CHAPTER ONE

INTRODUCTION

1.1 General Background

Nepal, a land-locked mountainous country, lies between 26^0 20' to 30^0 10' N latitude and 80^0 15' to 88^0 10' E longitude. It covers an area of approximately 147,181 sq km. It extends 885 km along the East-West with an average width of 193 km along the North-South and is bound by China to the North and by India to the east, south and west. The altitude ranges from 60 m in the South to 8,848 m in the North. Consequently, the country has a wide range of climatic zones ranging from humid sub-tropical to alpine, within a short distance to 80-150 km.

Nepal is blessed by nature with varying array of water bodies supporting biologically diverse fish fauna. Rich fresh water resources comprising of snow-clad Himalayas, eternal glaciers, snow-fed rivers, lakes and torrential hill streams have given this country a sole identity in the world. Snow-fed river system of the Himalayas, deep valleys, broad plains all lead to the diversity of fish fauna. Fresh water fishes of Nepal show glorious diversity in their structure and have developed many specialties in response to the ever changing torrential environment.

Major river systems of Nepal are Koshi, Gandaki, Karnali and Mahakali. All these rivers have originated from the Himalayas and flow towards south. The water surface area of Nepal covers 0.1 percent of the total world water systems and fish diversity accounts 0.21 percent of total global fish diversity (Shrestha, 1995). The river system is one of the major habitats on earth which plays significant role in establishment and maintenance of rich biodiversity. They are good home for autotrophs, phagotrophs, saprotrophs, periphyton, nekton, neuston etc (Odum, 1971). River provides critical habitats for many species of fauna and flora. Rivers are rich for fauna and flora and they are among the most productive environments of the world. These rivers have provided suitable habitat for a number of fish species and their value is further evidenced by the fact that rivers can produce up to eight times as much plant matter as wheat field (Singh, 1994).

1.2 Water Resources of Nepal

Nepal is second richest country of the world water resource with enormous potential for hydropower development. Nepal is endowed with several types of wetlands. Wetlands cover about 7,435 sq km or approximately 5 percent of the total area of the country. The total estimated wetland resources consists of permanent fast flowing rivers to seasonal streams, high altitude glacial lakes to lowland on low lakes to swamps and marshy lands, river flow plains to paddy fields and man-made reservoirs to village ponds.

Table 1: Estimated water surface area in Nepal

S.N.	Resource details	Estimated area (ha.)	Coverage (%)
1	Natural water		
	1.1 Rivers	395000	48.35
	1.2 Lakes	5000	0.61
	1.3 Reservoirs	1500	0.18
2	Village ponds	5954	0.72
3	Marshy land	11500	1.4
4	Irrigated paddy field	398000	48.71
Total		816914	100.0

Source: Fisheries Development Directorate, 2001/2002.

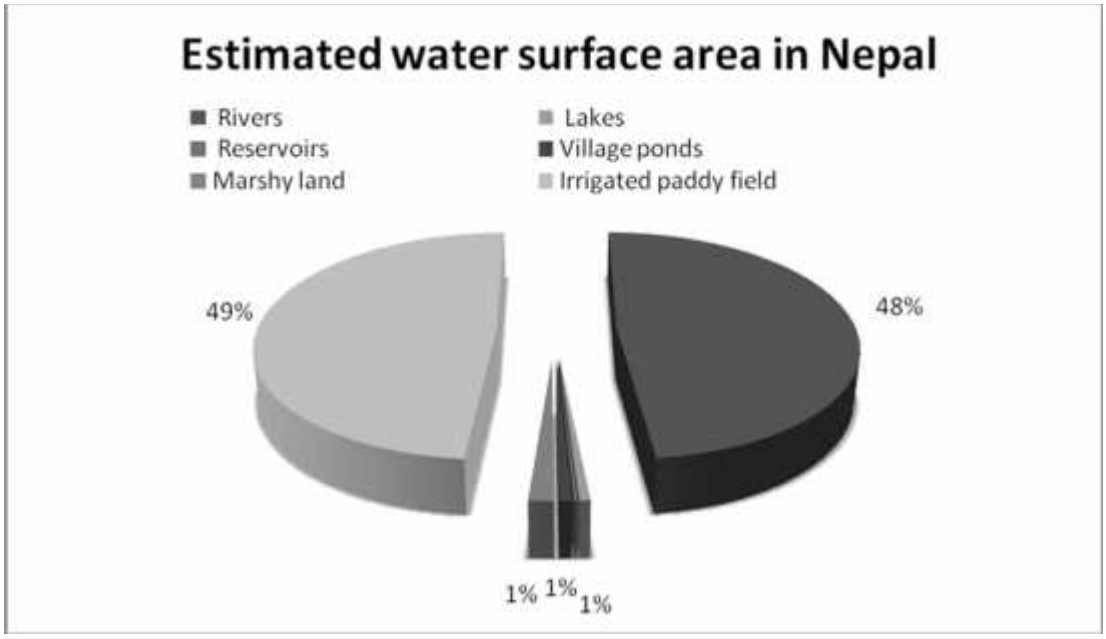


Figure -1: Estimated water surface area in Nepal

1.3 River Systems in Nepal

Nepal is a mountainous country and water resource is one of the chief natural resources of Nepal, which if harnessed and managed properly, can led the country towards all round development. Rivers in Nepal can be classified into three categories in terms of their sources of dry season discharge. Generally, responses of all rivers follow the rainfall pattern. The first groups of rivers have their water sources derived from snow and glaciers in the dry season. The Mahakali, the Karnali, the Gandaki and the Sapta Koshi are the four rivers in the first category. The second groups of rivers originate in the middle mountains, which are mostly rains fed and low flow in

dry season. Bagmati, west Rapti, Mechi, Kankai, Kamala and Babai are the rivers in the secondary category. Rivers in the third categories originate in the Churia southern face of the Mahabharat or in the Terai. These rivers have small catchments areas. In dry season, the discharge of these rivers become nominal while several rivers dry up. Tilawe, Sirsia Manusmara, Hardinath, Sunsari, Banganga are some of the rivers belonging to third category. All these large and small rivers give rise to about 6,000 rivers totaling about 45,000 km. in length. Approximately, 1000 of these rivers are more than 10 km. long and about 100 of them are longer than 160 km. (Sharma, 1977).

Out of four major rivers, Saptakoshi in the east, Saptagandaki in the center, Karnali in the west and Mahakali in the far west. Sapta Koshi, Saptagandaki, Karnali originate from the Tibetan platue and crosses the Himalayas. Each river system has seven tributaries which are fed by snow and glacier; melt form the Tibetan plateau and Himalayas.

1.4 Description of the Koshi River

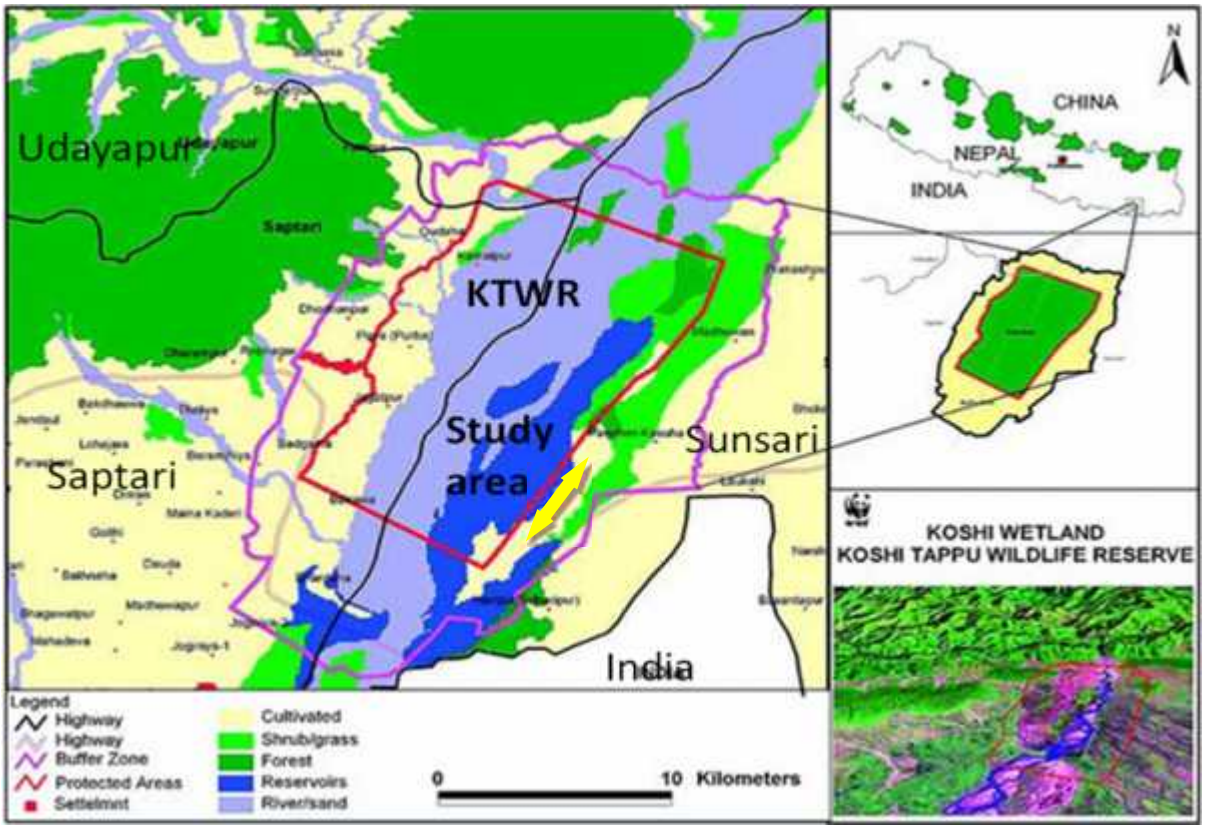
The Koshi River is the largest river of Nepal and is the largest tributary of the River Ganges. The Koshi river drains the region lying the east of Gosainsthan to west of Kanchanjunga, covering a total drainage area of 60,400 km^2, of which about 47% lies in Nepal. In Sanskrit, the Koshi River is called "Kaushik" and is commonly called Sapta Koshi (meaning seven rivers). The rivers Tamur Koshi, Arun Koshi, Dhudh Koshi, Tama Koshi, Sun Koshi, Bhote Koshi and Indrawati are the main tributaries of the Koshi basin. However, the Indrawati, Bhote Koshi, Tama Koshi, and the Dudh Koshi join the Sun Koshi before they join the Arun Koshi and the Tamur at Triveni, about 10 km upstream of Chatara, to form the Sapta Koshi or Koshi. The Koshi has an average flow of 1931 M^3/sec.

1.5 Description of the Koshi Tappu Wildlife Reserve (KTWR)

In the early 1970's a need was felt to establish a wildlife reserve in Koshi Tappu to conserve the wild water buffalo population under the section 10 of the National Parks and Wildlife Conservation Act, 1973 and gazetted as the Koshi Tappu Wildlife Reserve (KTWR) in 1976.

The Koshi Tappu Wildlife Reserve (KTWR) is an important wetland area in the Sapta Koshi river basin. It encompasses 175 sq km area of the river and associated floodplains lying in Saptari, Sunsari and Udaypur districts of Nepal. The KTWR is almost rectangular in shape running 17.3 km north south and 10.1 km east west, extending over 26 degree 35' -26 degree 40' N latitude and 85 degree 56'-87digree 05'E longitude. The site consists of the natural river floodplains, including numerous low islands, extensive mudflats, oxbow lakes, freshwater, marshes and grasslands. It is the only wetland area in Nepal of international importance. It was designated as a wetland of international importance and added to the Ramsar list on 17th Dec 1987 (IUCN 1998). Large numbers of local communities residing in 16 different village

development committees (VDCs) are dependent on these wetlands for their livelihoods (Shrestha et al., 2006). In 10 VDCs of Sunsari and Saptari districts, about 500 households solely rely on fishing. The Socio-economic status of the fishers' communities is the lowest in the society due to the high population growth rate, low fish catch and low income (Yadhav, 2002).



Koshi Tappu wildlife Reserve

Natural water fisheries resources basically fall upon public sectors domain. Quite a large segment of population, particularly the deprived and disadvantaged people are closely associated these resources for their livelihood and socioeconomic development. The fishers use different kinds of traditional fishing gear like nets, baskets, rod and line, spearing, and indigenous fish poisons. Today some destructive fishing methods are introduced like pesticides, dynamite and electricity. Such many irrational fishing practices have posed a serious threat to the diversities of fish species (Shrestha, 1994; Swar and Bisgard 1999; Yadav, 2002).

1.6 Fish Diversity in Nepal

The fishes of Nepal have wide distribution according to the climatic condition and altitudinal variation. According to Shrestha (1995) there are 184 indigenous fish species belonging to 92 genera, 31 families and 112 orders which are distributed in different rivers and water bodies of Nepal. On the basis of published literature, out of 184 species, 127 species are recorded from

Koshi, 157 from Gandaki, 119 from Karnali and 71 species from Mahakali River (Shrestha, 1992).

The fishes of Nepal are distributed from an altitude of few meters in Terai to 3323 m in Langtang Khola located in Langtang National Park (Shrestha, 1995). *Bagarius bagarius*, (Gonch) is the largest fish found in Nepal whereas *Brachydanio rerio* (Zebra fish) is the smallest fish (Shrestha, 2001, Shrestha and Chaudhary, 2003).

1.6.1 Status of Fish in Nepal

In Nepal none of the fish species has been included in the IUCN and CITES list of endangered wildlife. Shrestha (1995) has enumerated a list of indigenous fish species of Nepal for Biodiversity Profile Project along with their conservation and distribution status. The report indicates that out of 184 listed species 57 are common, 63 insufficiently known, 23 rare, 32 species threatened species and 8 species are categorized in vulnerable category whereas one species is given protected status.

Neolissocheilus hexagonslepis, Anguilla bengalensis, Tor putitora, Schizothorax richardsoni, Schizothoraichthyes progastus, Chagunius chagunio and Psilorhynchus pseudecheinus are few species listed in vulnerable category. *Tor tor* is the only endangered species found in Nepal. *Amblyceps mangois* and *Euchiloglarius hodgartitora* are categorized as rare.

