FISH DIVERSITY OF SAPTA KOSHI RIVER, SAPTARI, NEPAL

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A thesis submitted in the partial fulfillment of the requirements for the award of the degree of Master of Science in Zoology with special paper Fish &Fisheries

Submitted to

Central Department of Zoology
Institute of Science and Technology
Tribhuvan University
Kirtipur, Kathmandu
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February, 2017

DECLARATION

I hereby declare that the work presented in this thesis entitled “Fish Diversity of Sapta Koshi River, Saptari, Nepal”has been done myself and has not been submitted elsewhere for the award of any degree. All sources of information have been specifically acknowledged by references of the author(s) or institution(s).

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RECOMMENDATIONS

It is recommended that the thesis entitled **"Fish Diversity of Sapta Koshi River, Saptari, Nepal"** has been carried out by Mr. Shiv Shankar Yadav for the partial fulfillment of Master's degree of Science in Zoology with special paper Fish and Fisheries. This is his original work and has been carried out under my supervision. To the best of my knowledge, this thesis work has not been submitted for any degree in any institutions.

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EVALUATION

This thesis work submitted by Mr. Shiv Shankar Yadav entitled"**Fish Diversity of Sapta Koshi River, Saptari, Nepal**" has been accepted as a partial fulfillment for the requirements of Master's Degree of Science in Zoology with special paper Fish and Fisheries.

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ACKNOWLEDGEMENTS

This thesis entitled “Fish Diversity of Sapta Koshi River, Saptari, Nepal”is my thirst that may raise the income and employment of the country through effective management of the fisheries resources. I am really indebted to my respectable supervisor Dr. Archana Prasad (Associate Professor) for taking pains and sparing sufficient time for correction, review and making it coherent and logical in every possible way. I cannot repay her debt.

Similarly, I am equally indebted to respectable to Prof. Ranjana Gupta, Head of the Central Department of Zoology, T.U for her valuable guidance suggestion and encouragement during the research period.

Similarly, I am very much grateful to my respectable teachers Prof. Dr. Surya Ratna Gubaju, Prof. Dr. Kumar Sapkota and other faculty members of CDZ for their help to various steps of this study.

I am equally thankful to library staffs, administrative staffs and laboratory staffs for their kind cooperation.

My thanks and gratitude goes to my father Dr. Ram Khelawan Yadav, mother Sandhya Devi Yadav, younger brother Dr. Soni Yadav and my wife and others family members for their unconditional supports.

Last and not the least I cannot forget to thank Sri Kanchan Kumar Yadav for typing formatting and printing this thesis timely.

If any insufficiency crept in it is my own. Advices and criticisms are welcomed.

Shiv Shankar Yadav

CONTENTS

LIST OF APPENDICES

LIST OFTABLES

LIST OF FIGURES

LIST OF PHOTOGRAPHS

LIST OF ABBREVIATIONS

Abbreviated form	Details of abbreviations
AAPA	Aquatic Animal Protection Act
ADB	Asian Development Bank
AGDP	Agriculture Gross Domestic Product
CBS	Central Bureau of Statistics
CDZ	Central Department of Zoology
EIA	Environmental Impact Assessments
FAO	Food and Agriculture Organization
FFD	Fish Farming Development
GON	Government of Nepal
GDP	Gross Domestic Product
GPS	Global Positioning System
g	gram
HMG	His Majesty Government
KTWR	Koshi Tappu Wild Life Reserve
km	kilometer
m	meter
MOAD	Ministry of Agriculture Development
mt	Metric tone
NEPAP	Nepal Environmental Policy Action Plan
NTNU	Norwegian University of Science and Technology
NA	Not Available
NARC	Nepal Agriculture Research Council

ABSTRACT

The physio-chemical parameter of an aquatic environment exhibit influencing factor for the quantity of aquatic life. Present study (a ranging of 2.5 km) during the month of February and May 2015 in the Koshi River indicated a total account of 22 fishes species from 6 orders namely Anguilliformes (1.73%), Clupeiformes (1.73%), Cypriniformes (48.95%), Siluriformes (35.41%), Synbranchiformes (3.47%) and Perciformes (2.08%) of fish species out of 288 fish catch recorded 10 families and 17 genera. The most abundant family within catch was Cyprinidae. *Aspidoperia morar, Clupisoma garua* were the most abundant fishes in all the study sites during the month of May. *Labeo rohita, Puntius sophore, Mystus tengra* were the most abundant fishes in all the study sites during the month of February. Fishes belonged to different families like- Anguillidae (1.73%), Clupeidae (1.73%)), Cypinidae (46.52%), Cobitidae (2.43%), Bagridae (17.36%) , Schilbeidae (7.98%) , Clariidae (3.13%), Heteropneustidae (6.945) , Mastacembelidae (3.47%) and Channidae (2.08%).Here, occurrence of Cypriniformes - *Labeo spp. Cirrhinus* comprises the dominant group. One species belonging to Heteropneustidae family in the Koshi River during this investigation but *Anguillabengalensis, Labeo dero,* which were not reported from Koshi River. Number of fish species was recorded higher in stations I and III and lower in station II. The correlation between transparency and fish density was found negative at station I and positive at II and III. The transparency was change in the water depth and human activities.

