conducted for a period of about 10 months, from October 2014 to July 2015 to cover four different seasons. A total of 13 species of fish fauna were collected from different sampling station of Ghodaghodi Lake which belongs to five orders, eight families and 11 genera. IUCN (1998) identified 27 species of fish fauna from Ghodaghodi Lake Complex. DNPWC and WWF Nepal (2003) reported 29 fish species from Ghodaghodi Lake Complex. Kafle (2007) identified 25 species from same area. Recently Lamsal et al. (2014) recorded 9 fish species from Ghodaghodi Lake complex. Among them *Clarias batrachus*, *Channa striatus*, *Puntius sophore*, *Mastacembelus pancalus*, *Xanentodon cancila* are common fish species in all studies. Some species such as *Labeo boga*, *Mystus vitatus*, *Colisa fasciatus* etc were not found in present study.

In Ghodaghodi Lake, the dominant orders were Cypriniformes and Perciformes. Out of total fish species 78% belongs to these two orders. Similarly highest fish catch was from order Cypriniformes (40%), so the most dominant species was from order Cypriniformes. Edd (1986) also reported the order Cypriniformes was common order of Kaligandaki and Narayani Rivers. Sharma and Shrestha (2001) and Shrestha (2003) also reported order Cypriniformes constituting highest catch in the Tinau River and Dano River respectively. Majority of the fish species collected from the River fall under the order cypriniformes, this is the largest order of fresh water fishes, which includes 2,422 species (Nelson 1984).

Present study shows that 39% of fish species belongs to family Cyprinidae. While 40% of fish catch belongs to family cyprinidae and lowest fish catch was from family Mastacembelidae, which was only 2%. So the dominant family was found to be Cyprinidae. Sharma (1996), Karki (2000) and Bajaracharya (2001) have found that Cyprinidae as the most common family in Tinau, Karnali and Sunkoshi and Bhotekoshi River respectively. Pokharel (2007) has reported Cyprinidae was dominant family of Tinau River. K.C. (2015) also reported Cyprinidae as common family in Sharada River. Similarly *Labeo gonius* was the most dominant species in the Ghodaghodi Lake. This species was recorded throughout the year. The frequency occurrence of this species was 17% compared to *Macrornathus pancalus*, which was only 2%. Pokharel (2007) has reported *Labeo* spp. as a dominant species of Tinau River.

Ecological factors such as water temperature, depth, transparency, turbidity, conductivity, PH, DO, Free CO<sub>2</sub> and hardness play important role in fish diversity. Generally, increase in temperature increases the fish diversity. Present study shows that there is a positive correlation between temperature and fish diversity. Station III shows high fish diversity, it may be due to high mean temperature in this station compared to other station. The depth of water is important physical parameter which directly or indirectly affects the fish diversity. During the study it was observed that small species like *Puntius sophore*, *Channa* spp. etc were found to be a distributed in shallow habitat and large sized species like *Xenentodon cancila* were recorded in deeper area. The depth of Lake was found be ranging from 302cm to 98cm. The correlation between water depth and fish diversity was found to be positive during study period at Stations I (0.2476), II (0.4376) and IV (0.7597) while it was negative in station III (-0.2011). Transparency was recorded at highest value (83 cm) during January at Station I, where as minimum value was observed at Station II (60 cm) during July. Fish diversity and transparency was found to be positively correlated in station I (0.9724), III (0.3509) and IV (0.6779), but it was negative in station II (-0.4025). The level of turbidity was found higher at the station III during the study period in the month of July. Similar result was observed by Shrestha (2003) and Sharma and Shrestha (2001) from the river Dano and Tinau respectively. In the present study the correlation between fish diversity and conductivity was found to be negative except in station III.

The chemical parameters of the water also show great affect on the distribution of fish species in the Lake. The modification of physico-chemical environment has direct impact on the biotic response in the wetlands including the diversity of fishes (Gosselink and Tumer 1978). Among the chemical factors, the concentration of dissolved oxygen of water is the most important factors and dissolved oxygen above 5 mg/l is suitable to support diverse biota (APHA 1976). The dissolved oxygen of Ghodaghodi ranged from 3.2 - 5.6 mg/l with an average of 4.63 mg/l. The DO shows the high degree positive correlation (0.8242, 0.8074, 0.9345 and 0.6508) in all four stations. Natural water may be neutral, acidic or alkaline. It is an important environmental factor that influences the metabolic activities of fish. Generally low pH value is harmful to fishes. Water having pH value below 5.0 mg/l and above 9.5 mg/l are not suitable (APHA 1976). The pH ranging from 7.0 to 8.5 is considered to support rich biota and fish (Bell 1971). The pH of Ghodaghodi Lake ranged from 7.5 - 9.4 mg/l with an average value of 8.3 mg/l. High degree positive

correlation was found to be in station I, II, III and IV, which was 0.7701, 0.8256, 0.5767 and 0.7337 respectively. Most of the carbon dioxide in the water is formed by the decomposition of organic matter and from respiration of organism. The distribution of carbon dioxide in surface water varies seasonally. In the present study carbon dioxide varied from the 2.01 - 3.2 mg /l with an average value of 2.42 mg/l. The coefficient correlation between free carbon dioxide and fish diversity was found to be negative in station I (-0.6628) and II (-0.723) while it was positive in station III (0.769) and IV (0.3988).