Six species found in Nepal are given endemic status. *Schizothoraichthyes nepalensis, Schizothsraichthys macrophalmus, Schizothoraichthys rarensis*, and *Psilorhynchus pseudecheinus* are the endemic species of Nepal. The other species categorized under endemic category are *Myersglanis blythi* and *Pseudetropius murius batarensis* (Shrestha, 2001, Shrestha and Chaudhary, 2003).

1.6.2 Pollution in river

Today most of the rivers are subject to physical alteration, degradation and pollution. River receives tones of domestic and agricultural waste, urban sewage and industrial effluent. Industrial effluent contains heavy metals, toxic chemicals which may kill fish, aquatic vegetation and affects many aquatic/natural purification processes of the rivers (Manivasakam, 1999). Due to the growing urbanization and industrialization, rivers have been losing their physical, chemical and biological form, so that number of reptiles, amphibians, birds, mammals, fishes and invertebrate species are depleted severely due to devastation of their habitats needed for survival. Both in the industrialized and developing countries Rivers (wetlands) are prone to the activities and practices that are not always compatible with the balance of nature or with the very existence of these sites (Ramsar Convention 1992). The oxidisable and fermentable matter present in sewage causes depletion of dissolved oxygen in river water, thus the aquatic life is affected.

During last decades, inland water bodies of Nepal have been subjected to a range of stress factors caused by direct and indirect human activities such as irrigation, hydroelectric project, urbanization, industrialization, modernization of agriculture and changes in land use in the river floodplains. In particular, the river basins in Nepal have undergone an accelerated rate of change following tremendous demographic growth, which has created adverse effects upon biodiversity, especially the native fish fauna (Swar and Shrestha, 1996). Many problems associated with different human activities include siltation, chemical pollution, introduction of exotic species, over and irrational fishing and hydraulic engineering (dams and impoundments, channelization etc.). All these problems lead to threatening of many of the native fish species inhabiting water bodies (Shrestha, 1998).

1.7 Limitations of the study

This study is focused on fish diversity in the area of Koshi Tappu Wildlife Reserve that too in between 8 km range and covers limited sites for sampling of fish to access diversity. Apart from this, a survey was carried out about some fisher communities around the buffer zone area, but is unable to include whole community of buffer zone. This study is also based on some interviews with local fishermen who could not explain the disease, scientific name and order of extinct fishes. Laboratory facility was not available at nearby location. Similarly, this study also based on data taken on recall basis so there may be some response error.

1.8 Justification of the study

Koshi River is one of the main water resources of Nepal. The river bears great importance from the point of view of biodiversity. The Koshi River is inhabited by large numbers of aquatic animals, different fish species, reptiles and mammals like Dolphins. The fish population in the river is being declined due to several factors like heavy flooding, erosion, some diseases and illegal fishing practices. Therefore the present study has been undertaken to collect the information of the fish diversity and fishery resources of the Koshi River. The present work includes the study of water quality, fish and fisheries resources and socio economic status of local fisherman around the KTWR. The fishermen are closely familiar with the fish species and their behavior in the river. Thus this will be helpful for any further studies, research work on fish conservation, management and development plans.

1.9 Objective of the study

The general objectives are to identify the fish diversity and fishery resources of Koshi River. The following are the specific objectives:

- To explore the existing fish diversity of the Koshi River.
- To investigate the distributional pattern and frequency occurrence of fish species.
- To study the physico-chemical parameters of Koshi river.
- To identify the fishing implements and fishing techniques used by the local fishermen in the Koshi River.
- To collect information on the socio-economic condition of the local fishermen.

CHAPTER TWO

REVIEW OF LITERATURE

The commencement of the history of ichthyology coincides with that of Zoology which dates back from the time of Aristotle who is said to be the father of natural history. He had an accurate knowledge of the general structure of fishes and distinguished them precisely from the aquatic amphibians, mammals and from the various groups of aquatic invertebrates. All his information on the habitat of fishes, were from Argian Sea adjacent to Greece.

After Aristotle, proper work on fishes was available for nearly 1800 years, which considered as a period of regression in the science of ichthyology; hence it is regarded as a dark age in the history of ichthyology. Piersa Belon (1517-1575 A.D.) contributed in the field of ichthyology which was based on his original observations of the 110 fishes of Mediterranean Sea in Europe. In the next century, Piso (1611-1678 A.D.) was noteworthy scholar of ichthyology. His notable contributions were the arrangement of various species of fishes in proper systematic manner. He also gave them independent and proper scientific names. He and his colleagues catalogued about 420 species including those which were already recorded.

Different workers have contributed from time to time in exploring the ichthyio fauna of Nepal. 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 Ganges and its tributaries'. Gunther (1861) reported some cold-blooded vertebrates including fishes, collected by Hodgson in Nepal. Altogether 35 fish species were included in his checklist. Similarly, McClelland (1839), Beaven (1877), Boulenger (1907) and Regan (1907) also reported fish fauna of Nepal. Regan (1907) reported five species from Nepal. Hora (1920-1952) studied the Himalayan fishes with particular emphasis on zoo-geographical distribution. He obtained a collection of 22 specimens comprising 15 different genera. He also included a full description of *Glyptothorax* collected from Pharping.

Menon (1949) collected 11 families of fishes comprising 26 genera and 52 speceis form 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. Menon and Dutta (1961) reported a new cyprinid fish *Psilorhynchus pseudocheneis* in India and Choyu Expedition in Nepal. Dibbs (1965) reported various aspects on the development of fisheries of Nepal. Thapa and Rajbanshi (1968) studied the ecology of hill stream fishes of Nepal.

Majupuria and Shrestha (1968) published paper on fresh water fishes of Nepal. Shrestha (1970) worked on the taxonomy of fishes of Nepal. Bhatt (1990) listed about 57 species of fishes from Nepal. Bhatt and Shrestha (1973) have studied the fish fauna of Suklaphanta and listed out 27 species.

Hickel (1973) studied lakes of Pokhara valley and also studied the phytoplankton in Taudah and Nagdah in Kathmandu valley in relation to the vertical distribution. Ferrous 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 (1979) studied the resource biology and aquatic ecology of fresh waters in Kathamndu valley with particular reference to fish population, marketing management and conservation. Shrestha and Pradhan (1979) studied the aquatic ecology and fishing potential of Bagmati River. 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. rarensi*s. Edds (1985) added a list of eight new records of fish previously not recorded from Nepal. Jha and Shrestha (1986) highlighted the prospects of fishery resources of Karnali River and recorded 51 species of fishes. Masuda and Karki (1986) compiled a checklist of fish fauna of the Trisuli River and reported 28 species of fish belonging to 6 families and 16 genera. Joshi (1988) studied fishery resources of Sunkoshi River with particular reference to dam and its impact on fishery. The fishes from Koshi and Karnali were collected by Ichthyologist Edward Migdalski (1989) and were deposited in Indian museum while studying the environmental impact and mitigation prepared the total list of 58 fish species present in Karnali and Bheri river system. Shrestha (1991) reported 59 species of coldwater fishes from the natural water bodies of mountains and Himalayan region of Nepal. 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 but again in 2001, she revised her work with a total of 182 species belonging to 93 genera, 131 families and 11 orders. John (1986) studied the morphological adaptations of fishes of river Seti and adjoining areas. Smith, Bhandari and Sapkota (1996) submitted a report of Aquatic Biodiversity in the Karnali and Narayani River basins. In their report they mentioned the main aquatic wildlife in the Karnali and Narayani river basins. Few of the aquatic animals recorded were Ganges River Dolphins (*Platanista gangetica*), Gharial (*Gavialis gangeticus*), mugger Crocodile, Asian small-clawed otter, different species of turttles like *Chitra indica, Aspideretes gangeticus, Kachuga dhangoka, Kachuga kachuga* etc. Apart from these riverine birds like Egretta, Alba, Ardea purpurea, Lapwings, Duck, Greese, Kingfisher, Stroks, Cranes etc were also recorded. A total of 121 and 135 fish species have been recorded in the Karnali and Narayani river basins. Pokhrel (1998) reported altogether 18 fish species form the lakes situated in Pokhara Valley. Dhital et al. (2001) have studied the fish fauna of Narayani River system and their impact on the fishermen community in Chitwan Nepal. They listed 69 species of fish belonging to 9 orders and 19 families. Bajracharya, (2001) studied the fish and fishery resources of the Bhotekoshi and

Sunkoshi River and reported 16 fish species. Singh (2001) reported a total of 40 fish species belonging to 6 orders, 13 families and 26 genera form the Babai River, Nepal.

Dr. Bharat Raj Subba and Kul Prasad Limbu studied "Biodiversity assessment of Koshi Tappu Wildlife Reserve after Koshi flood disaster 2008", a total number of 64 fish species belonging 15 families but has not described the order of fishes.

Mr. Pramod Kumar Rijal studied (2008) "Role of fisheries and aquaculture in livelihoods of Koshi Tappu Buffer zone community" the total number of 60 fish species belonged to 7 order, 20 family and 40 Genera.

In Nepal, very little work on physical, chemical and biological feature of the river system have been done till now. Specially, studies focusing in effects of pollution on aquatic habitat are also in initial stage. Some studies have been concentrated in the field of limnology by some ecologists. Brehm (1953) studied some aquatic fauna along with the limnological studies from Kalipokhari, Eastern Nepal. Hiriono (1955) and Foster (1965) published few papers concerning to the Nepalese algae. Ferrow (1978) studied the limnology of the lakes in Pokhara valley and its implication for the fishery and fish culture. Shrestha et al. (1979) studied the limnology of Bagmati and Trishuli rivers to some extent. Swar (1980) described the status of limnological studies and records in Nepal. Upadhya and Ray (1982) have studied river pollution in Kathmandu valley concluding the critical condition of river system.

Mahaseth (1988) studied the physiochemical parameters of Tadi River in relation to fish production and management. Nakanishi et al (1988) categorized Begnas and Rupa lakes as eutrophic lakes and obtained limnological data during late monsoon and dry season. Bhattarai (1996) studied hydrological characteristics and primary productivity of Kamalpokhari, Bhaktapur. Khadka (1996) studied some parameters of the Nagdah pond, Lalitpur. Talling and Lamolle (1998) reported some information about tropical and temperate lakes of Nepal.

Some workers studied on socio-economic status of fisher communities .Timsena (1987) carried out a study on Majhi; Thapaliya (1988) also published" an introduction to Bote ethnic group" Subba (1989) has undertaken an intensive study on socio-economic and cultural life of Bote in Tanahun district. Kaini (1996) has written an article recently on Bote tribal community belonging to three districts Gorkha, Tanahun and Chitwan. Gyawali (1997) also studied about socio-economical aspect of Bote. Gubhaju et al. (2002) studied the contribution of cold water fishes in the livelihood of mountain people of Nepal. They reported that indigenous cold water fishes have significant contribution as nutritional protein supplement and as a means of income source on the livelihood of local ethnic fish communities. Thus the present study entitled "Fish Diversity and Fishery Resources of the Koshi River at KTWR area" is carried out to contribute further knowledge about the fish fauna, their productivity and socio-economic status of the fishermen of the Koshi river.

CHAPTER THREE

MATERIALS AND METHOD

3.1 **Materials**

Following materials were used during present dissertation

3.1.1 **Glassware**

Conical flask, Pipettes, Burette, Beaker, Volumetric flasks, BOD bottles, Droppers, Petri, Disc, Glass rods, Measuring cylinders, Standard mercury thermometer , Separator funnels, Secchi disc.

3.1.2 **Chemicals**

Hydrochloric acid (0.1 N), Sodium Hydroxide (0.1N), Conc. Sulphuric acid, Sodium Thiosulphate 0.025N, Sodium Carbonate 0.1N, Methyl orange indicator (0.65%), Manganese sulphate solution, Phenolphthalein indicator, Starch solution, EDTA solution (0.01N), Buffer solution, Eriochrome Black-T indicator, Formalin.

3.1.3 **Laboratory instrument**:

PH meter, Camera, Measuring tape, Field book.

3.2 **METHODS**

3.2.1 Study Period

The field study was carried out for nine months starting from March 2010 to November 2010 covering four different reasons i.e. March (spring), June (summer), September (autumn) and December (winter). Each sampling station was visited four times during the study period and thus the totals of 16 different samples were collected altogether.

3.2.2 Study Area

The present study on fish diversity and fishery resources was carried out in the River Koshi, one of the important and major river systems of the state. The survey stations were inside the Koshi Tappu Wildlife Reserve spreading at almost 7.5 km in distance from west Kushaha to Haripur. Altogether four stations were established at approximate distance of 2.5 km. Four major sampling stations established were as mentioned below:

Station -I:

The first station was situated to the near location of KTWR office at west Kushaha, at a distance of approximately 7.5 km north from the East West highway Haripur and East bank of the Koshi River. As this site was very near to the Reserve office this site was more protected and ample number of fishes were found. Almost all kind of fish species were found. This station was undisturbed by the local population only the license holder fishermen used to come for fishing purpose. The water was good and transparent.

Station -II:

The second station was located at a distance of approximately 2.5 km south from the first station. The local name of the place was called as Titri Gachhi. Since this station was also near to the Reserve office and inside the protected area it has the same characters as in first station.

Station -III:

The third station was located at a distance of 5 km south, downward from the first station. This station had more vegetation comparing to the first and second stations. Almost all kind of the fishes were available at this station. More fishermen used to fish for their livelihood.

Station: IV:

The fourth station was located at a distance of 7.5 km south and downwards from the first station. This station was near to the Army Camp and the location was called as Haripur. This station had much more vegetation and protected. Almost all the license holder fishermen used to enter the river from this station. Since the exit point was also same point, there was small fish market near this station. The same kind and amount of fishes were available at this station. Much more information was gathered from this place.

3.2.3 Data Collection

Primary as well as secondary data were collected during study. Primary data were collected directly by field observations, interviews and questionnaire. Field observations were made to study the fish diversity and water quality analysis. Socioeconomic condition of fishermen was also taken by interview.

3.3 Fish Sampling:

The field study was carried out for nine months starting from March 2010 to November 2010 covering four different reasons i.e. March (spring), June (summer), September (autumn) and December (winter). Each sampling station was visited four times during the study period and thus the totals of 16 different samples were collected altogether. Local fishermen were also used for the collection of fishes from sampling sites. Cast net, gill net, ghorlong, hook and line, dhadiya and other locally available devices were used for the collection of fish sample. Number of total fish species collected from each sampling site was recorded. Then different species of the collected fish were preserved in 4-8% formaldehyde solution. These collected fishes were identified after Shrestha (1991, 1994, and 2001) and Jayaram (1999).