The study showed riverine environment undergone degradation due to various natural landslide, soil erosion and manmade activities like road construction alongside of the river bridge, construction, over fishing, illegal fishing, use of soap and detergent, stone extraction etc

1. INTRODUCTON

1.1 General Background

Water is a dominant constituent of living matter. The chemistry of water is a function of the land it flows through. There are also important other factors, such as an amount of sunlight, depth of water, turbidity and volume. Water chemistry plays a vital role in the development of fisheries in fast flowing mountain stream. It determines an existence of micro flora and fauna in different stretches of the water body. The water quality such as balanced amount of oxygen, carbon dioxide and minerals are the detrimental factors to fresh water life.

The rivers and lakes of Nepal contain protein rich living organism, which can be helpful in fishing resources as well as different aquatic flora and fauna. Nepal, is a small land locked country which possesses 2.27% of the water resources in the world has great potential for hydropower generation (Rai, 2008; Gubhaju, 2012).It bears snow clad mountains, eternal glaciers, ice cold torrents, clear –water and lakes which contribute too much of its hydrosphere. These vast stretches of inland water support many and varied forms of freshwater life including fish.

Nepal has tremendous geographic diversity and is divided into three belts: Terai, Hill and Mountain Regions. The Terai lies between 130 m and 500 m elevation, the lower hills up to 2700 m, the upper hills up to 4000 m and the Himalayas are located above the 4600 m (Appendix 1). The Terai region begins at the Indian border and forms the northern extension of the Gangetic plainwithRohu (*Labeo* spp.) Sidre (*Puntius* spp.) Catfishes (like *Heteropneusteus fossilis, Wallagoattu, Clarias batrachus* etc) as important fishes found in this region (Shrestha 1981). Hill region is situated south of the Mountain Region, mostly between 700 and 3,000 meters (2,000 and 10,000 ft) altitude. Snow Trouts (*Schizothoraichthys* spp.), Sucker Headed (*Garra* spp.), Stone Loaches (*Nemacheilus* sp.) and *Glyptothorax* spp. are found in the upper part and Sahar (*Tor* sp.), Bhakur (*Catla catla*), Rohu (*Labeo* sp.), Faketa (*Barilius* sp.) Kabre (*Pseudochenesis sulacatus*) are found in the lower region (Shrestha 1981). Mountain Region begins where high ridges begin substantially rising above 3,000 meters (10,000 ft.) into the subalpine and alpine zone. Fishes are not recorded from this region.

Mountain and hills make up 83 percent while Terai occupies only 17 percent. The country may be divided into three climatic zones according to altitude- Subtropical in the Terai, temperate in the hills and alpine in the mountains. The climate varies little from east to west. Rainfall is adequate in the eastern portion of the Terai, which ranges 1788mm to 1905mm. Western portion of Nepal is dry and it has rainfall of 1396 mm, however in Pokhara valley reached to 3486mm. In Terai temperature ranges from 36.6^0C-48^0 C highest in July and 6-10^0 C in November/ December.

a. Water Resources and River System in Nepal

1.2.1 Water Resources of Nepal

Water one of the fundamental feature of the earth, which covers 71% of its surface exists as 97% in the seas as salt water and remaining 3% exists as freshwater in rivers, lakes, streams, reservoirs, underground water, polar and permanent glaciers etc. (Wetzel 1983). Nepal possesses 2.27% of the world water resources (Rai 2008 Gubhaju, 2012) in the form of rivers, rivulets, streams, lakes, reservoirs, ponds, swamps, wetlands and paddy fields. The water surface area of Nepal covers 0.1% of the total world water systems and fish diversity accounts 0.21% of total global fish diversity (Shrestha, 1995).