The pollution of lake also leads to the decline in fish diversity. Jayadav et al. (2013) found that diversity of fishes is diminishing due to pollution in Akkulam-veli Lake. In Ghodaghodi Lake fish diversity is declining day by day, it might be due to pollution of water such as bathing, flood during rainy season, throwing mud and waste materials etc. Similarly, illegal fishing also causes the decrease in fish diversity. Generally the local Tharu people are involved in illegal fishing. Another important factor of declining in fish diversity is aquatic weeds like Water hyacinth, Lotus, *Hydrilla* etc in Ghodaghodi lake. The extremely rapid rate of proliferation of aquatic weeds result in reduction of dissolved oxygen in water bodies, change water chemistry, affect flora and fauna, increase rate of water loss due to evaporation and is now presently being considered as a serious threat to biodiversity (IFPRI 2009). Aquatic weeds also lower the temperature of the water PH, bicarbonate and alkalinity and increases the free carbon dioxide contents affecting the Biological Oxygen Demand (BOD) and nutrient levels (Obiero and Munyirwa 1998).

A biodiversity index seeks to characterize the diversity of a sample or community by a single number (Magurran 1988). The concept of the “species diversity” involves two components: the number of species or richness and the distribution of individuals among species. However, the formal treatment of the concept and its measurement is complex (Williamson 1973). Shannon–Wiener diversity index considers the richness and proportion of each species while Evenness and Dominance indices represent the relative number of individuals in the sample and the fraction of common species respectively. The biodiversity index values obtained from present study is not so very high according to Shannon-Weaver biodiversity index values and they do not exactly show the differences occurring among the stations either. According to Keskin and U'nsal (1998), the reason for showing lower species biodiversity is that fishing gears used have high selectivity effect. The equipment effect of the fishing gear used in this study was ignored. Highest Shannon diversity index was found in station III (2.46) and during January (2.42) where as lowest

value was observed at station II (1.75) and during October (2.25). The main causes of the differences occurring in the biodiversity indexes are atmospheric air currents and environmental conditions (Keskin and U'nsal 1998). The evenness index was found to be highest at station III (0.96) and during the month January (0.95), where as the lowest was found to be at station II (0.90) and during the month October (0.88). The maximum (6.14) Margalef richness value was observed at station III and during the month January (6.32) where as minimum value was observed at station I (3.91) and during the month July (5.82). In diversity index (H'), Evenness (E) and Mergalef richness (d), there was no significant difference observed. Therefore, it may be concluded that the seasonal difference in species diversity is a common phenomenon in the studied area.

## 6. CONCLUSION AND RECOMMENDATIONS

### 6.1 CONCLUSION

A total of 13 fish species were collected from the different section of Ghodaghodi Lake, belonging to five order, eight family and eleven genera. Fishes were not found uniformly distributed in the lake, it might be due to variation in temperature, depth, transparency, turbidity, conductivity, PH, DO, Free CO<sub>2</sub>, hardness etc of water. Ghodaghodi Lake is the habitat for different species of fish like *Labeo gonius*, *Mystus tengara*, *Nandus nandus*, *Channa striatus*, *Channa punctatus* etc. The dominant order, family and genus of lake were Cypriniformes, Cyprinidae and *Labeo gonius* respectively. *Puntius sophore* and *Pseudambassis baculis* were rare species recorded from the present study where as other species were common. No significant difference in the diversity status was obtained during the investigation period rather it was a seasonal phenomenon in the composition of fish species. The study shows the decline in number and diversity of fishes, it may be due to illegal fishing, pollution and aquatic weeds.

### 6.2 RECOMMENDATIONS

The initiation towards conservation and management of fishery resources in Ghodaghodi Lake has not been taken seriously. No work had been done so far for the conservation of fish fauna in Ghodaghodi Lake, as a result there is decline in density and diversity of fish species. Therefore for successful conservation and management of indigenous fish species, following recommendation are suggested.

- Community and school based awareness program should be conducted, regarding the conservation of lake.
- The aquatic Animals Protection Act (AAPA) should be implemented effectively through the concerned governmental agencies.
- Aquatic weeds should be cleared time to time without disturbing the habitat of fish.
- An intensive survey and regular monitoring of fish should be conducted by government and other concerned agencies.
- Pollution caused due to human activities should be controlled.

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**PALATE I Ghodaghodi Lake area**



Outlet of Ghodaghodi Lake



Ghodaghodi Lake



Aquatic weeds in Ghodaghoda Lake

## PALATE II Collection and analysis of water of Ghodaghodi Lake



Boating and sampling at Ghodaghodi Lake



Water quality analysis



Water parameter analysis at Dhangadhi Laboratory

## APPENDIX 1

### Estimated water surface area in Nepal

S.N	Resource details	Estimated area (ha)	Coverage (%)
1	Natural water	4,01,500	49.13
	Rivers	3,95,000	48.34
	Lakes	5,000	0.61
	Reservoirs	1,500	0.18
2	Village ponds	18,600	0.80
3	Marginal swamps	11,100	1.36
4	Irrigated paddy field	3,98,000	48.71
	Total	8,17,100	100

Source: Directorate of Fisheries Development, (2013/2014)

### List of conservation status of fishes of Nepal

S.N	Categories	Designated as	Number of fish species
1.	Common	C	71
2.	Uncommon or lower Risk/ Least Concern	UN	53
3.	Conservation Dependent and Rare	CDR	27
4.	Data Deficient Pristine Rare ornamental	PRO	32
5.	Critically Endangered	CE	0
6.	Endangered	EN	2
7.	Extinct	EX	0
8.	Vulnerable	VU	9

Source: Ichthyology of Nepal (Shrestha, T.K., 2008)