3.4 Water Quality Analysis

Water, renewable natural resources is a fundamental requisite that nature has provided to sustain life on earth, and is the most common substance on earth. The physico-chemical parameters of an aquatic ecosystem regulated by many factors viz. the depth of water body, existing meteorological condition, fluctuation of weather, varied climatic conditions and other chemical properties, while the living organisms present in an aquatic medium tend to balance the physical and chemical properties of water by the process of photosynthesis, respiration or decomposition. Conversely, the life of living organisms and their life processes also depend directly and indirectly on limnological aspects as physico-chemical parameters.

The various physico-chemical parameters of water observed and analyzed during the sampling investigation period includes temperature(water and air), transparancy, turbidity, velocity, water co lour, pH, free CO_2, dissolved oxygen, total alkalinity, depth and total hardness. Analysis of physico-chemical parameters of water carried out following "Standard Methods for Analysis of Water" by Adoni (1985), Tribedy and Goel (1986) and APHA (1998).

3.4.1 Physical Parameters

The main physical parameters studied during the study period are as follows:

3.4.1.1 Water Colour

Simple method was used to determine the colour of water. A little amount of water was collected from the river and placed on a white paper and the colour was then observed.

3.4.1.2 Temperature:

Temperature of the surface water of the study area was recorded with the help of standard mercury thermometer. The recording was done by dipping directly the thermometer bulb into water for about two minutes at each station.

3.4.1.3 Transparency

A Secchi disc method was applied to measure the transparency of the water. Secchi disc is a metallic device of 20 cm diameter painted black and white in quadrant used universally for studying the transparency of aquatic bodies (APHA: 1979) and it was designed by an Italian Scientist named Secchi in 1965.

To determine the transparency of the water, the disc was first lowered in the water until it becomes invisible and the reading was noted down. Then the disc was gradually pulled up and again the reading was noted at which the metallic surface of the disc becomes first visible. Then the transparency was calculated by applying the following formula and the final reading was recorded as transparency in cm.

$$\text{Transparency (D)} = \frac{X \Gamma Y}{2} \text{cm}$$

Where,

D = Transparency in cm

X = Depth at which sacchi disc disappears

Y = Depth at which secchi disc reappears

3.4.2 Chemical Parameters

Among the various chemical parameters of water, pH of water was measured at the sampling station during each field visit. While the other chemical parameters like dissolved oxygen, free CO_2, total alkalinity and total hardness were analyzed and recorded in the laboratory since it was difficult to carry all the required chemicals and apparatus during the field investigation. The water samples were collected from each and every sampling site and taken to my own school laboratory to analyze remaining chemical parameters

3.4.2.1 Dissolved Oxygen (DO)

Dissolved oxygen is one of the important parameters in water quality assessment and reflects the physical and biological processes prevailing in the water. It exists as a gas in water and therefore, it requires special precaution to deal with, although it is determined by simple titration. It was

measured by using Winkler's Iodometric method which was originally developed by Winkler in 1888.

For this, the sample of water was taken in 250ml B.O.D. bottle by allowing the water to overflow the bottle avoiding the air bubbles from each sampling sites. Then the Winkler's solution-A (MnSo4 solution) and Winkler solution-B (alkaline KI solution), 1ml each, was added into the water sample so as to fix the dissolved oxygen. Then the oxygen fixed water sample was taken to the laboratory with due care and the titration against sodium thio-sulphate ($Na_2 S_2 O_3$) of 0.025 N strength was performed accordingly by adding conc. $H_2 SO_4$ solution and starch indicator. The calculation was made by using the following formula:

$$\text{Dissolved Oxygen (mg/l)} = \frac{(\text{ml} \mid \text{N}) \text{ of } Na_2S_2O_3 \mid 1000}{V_2 \dfrac{(V_1 \, Z V)}{V_1}}$$

Where,

V = Volume of $MnSo_4$ and KI added

V_1 = Volume of sample bottle after placing the stopper i.e. BOD bottle

V_2 = Vol. of the contents titrated

3.4.2.2 Free Carbon-dioxide (CO_2)

The amount of the carbon-dioxide in water is necessary to retain calcium in the form of calcium carbonate. The large amount of CO_2 is available to the water through respiration by plants and animals and it is also derived from atmosphere as well as bacterial decomposition of organic matter. The presence of CO_2 is essential for photosynthetic activity to the aquatic vegetation and phytoplankton but excess is harmful to the aquatic animals.

To determine the free carbon-dioxide present in the water, 100ml of sample water was taken in a conical flask and 3-4 drops of phenolphthalein indicator was added to it and titrated against the standard alkali solution (NaoH soln.) of 0.05N strength. The calculation was done by using the following formula;

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

3.4.2.3 Hydrogen-Ion Concentration (pH)

pH is the measure of the intensity of acidity or alkalinity and measures the concentration of hydrogen ions in water. It is one of the most important environmental factors that affect the composition and distribution of all aquatic animals. pH is generally measured on a log scale and

equals to negative logarithm of hydrogen-ion concentration which may be expressed mathematically as follows:

$$pH = -\log_{10}[H^+]$$

$$= \log_{10} \frac{1}{H^r}$$

Where, $[H^+]$ is the concentration of hydrogen ions in water in moles per liter.

A battery operated portable digital pH meter was used to record the pH of the water in each and every sampling station.

3.4.2.4 Total Alkalinity

Alkalinity of the water is its capacity to neutralize a strong acid and is characterized by the presence of hydroxyl-ions. The alkalinity in the water is generally imparted by the salts of carbonates, bicarbonates, phosphates, nitrates, borates, silicates etc. together with the hydroxyl ions in Free State. In the present study only carbonate alkalinity was measured.
To the 50ml of water sample; one drop of phenolphthalein indicator was added and mixed thoroughly. Then 0.5ml of methyl red bromo-cresol green indicator was added to it and finally titrated against standard sulphuric acid solution (0.02N) until the colour changes from green to pink. Calculation was done by using the following formula and the result was expressed in parts per million (ppm)

$$\text{Total alkalinity as } CaCO_3 \text{ (mg/l)} = \frac{\text{Normality of } H_2SO_4 \mid 50.50 \mid 1000}{\text{Vol. of sample used in ml}}$$

3.4.2.5 Total hardness

Hardness is the total amount of soluble salts as calcium and magnesium chlorides, bicarbonates and sulphates present in water. It prevents the lather formation with soap and increases the boiling point of water. Besides calcium and magnesium other metals like strontium, iron, manganese etc. are also capable of precipitating the soap and constitute to hardness. The total hardness of the river water was estimated by EDTA Titrimetric method. For this, 50ml. of water sample was taken in a conical flask collected from sampling sites, 2 ml of ammonia buffer solution and 200mg. of Erichrome Black -T indicator were added and thoroughly mixed by shaking the flask until the wine red colour appeared. Then, the titration of the solution against the standard EDTA solution of 0.01N strength was performed till the clear blue colour appeared. The total hardness was calculated by using the formula as follows:

$$\text{Total hardness as } CaCo_3 \text{ (mg/l)} = \frac{\text{Vol. of EDTA used in ml} \times 1000}{\text{Vol. of sample used in ml.}}$$

3.5 Socio-economic Condition of Fishermen Community

A set of questionnaires were developed and administered in different villages located in the buffer zone of KTWR near the Koshi river that were West Kushaha, Pratitol and Haripur villages. The general information were regarding the distribution of fish species, fishing methods, fish market, ecological behaviours of fish, fish yield, fishing implements, socio-economic condition of fishermen and other several information were obtained by interview with local fishermen. The questionnaire set is given in Appendix I. Introduction and photographs of fishermen are given in Appendix II and III.

3.6 Statistical Analysis

Statistical analysis of fish number in relation with temperature, total alkalinity, total hardness, dissolved oxygen, carbon dioxide, pH and transparency in four different seasons of water were performed by using formula given by Karl-Pearson as referred by Gupta (1988) as below;

$$\text{Coefficient of correlation (r)} = \frac{N.\phi XY - \phi X.\phi Y}{\sqrt{\left[N.\phi X^2 - (\phi X^2)\right]\left[N.\phi Y^2 - (\phi Y^2)\right]}}$$

$$\text{Probability error (P.Er.)} = \frac{1 - r^2}{\sqrt{N}} \times 0.6745$$

Probability error is useful in interpreting Karl Pearson's co-efficient of correlation.

CHAPTER- FOUR

OBSERVATION AND RESULTS

Water of Koshi River and different fish species were collected from four sampling stations of all four seasons: spring, summer, autumn and winter. The physical and chemical parameter of water in the Koshi River was analyzed and fishes were collected from March 2010 to November 2010.

4.1 Physicochemical Parameters:

4.1.1 Temperature

The temperature of the water in the Koshi River was found ranging between15^0 C to 24.5^0 C. The maximum temperature (24.5^0 C) was recorded at stations III and IV in summer and the lowest temperature (15^0 C) at Station I in winter season. (Table 2 and Fig 2)

Table 2: Seasonal variation in temperature (^{0}C) at different stations in Koshi River (2010)

Seasons	Stations				Max	Min
	I	II	III	IV		
Spring	19	19.5	19.5	19.5	19.5	19
Summer	24	24	24.5	24.5	24.5	24
Autumn	21.5	22	22	22.5	22.5	21.5
Winter	15	16	16	16.5	16.5	15
Average	19.8	20.3	20.5	20.7	20.7	19.8

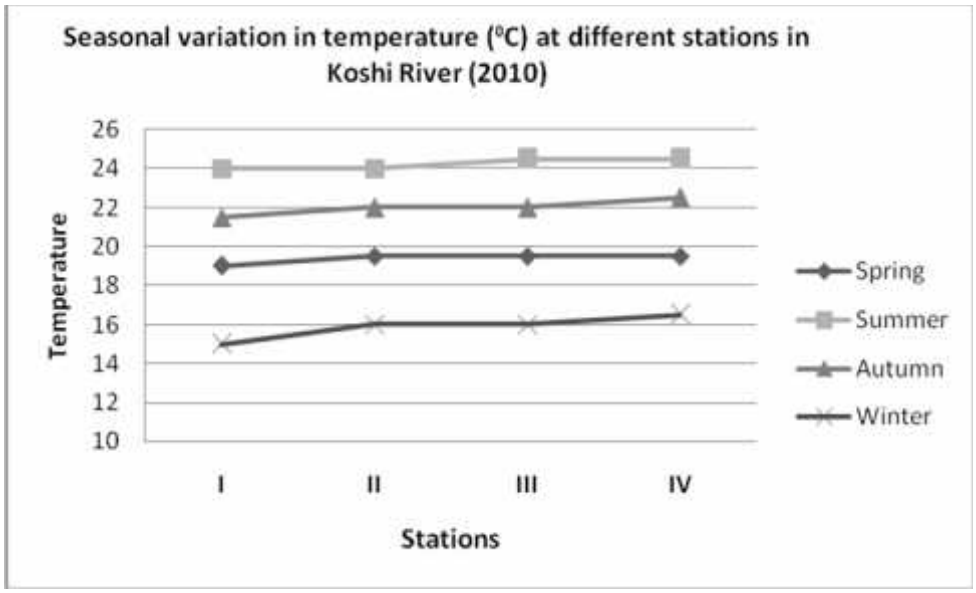


Figure 2. Seasonal variation in temperature (^{0}C) at different Stations in Koshi River (2010)

4.1.2 Transparency:

The transparency of Koshi River recorded during the study period ranged from 10 cm To 48 cm. The maximum value 48 cm was recorded at Station I in the winter season, while the minimum value of 10 cm was recorded at Station IV in summer (Table 3, Fig 3).

Table 3: Seasonal variation in transparency (cm) at different stations in Koshi River 2010

Seasons	Stations				Max	Min
	I	II	III	IV		
Spring	44	40	38	36	44	36
Summer	12	11	11	10	12	10
Autumn	47	45	40	38	47	38
Winter	48	45	42	41	48	41
Average	37.7	35.2	32.7	31.2	37.7	31.2

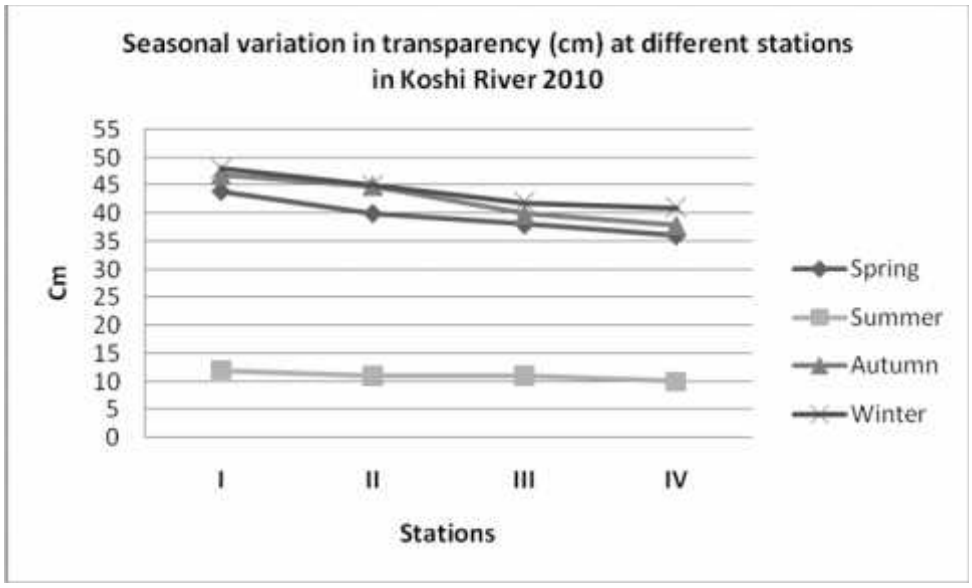


Figure-3: Seasonal variation in transparency (cm) at different stations in Koshi River 2010

4.1.3 pH:

The pH was found to be varied between 7.6 to 9 in Stations IV and I respectively. Maximum pH was recorded at Station I in summer and minimum at Station IV in winter (Table 4, Fig 4).