1.2.2 Natural water resources

Nepal is endowed with several types of wetlands as shown in Table 1. The rivers are of major importance as it occupies 48.34% of the total area with lake and reservoirs only 0.8%.

Table1. Available water resources in Nepal

S.N	Resource details	Estimated area (ha)	Coverage (%)	Potential area (ha)
1	Natural water	4,01,500	48.9	78,000
	Rivers	3,95,000	48.1	
	Lakes	5,000	0.6	
	Reservoirs	1,500	0.18	
2	Ponds	8,600	1.1	14,000
3	Marginal swamps	12,500	1.5	
4	Irrigated paddy fi	3,98,000	48.5	
	Total	8,20,600	100	92,000

Source: DoFD, (2013/2014)

1.2.3 River Systems in Nepal

There are more than 6000 rivers and the major of them are: Koshi, Gandaki , Karnali and Mahakali running southward through steep valley and deep gorges . The water shed of these rivers lies usually in Tibet having little problem of floods in hills but serious problem in Terai.

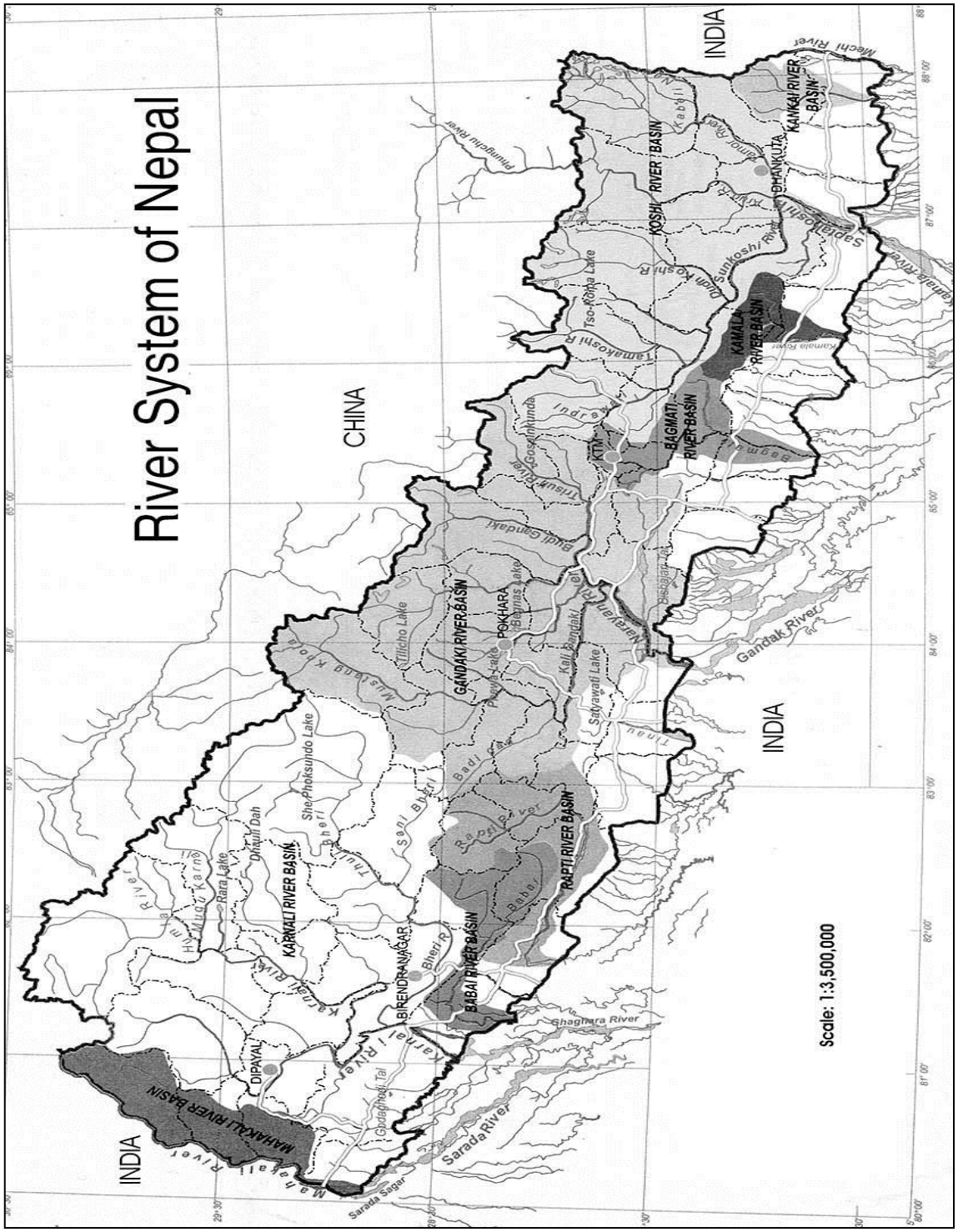

Figure 1 Major rivers of Nepal

1.2.3.1 Description of The Sapt Koshi River

Rajbiraj is situated in the eastern part of Nepal at latitude of 26°32' North and longitude of 86° 44'East. Rajbiraj is one of the cities in Nepal that connected by East West Highway about 10 km to the north and 17 km to the east also known as "Hulaki Rajmarg". It has tropical climate with three main seasons like summer – from early April to August and temperature ranging from of 23°C to 44°C, monsoon- July to September 22°C to 38°C and winter - prevails from October to March 10°C to 35°C. Humidity, which prevails during monsoons, diminishes at the arrival of winters. The annual precipitation is about 1000–1500 mm in the tropical region (Chen et al.2013).Koshi river basin which is one of the largest river basins of Nepal has its headwaters in the northern Himalayan region of the country. The Koshi system drains almost 60,000 km^2 of eastern Nepal and southern Tibet before entering Bihar. North of the India-Nepal border, the river is known as the Sapt Koshi or "Seven Rivers" in reference to its seven principal tributaries. Its three main tributaries join at Tribeni, only 60 km north of India. Downstream of Tribeni, the Sapt Kosi flows through a narrow gorge for 11 km, passing the gaging station at Barakhshetra, before spreading over the Gangetic plain below Chitale at 100 m elevation (Gole & Chitale, 1966). The Koshi is the largest river of Nepal and is the third largest in Asia after the Indus and Brahmaputra. This river is formed by the rivers Indrabati, Tama Koshi, Likhu Khola, Sun Koshi, Dudh Koshi, Arun and Tamor. The Koshi basin occupies a large area in Tibet as well as in Nepal. The length is 266 km whereas a width is 117 km in Nepal. Its total catchment area is 60,400 km^2.The total length is 50 km up to the Indian border. The drainage area of Koshi in Nepal is 54,100 sq. km. (Joshi, 2012). Some parts of the basin have extremely high annual mean evapotranspiration and they suffer from frequent droughts and soil erosion (Chen et al. 2013).