Table-4: Seasonal variation in pH at different stations in Koshi River, 2010

Seasons	Stations				Max	Min
	I	II	III	IV		
Spring	8.5	8.7	8.6	8.5	8.7	8.5
Summer	9	8.8	8.7	8.8	9	8.7
Autumn	8	8.1	8	7.9	8.1	7.9
Winter	7.8	7.9	7.8	7.6	7.9	7.6
Average	8.3	8.4	8.3	8.2	8.4	8.2

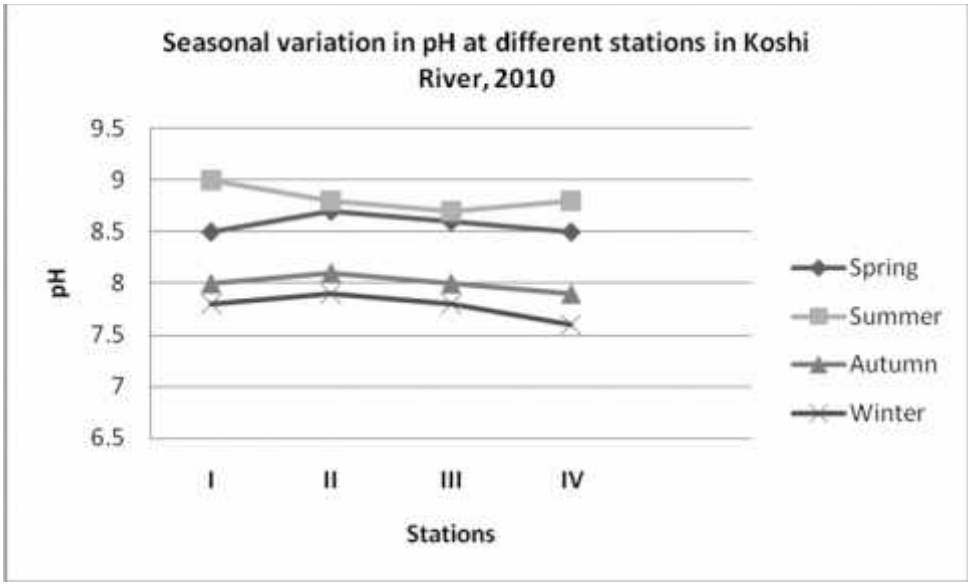


Figure-4: Seasonal variation in pH at different stations in Koshi River 2004/2005

4.1.4 Dissolved Oxygen (DO):

The dissolved oxygen content in the sample was found to be ranged from 10.5 mg m/l to 14 mg/l/. The DO was found minimum at the station III during summer and maximum at the station I during spring season (Table 5, Fig 5).

Table-5: Seasonal variation in dissolved oxygen at different stations in Koshi River, 2010.

Seasons	Stations				Max	Min
	I	II	III	IV		
Spring	14	13	12.7	12.5	14	13
Summer	11	11	10.5	10.8	11	10.5
Autumn	12	11	12.5	12.4	12.5	11
Winter	13	12	13.3	13.2	13.3	12
Average	12.5	11.7	12.2	12.2	12.7	11.6

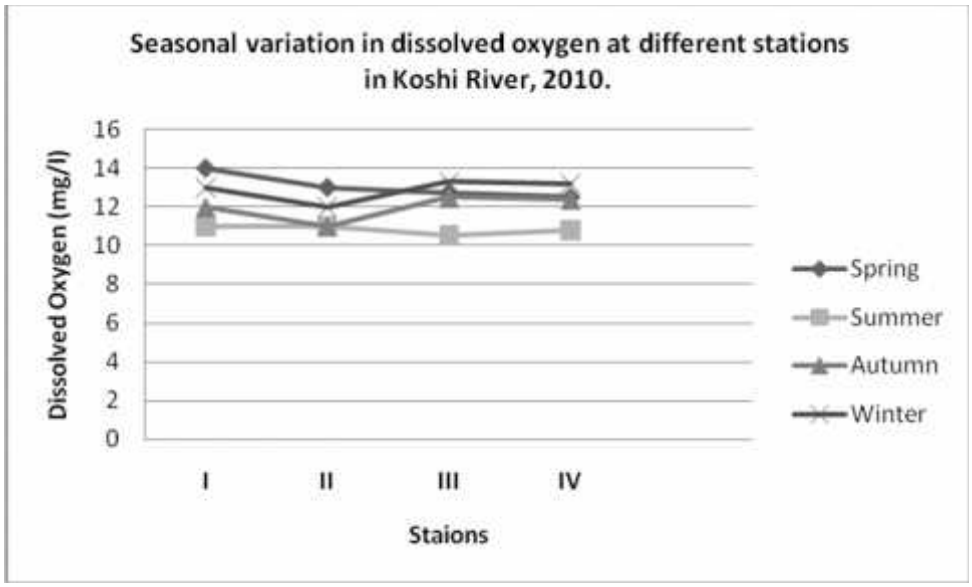


Figure-5: Seasonal variation in Dissolved Oxygen (mg/l) at different stations in Koshi River, 2010.

4.1.5 Free Carbon dioxide (CO_2):

The carbon dioxide in the Koshi River was found to be ranging from 4.1 mg/l to 5.2 mg/l. The maximum value of 5.2 mg/l was observed at the station II in summer and minimum value 4.1 mg/l at the station III in the winter (Table 6, Fig 6).

Table-6: Seasonal variation in free carbon dioxide CO_2 (mg/l) at different stations in Koshi River, 2010

Seasons	Stations				Max	Min
	I	II	III	IV		
Spring	4.5	4.5	4.4	4.5	4.5	4.4
Summer	5	5.2	5.1	5	5.2	5
Autumn	4.3	4.4	4.3	4.4	4.4	4.3
Winter	4.2	4.3	4.1	4.2	4.3	4.1
Average	4.5	4.6	4.5	4.5	4.6	4.4

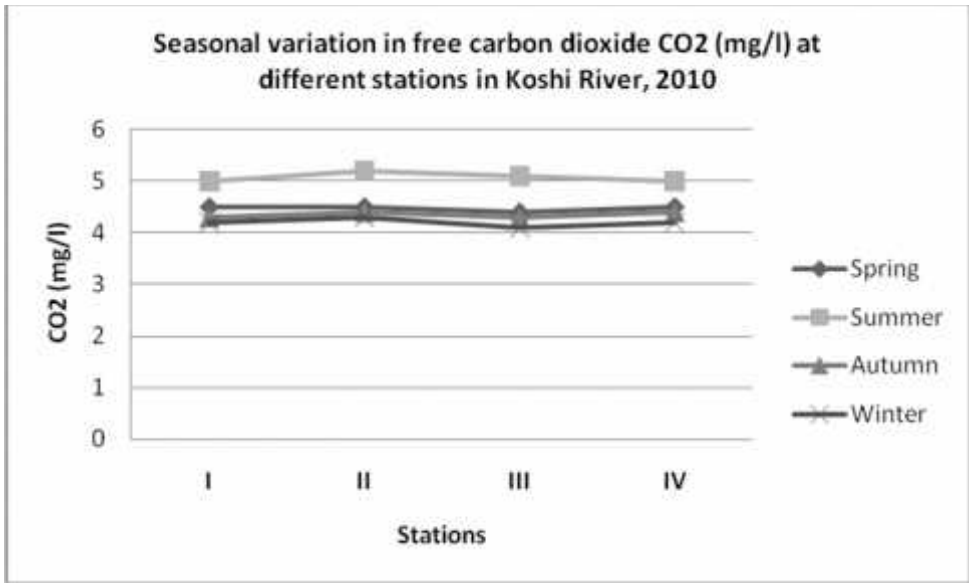


Figure-6: Seasonal variation in free carbon dioxide (mg/l) at different stations in Koshi River, 2010.

4.1.6 Total Alkalinity:

The value of total alkalinity ranged from 60 mg/l. to 69 mg/l. The maximum value 69 mg/l was recorded at station I in autumn and minimum value 60 mg/l at station I in summer (Table 7, Fig 7).

Table-7: Seasonal variation in total alkalinity (mg/l) at different stations in Koshi River, 2010

Seasons	Stations				Max	Min
	I	II	III	IV		
Spring	65	65	64.5	64.9	65	64.5
Summer	60	61	61.4	62	62	60
Autumn	69	68	68.2	68.8	69	68
Winter	67	66	66.3	67	67	66
Average	65.25	65	65.1	65.6	65.7	64.6

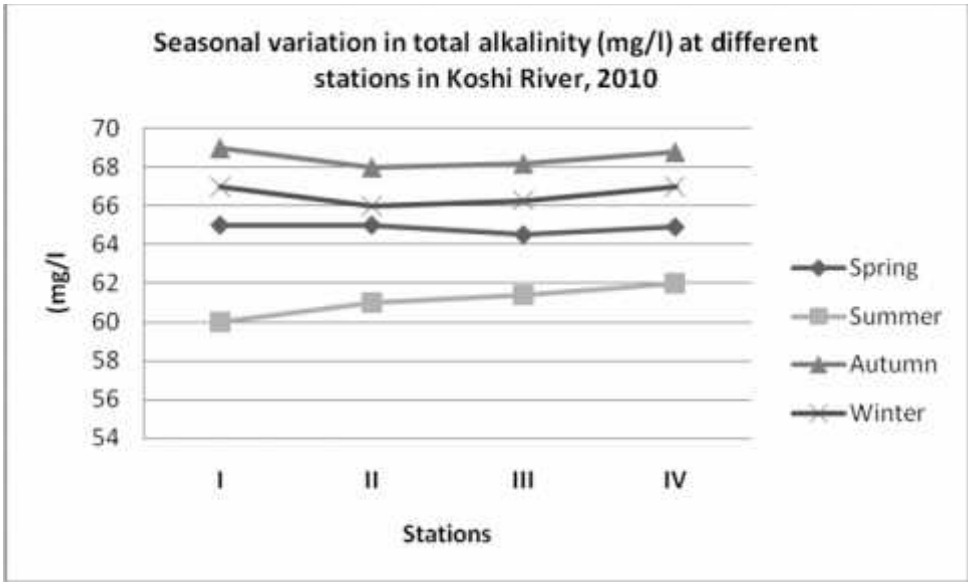


Figure-7: Seasonal variation in total alkalinity (mg/l) at different stations in Koshi River, 2010.

4.1.7 Total Hardness:

Total hardness ranged from 46 mg/l to 53 mg/l. The maximum total hardness was found 53 mg/l at Station II and IV in autumn and winter season while the minimum value of 46 mg/l recorded at Station III in summer season (Table 8, Fig 8).

Table-8: Seasonal variation in total hardness (mg/l) at different stations in Koshi River, 2010

Seasons	Stations				Max	Min
	I	II	III	IV		
Spring	49	51	47	48	51	47
Summer	48.5	49	46	47	49	46
Autumn	50	52	52	53	53	50
Winter	52	53	52.5	52	53	52
Average	49.8	51.2	49.3	50	51.5	48.7

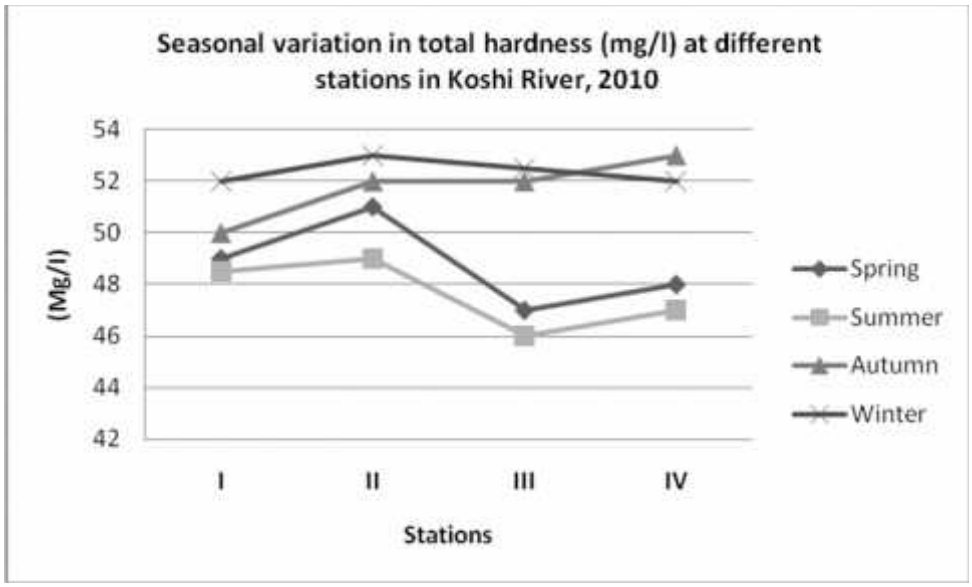


Figure -8: Seasonal variation in total hardness (mg/l) at different stations in Koshi River, 2010.

4.2 Fishery Resources

4.2.1 Species Diversity

Koshi River was found to be a good habitation for various types of fresh water fishes. A total number of 60 fish species were found during the study period.

These fishes belonged to 7 orders, 20 families, and 40 genera.

4.2.2 Systematic Position of Fishes

The collected fishes were identified and classified based on classification after Shrestha (2001) and Jayaram (1999).

I. Order		**- Osteoglossiformes**
Family		**- Notopteridae**
	Genus	- *Notopterus* (Lacopede), 1800
	Species	- *N. notopterus* (Pallos), 1767
	Local name	- Golhi
II. Order		**-Cypriniformes**
Family		**-Cyprinidae**
	Genus	-*Labeo*, 1822

Species	-L. *pangusia* (Ham.), 1877
Local name	-Latani (Kalancha)
Genus	-*Crossocheilus* (Vank.), 1822
Species	-C. *Latius* Hora and Misra, 1938
Local name	-Dhurla
Genus	-*Branchydanio* (Weber, 1822
Species	-B. *rerio* (Ham.), 1878
Local name	-Zebra
Genus	-*Lebeo* , 1822
Species	-L. *boga*, 1877
Local name	-Tilke
Genus	-*Danio*, 1822
Species	-D. *devario* (Ham.), 1878
Local name	-Gairtirrhi (Panaki)
Genus	-*Puntius*
Species	-P. *sarana* (Ham.), 1822
Local name	-Darahi
Genus	-*Barilius*, 1822
Species	-B. *vagara* (Ham.), 1822
Local name	-Hakrahi
Genus	-*Barilius* (Ham.), 1822
Species	-B. *barila* (Ham.), 1878
Local name	-Tile

Genus	-*Aspidoperia* (Ham.), 1822
Species	-*A. jaya* (Ham.), 1878
Local name	-Solhi
Subfamily	-Cyprininae
Genus	- *Chagunius* (Smith), 1945
Species	-*C. chagunio* (Hamilton-Buchanan), 1822
Local name	-Rewa
Genus	- *Cirrhinus* Cuvier, 1917
Species	-C. *mrigala* (Hamilton-Buchanan), 1822
Local name	-Naini
Genus	- *Cirrhinus* Cuvier, 1917
Species	- *C. reba* (Hamilton-Buchanan),1822
Local name	-Rewa
Genus	- *Labeo* Cuvier, 1816
Species	- *L. angra* (Hamilton-Buchanan), 1822
Local name	-Thed
Genus	- *Labeo* Cuvier, 1816
Species	- *L. gonius* (Hamilton- Buchanan), 1822
Local name	-Kursa
Genus	- *Labeo* Cuvier 1816
Species	-*L. rohita (*Hamilton- Buchanan),1822
Local name	-Rohu

Genus - *Puntius* (Hamilton- Buchanon), 1822

Species - *P. chola* (Hamilton-Buchanan), 1822

Local name -Pothi

Genus - *Puntius* (Hamilton- Buchanon), 1822

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

Local name -Pothi

Genus - *Tor* Gray, 1833

Species - *T. putitora* (Hamilton- Buchanan), 1822

Local name -Sahar

Genus - *Tor* Gray, 1833

Species - *T. tor* (Hamilton-Buchanan), 1822

Local name -Sahar

Subfamily - Rasborinae

Genus - *Aspidoperia* Heckel, 1934

Species - *A. morar* (Hamilton-Buchanan), 1822

Local name -Bhegna

Genus - *Barilius* (Hamilton-Buchanan), 1822

Species - *B. guttatus* (Day), 1869

Local name -Goha

Genus - *Barilius* (Hamilton-Buchanan), 1822

Species - *B. barna* (Hamilton-Buchanan), 1822

Local name -Fageta

Genus - *Barilius* (Hamilton-Buchanan) ,1822

Species - *B. bendelesis* (Hamilton-Buchanan), 1822

Local name -Fageta

Genus - *Rasbora* Bleeker, 1960

Species - *R. daniconius* (Hamilton-Buchanan), 1822

Local name -Khasara

Subfamily - Garrinae

Genus - *Garra* (Hamilton-Buchanan), 1822

Species - *G. aunandalei* Hora, 1921

Local name - Buduna

Family - Baltioridae

Subfamily - Nemacheilinae

Genus - *Acanthocobatis* Peters, 1861

Species - *A. botia* (Hamilton-Buchanan), 1822

Local name - Gadelo

Genus - *Noemacheilus* (Bleeker)

Sspecies - *N. corica* (Menon), 1987

Local name - Gadelo

Family - Cobitidae

Subfamily - Botinae

Genus -*Botia* Gray, 1831

Species -*B. lohachata* (Chaudari)

Local name - Baghi

Genus -*Somileptes* (Swai.)

Species -*S. gongota* (Ham.), 1878

Local name - Lata

Subfamily - Cobitinae

Genus - *Lepidocephalus* Bleeker, 1859

Species - *L. guntea* (Hamilton-Buchanan), 1822

Local name - Lata

III. Order - Siluriformes

Family - Bagridae

Subfamily - Bagrinae

Genus - *Mystus* Scopoli, 1777

Species - *M. cavasius* (Hamilton- Buchanan), 1822

Local name -Tengra

Genus - *Aorichthys* Wu, 1939

Species - *A. aor* Sykes, 1841

Local name -Kanti

Genus - *Mystus* Scopoli, 1777

Species - *M. bleekeri* (Day), 1878

Local name -Tengra

Genus - *Mystus* Scopoli, 1777

Species - *M. tengara* (Misra), 1976

Local name -Tengri

Genus - *Aorichthys* Wu, 1939

Species - *A. Seenghala* (Hamilton- Buchanan), 1822

	Local name	-Gochara
Family		**- chacidae**
	Genus	- *Chaca (Ham),* 1822
	Species	- *C. chaca (Misra),* 1976
	Local name	-Khirkiri
Family		**- Claridae**
	Genus	- *Clarias (*scopoli*)*
	Species	- *C. batrachus* (Linnaeus), 1758
	Local name	-Magur
Family		**- Schilbedae**
	Genus	- *Eutropichthys (*Ham.*),* 1822
	Species	- E. vacha (Ham.), 1877
	Local name	-Bachawa
Family		**- Schilbedae**
	Genus	- *Clupisoma garua* (Ham.) ,1822
	Species	- *C. garua (*Hora), 1937
	Local name	-Jalkapoor
Family		**- Siluridae**
	Genus	- *Ompok* Lacepede, 1803
	Species	- *O. bimaculatus* (Bloch), 1797
	Local name	-Phabata
	Genus	-W*allago*
	Species	- *W. attu* (Schneider), 1801
	Local name	-Buhari

Family **- Sisoridae**

Genus - *Gagata*, 1822

Species - *G.* cenia *(Ham.),* 1877

Local name -Gonche

Genus - *Glyptothorax*

Species - *G. Pectinopterus (Mc.),* 1842

Local name -Karsingha

Family **- Heteropneustidae**

Genus - *Heteropneuste*s Muller,1840

Species - *H. fossilis* Bloch, 1785

Local name -Singhi

IV. Order **- Beloniformes**

Family **- Belonidae**

Genus - *Xenentodon Regan,* 1912

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

Local name - Kauwa machha.

V. Order **- Perciformes**

Family **- Channidae**

Genus - *Channa Scopoli,* 1777

Species - *C. punctatus* (Bloch), 1785

Local name -Garai

Genus - *Channa Scopoli,* 1777

Species - *C. orientalis* Bloch & Schneider, 1801

Local name -Hile

Genus - *Channa Scopoli*, 1777
Species - *C. striatus* (Bloch), 1793
Local name - Saura

Genus - *Channa Scopoli* ,1777
Species - *C. marulius* (Hamilton-Buchanan), 1822
Local name - Bhorha

Family - Ambassidae

Genus - *Chanda* (Hamilton-Buchanan), 1822
Species - *C. nama* (Hamilton-Buchanan), 1822
Local name - Nata

Genus - *Parambasis* Bleeker, 1874
Species - *P. ranga* (Hamilton-Buchanan), 1822
Local name -Chanda

Family - Nandidae

Genus - *Nandus*
Species - *N.nandus* (Ham.), 1822
Local name -Dhalle

Sub Family - Badinae
Genus - *Badis Bleeker*, 1853
Species - *B. badis* (Hamilton-Buchanan), 1822
Local name -Jharki- Kotari

Family	**- Belontidae**
Sub Family	- Trichogasterine
Genus	- *Colisa Cuvier* , 1831
Species	- *C. fasciatus* (Schneider), 1801
Local name	-Katara

Family	**- Gobiidae**
Sub Family	- Gobiinae
Genus	- *Glossogobius* Gill, 1839
Species	- *G.giuris* Gill, 1839
Local name	- Bulla

VI. Order	**- Synbranchiformes**
Family	**- Synbranchidae**
Genus	- *Monopterus (Lace)*
Species	- *M. cuchia (Ham.)*, 1822
Local name	-Andha Bam

Family	**- Mastacembelidae**
Genus	- *Macrognathus (Lace)*
Species	- *M. pancalus (Ham.)*, 1822
Local name	- Kathgainchi

Sub Family	- Mastacembelinae
Genus	- *Macrognathus* Lacepede , 1800
Species	- *M. aral* (Bloch & Schneider), 1801
Local name	- Chuchche Bam

Sub Family	- Mastacembelinae
Genus	- *Mastacembelus* Scopli, 1777

Species - *M. armatus* (Lacepede), 1800

Local name - Bam

VII. Order -Tetradontiformes

Family - Tetradontidae

Genus -*Tetraodon* (Lin)

Species - *T. cutcutia (Ham.)*, 1822

Local name - Pokcha

4.3 Fish distribution and frequency occurrence in the Koshi River

Altogether 61 species of fish were recorded during this study period. *Aspidoperia morar* (local name Bhegna) species dominated all the fishes in terms of frequency distribution and recorded in all the sampling stations. *Channa marulius* local name Bhorha, Channa *striatus* local name Hile, Clarias batrachus local name Magur, *Eutropichthys vacha* local name Bachawa, *Garra annandalei* local name Buduna, *Heteropneustes fossilis* local name Singhi, *Labeo gonius* local name Kursa, *Labeo pangusia* local name Lagtani and *Mystus cavasius* local name Tengra were found only one single/single piece during the study period. Since the stations were approximately at 2.5 km in distance most of the fishes were available as shown in table 9.

Table- 9. Fish distribution and frequency occurrence at four different stations of Koshi River

S.N.	Scientific name	Local name	Total no. of fish	Frequency (%)	Sampling Stations			
					I	II	III	IV
1	*Acanthocobitis* botia	Gadelo	25	3.48	7	8	5	5
2	*Aorichthys aor*	Kanti	30	4.17	8	7	9	6
3	*Aorichthys seenghala*	Gochara	10	1.39	4	4	0	2
4	*Aspidoperia jaya*	Solhi	50	6.96	13	15	12	10
5	*Aspidoperia morar*	Bhegna	60	8.35	17	13	10	20
6	*Badis badis*	Jhakri kotare	15	2.08	8	7	0	0

7	*Barilius barila*	Tile	25	3.48	8	7	4	6
8	*Barilius barna*	Fageta	35	4.87	10	9	9	7
9	*Barilius bendelisis*	Fageta	15	2.08	0	9	6	0
10	*Barilius guttatus*	Ghoha	25	3.48	9	10	6	0
11	*Barilius vagara*	Hakrahi	10	1.39	6	4	0	0
12	*Botia lohachata*	Bhagi	7	0.97	4	3	0	0
13	*Branchydanio rerio*	Zebra	5	0.69	5	0	0	0
14	*Chaca chaca*	Khrikiri	2	0.27	0	2	0	0
15	*Chagunius chagunio*	Rewa	11	1.53	0	6	5	0
16	*Chanda nama*	Nata	15	2.08	6	4	5	0
17	*Channa marulius*	Bhorha	1	0.13	1	0	0	0
18	*Channa orientalis*	Hile	11	1.53	0	0	5	6
19	*Channa punctatus*	Garai	25	3.48	6	7	5	7
20	*Channa striatus*	Saura	1	0.13	0	0	1	0
21	*Cirrhinus mrigala*	Naini	2	0.27	2	0	0	0
22	*Cirrhinus rewa*	Rewa	12	1.67	7	5	0	0
23	*Clarias batrachus*	Magur	1	0.13	1	0	0	0
24	*Clupisoma garua*	Jalkapur	5	0.69	2	0	0	3
25	*Colisa fasciatus*	Katara	30	4.17	7	8	6	9
26	*Crossocheilus latius*	Dhurla	2	0.27	2	0	0	0
27	*Danio devario*	Gairtirrhi	12	1.67	0	4	5	3
28	*Eutropichthys vacha*	Bachawa	1	0.13	1	0	0	0
29	*Gagata cenia*	Gonch	8	1.11	0	5	0	3
30	*Garra annandalei*	Buduna	1	0.13	0	1	0	0
31	*Glossogobius giuris*	Bulla	7	0.97	0	5	2	0
32	*Glyptothorax pectinopeterus*	Karsingha	2	0.27	0	2	0	0
33	*Heteropneustes fossilis*	Singhi	1	0.13	1	0	0	0
34	*labeo angra*	Thed	25	3.48	7	5	8	5
35	*Labeo boga*	Tilke	15	2.08	4	5	5	1
36	*Labeo gonius*	Kursa	1	0.13	0	1	0	0
37	*Labeo pangusia*	Latani	1	0.13	1	0	0	0

38	*Labeo rohita*	Rohu	3	0.41	0	2	1	0
39	*Lepidocephalus guntea*	Lata	10	1.39	5	0	2	3
40	*Macrognathus aral*	Chuchche bam	10	1.39	2	3	3	2
41	*Macrognathus pancalus*	*Kathgainch i*	7	0.97	0	0	4	3
42	*Mastacembelus armatus*	Bam	10	1.39	3	4	3	0
43	*Monopterus cuchia*	Andha bam	5	0.69	4	1	0	0
44	*Mystus bleekeri*	Tengra	5	0.69	0	0	2	3
45	*Mystus cavasius*	Tengra	1	0.13	1	0	0	0
46	*Mystus tengara*	Tengri	15	2.08	3	4	2	6
47	*Nandus nandus*	Dhalle	2	0.27	0	2	0	0
48	*Noemacheilus corica*	Gadelo	3	0.41	1	2	0	0
49	*Notopterus notopterus*	Golahi	2	0.27	0	0	0	2
50	*Ompok bimaculatus*	Phabata	7	0.97	0	4	3	0
51	*Parambassis ranga*	Chanda	11	1.53	3	3	4	1
52	*Puntius chola*	Pothi	25	3.48	7	4	10	4
53	*Puntius sarana*	Darhi	10	1.39	6	4	0	0
54	*Puntius sophore*	Pothi	20	2.78	4	6	5	5
55	*Rasbora daniconius*	Khasara	10	1.39	0	7	0	3
56	*Somileptes gongota*	Lata	7	0.97	2	3	2	0
57	*Tetraodon cutcutia*	Pokcha	8	1.11	0	2	2	4
58	*Tor putitora*	Sahar	7	0.97	0	3	4	0
59	*Tor tor*	Sahar	11	1.53	1	3	5	2
60	*Wallago attu*	Buhari	10	1.39	0	3	7	0
61	*Xenintodon cancila*	Kauwa machha	15	2.08	4	3	4	4
	Total		718	100 %	193	219	171	135

Diversity of fishes in Koshi River, KTWR

1 *Chanda nama*, Nata

2. *Parambassis ranga*, Chanda

3. *Aorichthys aor*, Kanti

4. *Aorichthys seenghala*, Gochara Kanti

5. *Mystus bleekeri*, Tengra

6. *Mystus cavasius*, Tengra

7. *Mystus Tengra*, Tengri

8. *Acanthocobitis botia*, Gadelo

9. *Nemacheilus* corica, Gadelo

10. *Xenentodon cancila*, Kauwa Machha

11. *Colisa fasciatus*, Katara

12. *Chaca chaca*, Khirkiri

13. *Channa marulius*, Bhaura

14. *Channa orientalis*, Hile

15. *Channa punctatus*, Garai

16. *Channa striatus*, Saura

17. *Clarias batrachus*, Magur

18. *Botia lohachata*, Bagi

19. *Somileptes gongota*, Panya Lataa

20. *Lepidocephalus guntea*, Balgada Lataa

21. *Aspidoparia Jaya*, Solhi

22. *Aspidoparia morar*, Bhegana

23. *Barilius barna*, Fageta

24. *Barilius barila*, Tile

25. *Barilius bendelisis*, Fageta

26. *Barilius guttatus*, Goha

27. *Barilius vagra*, Hakrahi

28. *Brachydanio rerio* , Jebra

29. *Chagunius chagunio*, Reba

30. *Cirrhinus mrigala*, Naini

31. *Cirrhinus reba*, Reba

32. *Crossocheilus latius*, Ghurla(kondi)

33. *Danio devario*, Geratihi

34. *Garra annandalei*, Buduna

35. *Labeo* angra, Theda

36. *Labeo boga*, Tilke

37. *Labeo gonius*, Kursa

38. *Labeo pangusia*, Kalancha

39. *Labeo rohita*, Rahu

40. *Puntius chola*, Pothi

41. *Puntius sarana*, Darhi

42. Puntius *sophore*, Pothi

43. *Rasbora daniconius*, Khasara

44. *Tor putitora*, Sahar

45. *Tor tor*, Sahar

46. *Glossogobius giuris*, Bhulla

47. *Heteropneustes fossilis*, Singhe

48. *Macrognathus aral*, Chuche Bam

49. *Macrognathus pancalus*, Kathgainchaa

50. *Mastacembelus armatus*, Bam

51. Badis badis, Jharki kotari

52. Nandus nandus, Dhalle

53. *Notopterus notopterus*, Golhi

54. *Clupisoma garua*, Jalkapoor

55. *Eutropiichthys vacha*, Bachwa

56. *Ompok bimaculatus*, Fawataa

57. *Wallago attu*, Buhari

58. *Gagata cenia*, Padanaa

59. *Glyptothorax pectinopterus*, Karsingha

60. *Monopterus cuchia*, Andha Bam

61. *Tetradon cutcutia*, Fokchaa

4.3.1 Genus-wise fish distribution and frequency occurrence:

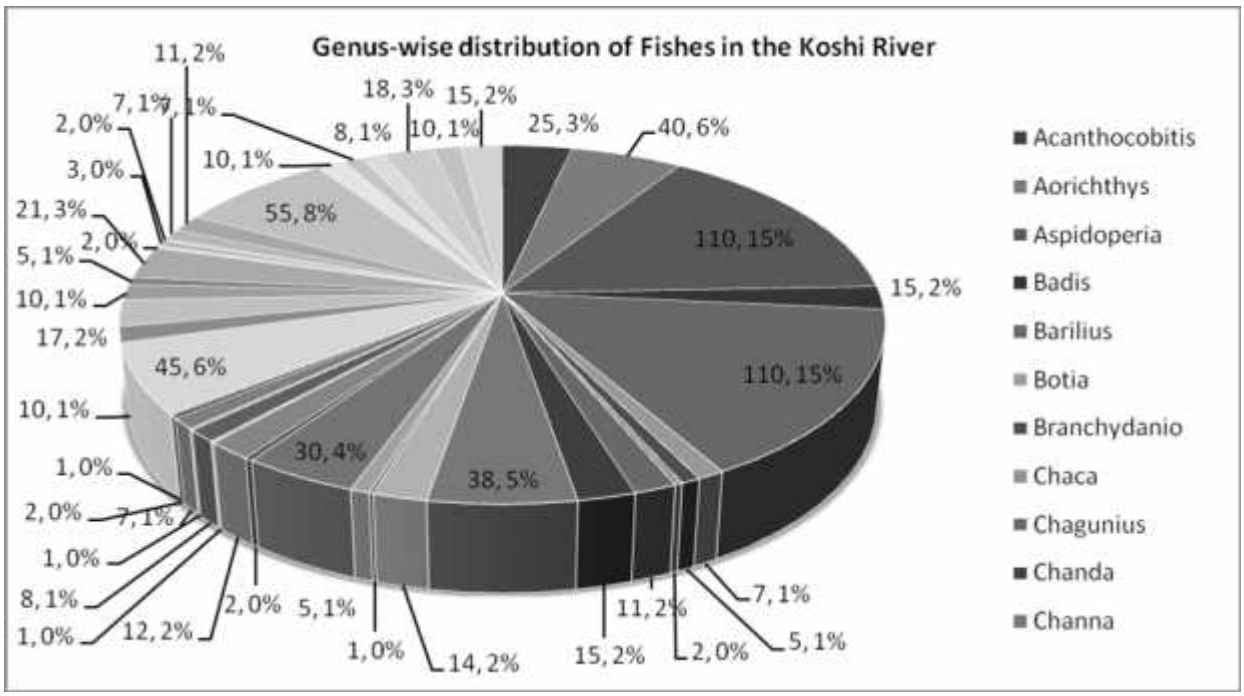
Altogether, 41 different genus were recorded in this study. The largest fish catch was from the *Barilius* and *Aspidoperia* at number of 110 each which covered 30.64% of total collected fishes.The lowest were *Clarias*, *Eutropichthys*, *Garra* and *Heteropneustes* which constituted the 0.13 percent of total number each as shown in table 10.

Table-10: Genus-wise distribution of Fishes in the Koshi River

S.No.	Genus	No. of fishes caught	Composition by No. (%)
1	*Acanthocobitis*	25	3.48
2	*Aorichthys*	40	5.57
3	*Aspidoperia*	110	15.32
4	*Badis*	15	2.08
5	*Barilius*	110	15.32
6	*Botia*	7	0.97
7	*Branchydanio*	5	0.69
8	*Chaca*	2	0.27
9	*Chagunius*	11	1.53
10	*Chanda*	15	2.08
11	*Channa*	38	5.29
12	*Cirrhinus*	14	1.94
13	*Clarias*	1	0.13
14	*Clupisoma*	5	0.69
15	*Colisa*	30	4.17
16	*Crossocheilus*	2	0.27
17	*Danio*	12	1.67
18	*Eutropichthys*	1	0.13
19	*Gagata*	8	1.11
20	*Garra*	1	0.13
21	*Glossogobius*	7	0.97
22	*Glyptothorax*	2	0.27

23	*Heteropneustes*	1	0.13
24	*labeo*	45	6.26
25	*Lepidocephalus*	10	1.39
26	*Macrognathus*	17	2.36
27	*Mastacembelus*	10	1.39
28	*Monopterus*	5	0.69
29	*Mystus*	21	2.92
30	*Nandus*	2	0.27
31	*Noemacheilus*	3	0.41
32	*Notopterus*	2	0.27
33	*Ompok*	7	0.97
34	*Parambassis*	11	1.53
35	*Puntius*	55	7.66
36	*Rasbora*	10	1.39
37	*Somileptes*	7	0.97
38	*Tetraodon*	8	1.11
39	*Tor*	18	2.50
40	*Wallago*	10	1.39
41	*Xenintodon*	15	2.08
	Total	718	100%

Figure-9: Genus-wise distribution of Fishes in the Koshi River



4.3.2 Family-wise fish distribution and frequency occurrence:

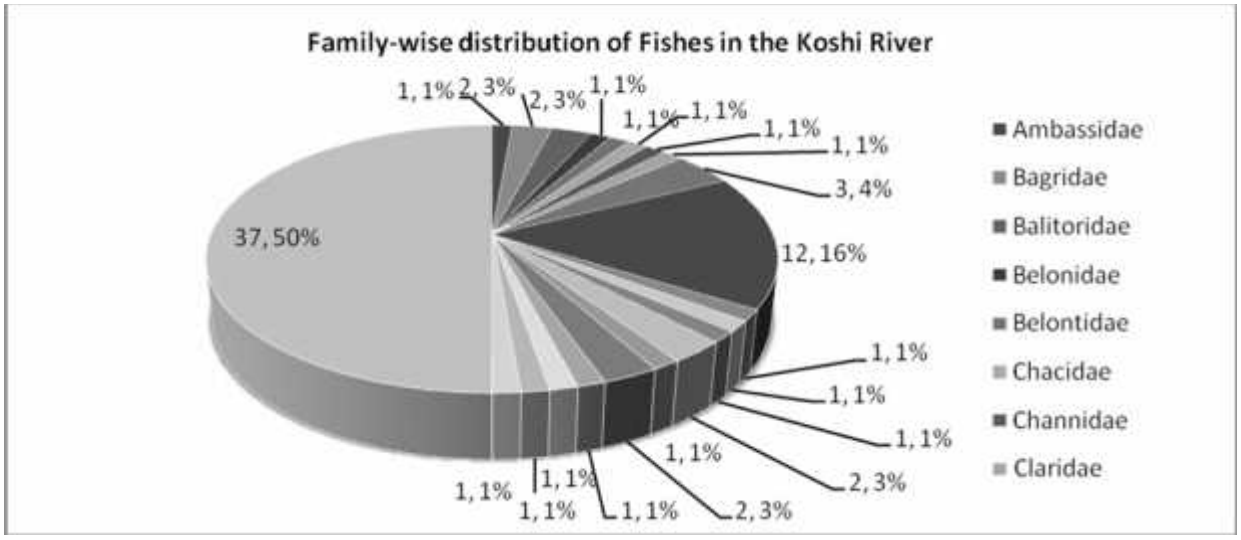
Total 20 different families were recorded during study from different sampling stations of Koshi River. *Cyrinidae* dominated all other comprising 40.98 % and rests were almost same amount in number as shown in table 11.

Table-11: Family-wise distribution of Fishes in the Koshi River

S. No.	Family	No. of Genus	No. of Species	Species composition (%)	Total No. of fishes caught	Composition by number (%)
1.	Ambassidae	1	2	3.27	26	3.62
2.	Bagridae	2	5	8.19	61	8.49
3.	Balitoridae	2	2	3.27	28	3.89
4.	Belonidae	1	1	1.63	15	2.08
5.	Belontidae	1	1	1.63	30	4.17
6.	Chacidae	1	1	1.63	2	0.27
7.	Channidae	1	4	6.55	38	5.29
8.	Claridae	1	1	1.63	1	0.13

9.	Cobitidae	3	3	4.91	24	3.34
10.	Cyprinidae	12	25	40.98	393	54.73
11.	Gobiidae	1	1	1.63	7	0.97
12.	Heteropneustidae	1	1	1.63	1	0.13
13.	Mastacembelidae	1	3	4.91	27	3.76
14.	Nandidae	2	2	3.27	17	2.36
15.	Notopteridae	1	1	1.63	2	0.27
16.	Schilbedae	2	2	3.27	6	0.83
17.	Siluridae	1	2	3.27	17	2.36
18.	Sisoridae	1	2	3.27	10	1.39
19.	Synbranchidae	1	1	1.64	5	0.69
20.	Tetradontidae	1	1	1.63	8	1.11
	Total	37	61	100%	718	100%

Figure-9: Family-wise Fish composition (%) of the total fish species in Koshi River.



4.4 Fish Composition and Total Catch in Koshi River

Cyprinidae comprised highest number of fish (54.73 %) followed by *Bagridae* (8.49%), *Channidae*(5.29%), *Belontidae*(4.17%) and rest were only 27.32% each in total number.

4.5 Important Species with their Ecological Behaviour

The total 61 fishes were found form Koshi River. These fishes can be categorized as (a) game fishes and (b) food fishes. All these species are edible and consumed by local inhabitants; however, some species have additional quality such as game or sport fishes. The most popular game fishes are *Tor tor*, *Tor putitora*, *Bagarius bagarius, L. angra, Wallago attu, Mystus seenghala* etc.

4.5.1 *Tor putitora* (Hamilton-Buchanon) 1822

Tor putitora is an important food and game fish, which is locally known as Sahar. This fish is characterized by elongated and slightly compressed body with long and pointed snout. It is generally olive green on dorsal side and silvery on belly (Plate-III). Sahar generally inhabits the deep pools of much snow fed rivers. It is a migratory fish usually moving upstream during their breeding season (Aug. /Sept.). According to the local fishermen the ideal time for spawning is during the month of June to September when the river becomes quite voluminous. Spawning takes place at the confluence of the tributaries to a main stream or in creeks, where water is well oxygenated and has moderate velocity. Eggs are found attached to the rock, pebble, gravel, sand, silt, logs and debris. *Tor putitora* is an omnivorous fish which feeds on filamentous algae like Sp*irogyra*, *Oscillatoria*, larva of insects or adults of mayfly, stone fly etc.

4.5.2 *Labeo Cuvier* 1816

Five different species of *Labeo* were captured from Koshi River. Most of them were distributed in all stations. *Labeo angra* is locally called Thed. These fishes are regarded as very tasty food fish. The average size of the captured fish ranged from 10-23 cm. These fishes breed during the month of June-July at gravel bottom breeding ground. *Labeo pangusia* is locally known as Kalanch. The size recorded was 12 cm-28 cm. *Labeo gonius* is locally known as Kursa and found only one number. All the species of *Labeo* are herbivorous and detrivores feeding on algae, vegetable, matter, detritus and mud. (Plate-II)

4.5.3 *Channa maurilus* (Hamilton-Buchinan) 1822

Channa maurilus is also called as Bhorah machha. This species is fairly common in Terai. According to the local fishermen, this fish breeds particularly in the early monsoon months of March-April. This species show the parental care. They build their rest with aquatic weeds in the stagnant areas of the water bodies. Their nests are locally called "Gund". Before copulation, the male bites the female excite her; this results in the liberation of eggs, which settle to the bottom and are simultaneously fertilized by the male.

4.5.4 *Clupisoma garua* (bleeker)

This fish looks similar to Eutropiichthys vacha (Bachawa) but nasal barbel are shoter and maxillary barbel are loner than bachawa respectively. The upper body has white brown colour which shines like a silver and similar to Bachawa. Whereas the stomach portion have light colour. Upper lip is slightly longer than the lower lip and mouth have 4 pairs of barbel. They bear adipose fin during childhood but do not bear it during adult stage. They are found up to 609 mm in length. These fish are decreasing and the more expensive in the river due to which they are categorized in the endangered fish.

4.5.5 *Aspidoperia morar (Ham.)*

Aspidoperia morar is locally called Bhegna. These fishes are sufficiently found in the Koshi River. The colour of the body is light yellow and fin is dark yellow. The body is flatted from right and left. The mouth is small and elongated at the front. The upper lip coincides with the lower lip. They are found up to 144 mm in length. Bhegna was found in large number during study period.

4.5.*6 Puntius chola*

This is smaller in shape. The right and left as well as the stomach have white colour whereas the dorsal portion have black colour. The tail part and dorsal part have black spot. One pair of barbel is found on the mouth. This type of fish is found up to 80 mm in length. This is the cheapest fish in local market and called sidre machha as shown in table 12.

Table- 12: Price-rate to different fish species at study area

S.No.	Local name	Rs./ kg
1.	Pothi *(Puntius chola)*	30
2.	Pausi *(Channa* orientalis)	100
3.	Lata *(Somileptes gongota*)	120
4.	Garai *(Channa punctatus*)	120
5.	Sahar *(Tor putitora*)	200
6.	Bhorha *(Channa marulius*)	200
7.	Kanti *(Aorichthys aor*)	350
8.	Buhari *(Wallago attu*)	350
9.	Mungri *(*Clarias *batrachus*)	400
10.	Jalkapur *(Clupisoma garua*)	500

4.6 Fishing practices and fishing implements:

Fishing is the main occupation of fishermen inhabiting around the Koshi River. They are found to be involved in this occupation since time immemorial. They follow different fishing practices depending upon different seasons. Most of fishermen had their own boat while only some Musahar had to depend on other rented boat. They generally use boat for fishing and for transportation in the river. Those who did not have their own boat, shared boat of relatives for fishing. Fishing activity was noted maximum during autumn and winter seasons; and minimum in summer (Rainy) season. The KTWR office imposes restriction on fishing during Aashad to Bhadau for 3 months for breeding purpose. Fishing at night is not allowed inside the buffer zone river.

Fishermen were found to use different types of traditional fishing implements. Most of them are made from locally available materials while some materials are bought from market. Most commonly used fishing implements are as follows:

A net is basically a piece of webbing of fine nylon or cotton threads in which the twines are intersected into regular meshes. Three types of nets have found in operation.

4.6.1 Gill Net

Gill net is most commonly used fishing implements. It is made from nylon thread. Fisherman either made it by themselves or bought from the market. Gill net has different mesh sizes ranging from 2.5 cm to 14 cm. But most commonly used mesh size is 6.5 cm to 7.5cm. Diameter of thread increases with the increase of mesh sizes. It is rectangular with varying length. It's one side has floating device and other side has fixed sinking devices like iron nails, or pieces of iron wire. The net remains floating vertically to trap fishes.

4.6.2 Cast Net

Cast net is a circular net made from nylon thread. The circumference of the net is wide which decreases towards the apex. Along the end of the net, the sinks or load of iron are attached to make the net sinkable in water. Usually a net is operated in the smooth but and shallow water areas. While operating net, the fisherman holds a long rope extending from the apex or the center of the net in his hand tightly and throws the net with a jerk into the water in a circular way. The sinkers settle down at the bottom of the river enclosing net area. After a little moment, the net is dragged with the help of central rope and the catch is collected in the bamboo basket or cotton bag. Cast net is effective throughout the year.

4.6.3 Tapi

Tapi is commonly used in ponds of the Terai region of Nepal. It is made of two bamboo flanks crossed each other and tied fast at the midpoint. A square nylon net is loosely tied at the four ends of bamboo flanks. A fisher dips the net in water and lifts it up. Small size fishes are caught with this net.

4.6.4 Dhadiya

Dhadiya is local name of a fishing implement made of bamboo. Fishermen made this implement in their leisure. It has conical shape, designed in such a way so that fish can enter inside but cannot escape from it. It is fixed in the small diverting water canal with its mouth (i.e. opening side) faced upwards. Small sized fishes were found trapped in this implement.

4.6.5 Balchi (Hook)

'Balchi' is local name for the hook tied in the tip of a long nylon thread lying on the long rod of bamboo. Bait like earthworm and small fish is kept in the hook and kept at the river bank. Fishermen place such balchi overnight in river and trapped fishes are collected in the next morning. But in KTWR balchi is not allowed for fishing purpose.

4.6.6 Sola

Its design is similar to the dhadiya but longer in shape and generally used in rainy season. It is fixed somewhere in the channel made in the river where water flow is made continuous. Fishes get trapped here because fishes can get inside but cannot escape out.

4.6.7 Poisoning

Fish poisons are reported to be used in killing the all type of fishes. Local people reported to kill fish by using DDT (Dichlorodiphenyltrichloroethane) BHC (benzenehexachloride), lime stone etc. Besides these chemicals, organic poisons like kettuke (*Agave americana),* khirre (*Sapium insihgne*), titepati (*Artemesia vulgaris*), kukur tarul (*Dioscorea deltoidea,* sihudi *(Euphorbia voyelana),* chilaune (*Schima wallichi*) etc in shallow and stagnant water. All these products are applied in water to paralyze fishes for easier large catch. Even though, any type of poisons are not allowed to use for killing fishes, locals are using illegally far away and outside from the KTWR.

4.7 Statistical Analysis

The statistical analyses to determine the coefficient of correlation between the different physico-chemical parameters and number of fish for all the station have been calculated by using the Karl Pearson (Gupta, 1988). Table 14 shows the correlation coefficient between some physico-chemical parameters (Temperature, Transparency, pH, Dissolved oxygen, Carbon dioxide, Total alkalinity, and Hardness).

Table-13: Correlation coefficient between some physico- chemicals parameter and fish numbers.

S.N.	Variants	Station I		Station II		Station III		Station III	
		Coefficient of correlation (r)	Probable Errors (P.Er.)	Coefficient of correlation (r)	Probable Errors (P.Er.)	Coefficient of correlation (r)	Probable Errors (P.Er.)	Coefficient of correlation (r)	Probable Errors (P.Er.)
1	Correlation between water temperature and fish number	-0.253	0.315	-0.860	0.088	-0.666	0.187	-0.532	0.241
2	Correlation between transparency and fish number	0.683	0.179	0.666	0.187	0.849	0.094	0.723	0.161
3	Correlation between pH and fish number	0.690	0.160	0.264	0.023	0.964	0.313	0.957	
4	Correlation between dissolved O_2 and fish number	0.539	0.308	0.521	0.091	-0.842	0.239	-0.857	0.247
5	Correlation between free CO_2 and fish number	0.159	0.008	0.690	0.160	-0.081	0.002	0.551	0.102
6	Correlation between total alkalinity and fish number	0.342	0.039	-0.684	0.157	-0.468	0.073	-0.621	0.130
7	Correlation between total hardness fish number	0.771	0.200	0.733	0.181	-0.532	0.095	0.690	0.160

CHAPTER FIVE

DISCUSSION

Koshi River is rich in water resources providing shelter for valuable fish stocks. The running water system provides a diverse range of habitats for different types of indigenous fishes. The physico-chemical parameters of an aquatic environment exhibit influencing factors for the quantity and quality of the total biota and their life processes directly or indirectly. The existing climatic condition and chemical properties highly regulate the physical properties of water in an aquatic ecosystem. The interactions of all these factors create favorable or unfavorable circumstances for the growth and development of any particular biotic element (Dutta and Malhotra 1986). It is seen that in many respects the physical quality of the water environment appears to be basically more important than chemical ones in governing the distribution of fishes (Hynes, 1970).

The physical parameters of water were recorded at four different stations, that were:-

Station –I: near to the location of KTWR office at west Kushaha, at a distance of approximately 7.5 km north from the East West highway Haripur and East bank of the Koshi River. As this site was very near to the Reserve office this site was more protected and ample number of fishes were found. Almost all kind of fish species were found. This station was undisturbed by the local population only the license holder fishermen used to come for fishing purpose. The water was good and transparent.

Station –II: at a distance of approximately 2.5 km south from the first station. The local name of the place was called as Titri Gachhi. Since this station was also near to the Reserve office and inside the protected area it has the same characters as in first station.

Station –III: at a distance of 5 km south, downward from the first station. This station had more vegetation comparing to the first and second stations. Almost all kind of the fishes were available at this station. More fishermen used to fish for their livelihood and the final station was,

Station: IV: at a distance of 7.5 km south and downwards from the first station. This station was near to the Army Camp and the location was called as Haripur. This station had much more vegetation and protected. Almost all the license holder fishermen used to enter the river from this station. Since the exit point was also same point, there was small fish market near this station. The same kind and amount of fishes were available at this station. Much more information was gathered from this place.

Among the physical parameters the temperature is the most important factor which affects the growth rate of the fishes and other aquatic animals. It is well defined that all the aquatic organisms including fishes have very limited temperature tolerance. For an aquatic organism, high temperature may lead to death of organisms. In this investigation, water temperature ranged

from 15^0C to 24.5^0C which was within the limit of Nepal Bureau of Standard and Meteorology. The maximum temperature (24.5^0C) was recorded at the stations III and IV while the minimum temperature 15^0C was recorded at the station I during winter season. The correlation value of water temperature with the fish numbers were found as -0.253, -0.860, -0.666 and -0.532 at I, II, III and IV station respectively. This showed decreased fish species composition with the rise in water temperature in the Koshi River. Water temperature showed variation in different seasons with the variation in fish catch also. The fish catch was found high in the autumn while minimum in summer (rainy) season likewise maximum number were found at station I and minimum at station IV.

Transparency indicates the clarity of water. Clay, silt, organic matters, phytoplankton and other microscopic organisms make natural water turbid to decrease the transparency. In the present study, transparency was recorded ranging from 10 cm-48 cm. Minimum transparency was recorded at Station IV in Summer (Rainy) Season as 10 cm and the maximum transparency was found at station I in winter season as 48 cm. The correlation value of the water with the fish numbers were found as 0.683, 0.666, 0.849 and 0.723 at I, II, III and IV station respectively. This showed increased fish species composition with the rise in water transparency in the Koshi River.

The chemical parameters greatly affect the distribution of fish species in the river. Among all the chemical factors, the concentration of dissolved oxygen (DO) is the most essential parameter for aquatic life. All the organisms inhabiting in aquatic system depend on the dissolved oxygen. Dissolved oxygen above 5 ppm is suitable for the support of diverse biota (APHA 1976). In this investigation, maximum DO (14 mg/l) was recorded in spring season at first station and minimum (10.5 mg/l) was observed in the summer season at station-III. Monitoring oxygen concentration is one of the convenient way of feeling the pulse of the aquatic ecosystem; as higher DO correlates with better water quality of river at range of 7-11 mg/l (Kudesia & Kudesia 1998).

A variation in the DO level might be explained due to the effect of temperature, photosynthesis and sediment concentration. Ellis (1973) stated that the increase in water temperature resulted decrease DO. Similarly, an increase in sediment concentration hampers the photosynthesis and reduces DO level. Correlation coefficient value of DO with the fish number is positive ($r = 0.539$) with the probable error 0.308, that means the fish number increased with the increase of dissolved oxygen of water. The increased number of fish with the increase of DO may be due to sufficient oxygen present for increased physiological.

The effect of pH variation on the fishes is very less. It is considered that the alkaline water up to 9.5 is suitable for fish growth. According to Jhingran (1991), fish dies at pH above 11. The current of biotic environment tends to keep pH uniform over considerable distance (Welch, 1952). Swingle (1867) stated that the pH value more than 9.5 is unsuitable because in this condition carbonate is not available. pH tolerance limit for fish is 6.0 to 9.0, water supply and bathing 6.0 to 9.0, irrigation 5.5 to 9.0 and industrial effluent 5.5 to 9.0 (Kudesia, 1988). For

drinking, pH should not be less than 6.5 or greater than 9.2 (WHO, 1971). In this investigation pH was ranged from 7.8 – 8.5, 7.9 – 8.8, 7.8 – 8.7 and 7.6 – 8.8 at stations I, II, III, and IV respectively.

The pH value was recorded to increase in the spring and summer at all the stations. The acidic water is unsuitable for fish and other aquatic organisms as it reduces the appetite of fish, tolerance to toxic substance affecting the growth. Lowering pH increases the toxicity of hydrogen sulphide, copper and other heavy metals to fish. The fishes are prone to attack by parasites and diseases in acid water (Jhingran, 1991). The correlation between fish composition and pH was recorded positive that 0.690, 0.264, 0.964 and 0.957 at I, II, III and IV station respectively. This shows slight increment of fish species composition with the rise of pH value. Koshi River is slightly alkaline which is suitable for fishes and its production.

Free carbon dioxide in water is also another component affecting the aquatic biodiversity. Carbon dioxide helps in the formation of carbonates and bicarbonates and keeps the fluctuation of pH under control. This comes in the river from the decomposition of organic matter and respiration of organisms. The free-carbon dioxide ranged from 4.2 – 5 mg/l, 4.3 – 5.2 mg/l, 4.1 – 5.1 mg/l and 4.2 – 5 mg/l at stations I, II, III and IV respectively. Free carbon dioxide has been found to be low during the winter season and high in the summer season in all four stations. Correlation coefficient between the free CO_2 and fish species composition were found as 0.159, 0.690, -0.081 and 0.551 at each station respectively. This explains the positive but slight effect of carbon dioxide on the composition of fish species.

The total hardness in the Koshi River have been found to be ranged from 48.5 – 52 mg/l, 49 – 53 mg/l, 46 – 52.5 mg/l and 47 – 53 mg/l at stations I, II, III and IV respectively. Total, hardness was detected higher in the station II and IV in winter and autumn seasons and lower hardness was observed at station III in summer season. Correlation coefficient between total hardness and fish species composition were found as 0.771, 0.773, -0.532 and 0.589 in each station I, II, III and IV.

During the study period the values of total alkalinity ranged from 60 mg/l – 69 mg/l, 61-68 mg/l, 61.4 mg/l -68.2 mg/l and 62 mg/l -68.8 mg/l at stations I, II, III and IV respectively. Acid condition affects negatively to the health of fish fauna but high alkalinity works as a counter to negative effect. High alkaline water has a high buffering capacity, as acid sources introduced into river are neutralized by it. Correlation coefficient between alkalinity and fish species composition were found as 0.342, -0.684, -0.468 and -0.621 at each station I, II, III and IV. The positive correlation r= 0.342 with probable error 0.039 shows the increment in fish's number.

In the present investigation, fishes were captured by using gill net, cast net, dhadiya and other locally available devices. Altogether 61 species of fishes belonging to 41 genera, 20 families and 7 orders were recorded from the sampling sites of the Koshi River at KWTR from West kushaha to Hariput at distance 7.5 km. Majority of the fish species collected from the river belonged to family cyprinidae, which included 12 genus and 25 species (40.98%). Among them *B.* rerio (Ham.) L. *boga, D. devario* (Ham.), *P. sarana* (Ham.), *B. vagara , B. barila* (Ham.), *A. jaya*

(Ham.), *C. chagunio* (Hamilton-Buchanan), *C. mrigala* (HamiltonBuchanan), *C. reba* (Hamilton-Buchanan) , *L. angra* (Hamilton-Buchanan) , *L. gonius* (Hamilton- Buchanan), *L. rohita (*Hamilton- Buchanan), *P. chola* (HamiltonBuchanan), *P. sophore* (Hamilton- Buchanan) , *T. putitora* (Hamilton- Buchanan) , *T. tor* (Hamilton-Buchanan), *A. morar* (Hamilton-Buchanan) , *B. guttatus* (Day), *B. barna* (Hamilton-Buchanan), *B. bendelesis* (Hamilton-Buchanan) , *R. daniconius* (Hamilton-Buchanan) and *G. aunandalei* were recorded.

Shrestha, 1980 (in Shrestha, 1990); WMI/IUCN-Nepal, 1994 recorded total number of family 26 and species 131.

Dr Bharat Raj Subba and Kul Pd Limbu (2005 15 Dec) recorded total number of family 15 and species 64. Pramod kumar Rijal recorded (2008) total number of family 20 and 60 numbers of species.

Among the four stations altogether 41 different genuses were recorded in this study period. The largest fish catch was from the Barilius and Aspidoperia at number of 110 each which covered 30.64% of total collected fishes. The lowest were *Clarias*, *Eutropichthys*, *Garra* and *Heteropneustes* which constituted the 0.13 percent of total number each as shown in table 11.
Total 20 different families were recorded during study from different sampling stations of Koshi River. *Cyrinidae* dominated all other comprising 40.98 % and rests were almost same amount in number as shown in table 12. *Cyprinidae* comprised highest number of fish species (40.98 %) followed by *Cobitidae* (4.91%) and *Bagridae*, *Balitoridae*, *Nandidae* and *Schilbedae* were found 3.27% each. Rests were only 1.63% percent each in total number (figure 12).
Of the observed species 718,

25 *Acanthocobitis* botia were recorded which was 3.48% of total number
30 *Aorichthys aor* were recorded which was 4.17% of total number
10 *Aorichthys seenghala* were recorded which was 1.39% of total number
50 *Aspidoperia jaya* were recorded which was 6.96% of total number
60 *Aspidoperia morar* were recorded which was 8.35% of total number
15 *Badis badis* were recorded which was 2.08% of total number
25 A*rilius barila* were recorded which was 3.48% of total number
35 *Barilius barna* were recorded which was 4.87% of total number
15 *Barilius bendelisis* were recorded which was 2.08% of total number
25 *Barilius guttatus* were recorded which was 3.48% of total number
10 *Barilius vagara* were recorded which 1.39% of total number
07 *Botia lohachata* were recorded which was 0.97% of total number
05 *Branchydanio rerio* were recorded which was 0.69% of total number
02 *Chaca chaca* were recorded which was 0.27% of total number
11 *Chagunius chagunio* were recorded which was 1.53% of total number
15 *Chanda nama* were recorded which was *2.08*% of total number
01 *Channa marulius* were recorded which was 0.13% of total number

11 Channa *orientalis* were recorded which was 1.53% of total number
25 *Channa punctatus* were recorded which was 3.48% of total number
01 *Channa striatus* were recorded which was 0.13% of total number
02 *Cirrhinus mrigala* were recorded which was 0.27% of total number
12 *Cirrhinus rewa* were recorded which was 1.67% of total number
01 *Clarias batrachus* were recorded which was 0.13% of total number
05 *Clupisoma garua* were recorded which was 0.69% of total number
30 *Colisa fasciatus* were recorded which was.4.17% of total number
02 *Crossocheilus latius* were recorded which was 0.27% of total number
12 *Danio devario* were recorded which was 1.67% of total number
01 *Eutropichthys vacha* were recorded which was 0.13% of total number
08 *Gagata cenia* were recorded which was 1.11% of total number
01 *Garra annandalei* were recorded which was 0.13% of total number
07 *Glossogobius giuris* were recorded which was 0.97% of total number
02 *Glyptothorax pectinopeterus* were recorded which was 0.27% of total number
01 *Heteropneustes fossilis* were recorded which was 0.13% of total number
25 *Labeo angra* were recorded which was 3.48% of total number
01 *Labeo gonius* were recorded which was 0.13% of total number
01 *Labeo pangusia* were recorded which was 0.13% of total number
03 *Labeo rohita* were recorded which was 0.41% of total number
10 *Lepidocephalus guntea* were recorded which was 1.39% of total number
15 *Labeo boga* were recorded which was 2.08% of total number
10 *Macrognathus aral* were recorded which was 1.39% of total number
07 *Macrognathus pancalus* were recorded which was 0.97% of total number
10 *Mastacembelus armatus* were recorded which was 1.39% of total number
05 *Monopterus cuchia* were recorded which 1.39% of total number
05 *Mystus bleekeri* were recorded which was 0.69 % of total number
01 *Mystus cavasius* were recorded which was 0.13% of total number
15 *Mystus tengara* were recorded which was 2.08% of total number
02 *Nandus nandus* were recorded which was 0.27% of total number
03 *Noemacheilus corica* were recorded which was 0.41% of total number
02 *Notopterus notopterus* were recorded which was 0.27% of total number
07 *Ompok bimaculatus* were recorded which was 0.97% of total number
11 *Parambassis ranga* were recorded which was 1.53% of total number
25 *Puntius chola* were recorded which was 3.48% of total number
10 *Puntius sarana* were recorded which was 1.39% of total number
20 *Puntius sophore* were recorded which was 2.78% of total number
10 *Rasbora daniconius* were recorded which was 1.39% of total number
07 *Somileptes gongota* were recorded which was 0.97% of total number
08 *Tetraodon cutcutia* were recorded which 1.39% of total number

07 *Tor putitora* were recorded which was 1.11% of total number was.0.97
11 *Tor tor* were recorded which was 1.53% of total number
10 *Wallago attu* were recorded which was 1.39% of total number
15 *Xenintodon cancila* were recorded which was 2.081.39% of total number

According to the locals and fishermen the fishes are now in decreasing order in Koshi River. Some of the fishes that have almost disappeared from this river are *Channa* str*iat*us, *Cirrhinus mrigala*, Clarias *batrachus*, *Channa marulius*,*Chaca chaca*, *Eutropichthys vacha*, Garra *annandalei*, *Glyptothorax* pect*i*nopeterus, *Heteropneustes fossilis*, *Labeo* gonius, *Labeo* pangusia, *Mystus cavasius* and *Nandus nandus*. Since these species are decreasing rapidly fisher men let them free to river if they come in net.

The causes of decreasing rate were because of heavy harvesting using all type of available nets and measures, illegal method of poisoning, killing the immature fry fishes before laying eggs and sweeping the fishes away to India with eggs in flooding season. The fishes cannot return back to their habitat because of closed Koshi Barrage in winter season. Gubhaju (2002) reported the fish catches have been declined due to the high fishing pressure, use of chemicals, dynamiting, electro fishing and use of small nets.

The socio economic condition is very poor and fishermen are uneducated. They are not skilled at any other jobs for livelihood. All the day they spend time just fishing but do not know about all rules and regulation that to be followed for the development of fishes which is another cause of declining in rate.

The price in the Market is not fixed, as it depends on the time, availability of fishes and local market. However the cheapest fish was Pothi (Sidre) 30 Rs/ Kg and expensive one was Jalkapur 500 Rs/kg during study period.

CHAPTER SIX

CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

Koshi River is a holy and scared river that flows through the Koshi Tappu Wildlife Reserve which is one of the renowned world heritages where endangered species of wildlife like buffalo, reptiles and birds have been surviving. The fishes of the Koshi River are biologically diverse. Fish diversity and fishery resources of Koshi River were studied for the period of nine months from March 2010 to November 2010 covering the four different seasons. During the study the fishes were sampled on an opportunistic basis from the catch of local fishermen. Information was collected on species composition, local names, location of catch and fishing methods used to catch different species from all four stations. Along with this physico-chemical parameters and management consideration of Koshi River was studied.

A total of 61 species were recorded form the Koshi River which belongs to 7 orders, 20 families and 41 genera. Economically important fishes found were *Tor putitora*, *Tor tor*, *Labeo* angra, L. *rohita*, *Aorichthys aor*, *A. seenghala*, *Wallago attu*, *Bagarius bagarius*, *Clupisoma garua* and *Anguilla bengalensis*.

The physical and chemical factors of the river being one of the important factors were specified at different section of Koshi River. The temperature and other chemical factors of the river provide an assortment of ecological niches that satisfy the environmental requirements of a large number of fish species.

Water quality in the Koshi River has been found to be in good condition, and it should be maintained in future too.

Among the four stations altogether 41 different genuses were recorded in this study period. The largest fish catch was from the *Barilius* and *Aspidoperia* at number of 110 each which covered 30.64% of total collected fishes.The lowest were *Clarias*, *Eutropichthys*, *Garra* and *Heteropneustes* which constituted the 0.13 percent of total number each.Total 20 different families were recorded during study from different sampling stations of Koshi River. *Cyprinidae* comprised highest number of fish (54.73 %) followed by *Bagridae* (8.49%), *Channidae*(5.29%), *Belontidae*(4.17%) and rest were only 27.32% each in total number.

The socio economic condition is found to be very poor and fishermen are uneducated. They are not skilled at any other jobs for livelihood. Irrational method of fishing is seemed to be the main cause of decline in rate. The other causes of decreasing rate were heavy harvesting using all type of available nets and measures, illegal method of poisoning, killing the immature fry fishes before laying eggs and sweeping the fishes away to India with eggs in flooding season.

6.2 Recommendations

To increase the number of fishes and to stop disappearing the species from Koshi River some improvement measures should be under taken instantly. A fishery in Natural waters offers a great opportunity for self-employment and income generation among poor people living along the rivers. One main advantage is that poor landless people can turn to fishing both as a source of income and as employment, which would benefit poor rural people by raising their economic status. For successful conservation and management of indigenous fish species in the Koshi River following recommendation can be made.

1. Use of fine meshed net like gill net, cast net, mosquito net and any other illegal fishing practices should be strictly banned.
2. The deep water pools of the Koshi River should be declared as fish sanctuaries for the protection of spawners.
3. Saura, Magur, Buduna, Singhi, Kursa, Latani, Khrikiri and Bhorha found very less in number, some protection measures should be taken immediately to protect such declining species.
4. An Aquaculture programme should be implemented involving the local fishermen providing necessary trainings and technological packages.
5. Local community should be made aware of Aquatic Life Conservation Act 2017 B.S.
6. Some vocational training should be launched to the local fishermen by the government or INGO at Buffer Zone area to uplift their economic status.
7. The facility of Fish ladder should be provided at Koshi Barrage to facilitate the fishes to return back to their own habitat.

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APPENDIX-I

A list of questionnaires used in interview with fishermen of Koshi River to study socio-economic condition and their demography

Zone: VDC: District:

Ward No.: Village:

1. Name of fisherman:

Cast	Age	Sex	Religion

2. Number of member of the family.

Total	Male	Female

3. Are you literate?

Yes: No:

4. Are you giving school education to your children?

Yes: No:

5. If no, then why?

6. Do you know about family planning?

7. How many members of your family are included in fishing?

8. How many fishermen come to fishing in this site?

9. Is fishing your main profession?

Yes	No

10. If yes in which category do you fall?

Full time fishermen	Part-time fishermen	Occasional

11. Is full time sufficient for your livelihood?

Yes	No

12. Which fish species is abundant/common/uncommon in this river?

Name of the fish	Abundant	Common	Uncommon	Remarks

13. What do you do with captured fish?

Consume	Sell	Both

14. If you sell fish where do you sell it?

Place	Market/village	Distance from home

15. How much fish do you capture per month?

16. What type of fishing gears do you use for fishing?

17. Do you observed or heard about fish spawning/breeding?

18. In which season or months do you observe more fry and fingerlings in the river in your catch?

19. Where do you catch the most number of species?

Station I, Station II, Station III or Station IV			
Running	Shallow	Sand bed	Large boulders

20. What do you think fish population has increased or decreased in the recent years?

Increased	Decreased	Don't know

21. If decreased please give the reason?

Over fishing	Use of dynamite	Pesticides/herbicides	Electro-fishing	Effluent of industry	Others

22. Which fish species are mostly captured by you?

23. What are the aquatic predators of this river?

24. Do you receive any facilities form public or private institutions at present?

Yes	No

25. Any suggestion would you like to give for the improvement of fishery of the Koshi River?

APPENDIX-II

LIST OF FISHERMEN WHO INVOLVED IN INTERVIEW AND OTHER STUDY ACTIVITIES

1. Name: - Gulabi Mukhiya,
   Age: - 33 years,
   Profession: - fishing, fishing since 19 years
   President of fishermen trade union of buffer one area

2. Name: - Mangal Mukhiya,
   Age: - 70 years,
   Profession: - fishing since 25 years

3. Name: - Bhola Mukhiya,
   Age: - 40 years,
   Profession: - fishing since 20 years

4. Name: - Naresh Mukhiya,
   Age: - 40 years,
   Profession: - fishing since 10 years

5. Name: - Bhanwar Mukhiya,
   Age: - 48 years,
   Profession: - fishing since 25 years

APPENDIX-III

SOME PHOTOGRALPHS WHILE STUDYING AROUND KOSHI TAPPU WILD LIFE RESERVE AREA

At West Kushaha KTWR office with 3 feet long Sahar machha.

At Koshi Barrage