1.3 Fish Diversity and Fishery Resources of Nepal

The Koshi River system probably represents the largest capture fisheries in Nepal, in terms of yield volume, fish species abundance and the number of fish farmers are dependent for their livelihood (Paudel et al. 2016; Gurung et al. 2016). Shrestha (2003) reported 184 fish species from Nepal belonging to 93 genera, 31 families and 11 orders. Rajbanshi (2005) reported 187 species belonging to 94 genera, 30 families and 10 orders whereas in the current context showed 232 species(Shrestha, 2008) belonging to 114 genera, 37families and 11 orders. In Nepal, none of the fish species has been enumerated in list of indigenous fish species of Nepal for Biodiversity profile project along with their conservation and distribution status by IUCN and CITES list of endangered wildlife. The report indicates that out of 184 listed species 57 are common, 63 insufficiently known, 23 rare, 32 species threatened species 57 are common, categorized in vulnerable category whereas one species is given protected status.

Based on taxonomic status, there are two endangered species (EN), nine vulnerable species (VU), 23 rare and threatened species (R), 32 Data deficient Pristine Rare Ornamental species (PRO), 27 Conservation Dependent and Rare species (CDR), 53

uncommon or Lower Risk Least Concern species (UN), 71 Common species (C) and 15 Exotic species (*). No fish species is identified as Critically Endangered (CE) and extinct (EX) in Nepal to date (Table 1).

Table 2 List of conservation status of fishes of Nepal

S.N	Categories	Designated as	Number of fish species
1.	Common	C	71
2.	Uncommon or lower Risk/ Least Concern	UN	53
3.	Conservation Dependent and Rare	CDR	27
4.	Data Deficient Pristine Rare ornamental	PRO	32
5.	Critically Endangered	CE	0
6.	Endangered	EN	2
7.	Extinct	EX	0
8.	Vulnerable	VU	9
9.	Rare Near Threatened	R	23
10.	Exotic	E	15
	Total		232

Source: Shrestha, 2008

It has been estimated that about 1, 27,000 families were engaged in aquaculture and fisheries activities and 4, 69,000 people being actively involved in the profession. About

6, 21,000 people or around two percent of the total population are estimated to benefit directly from aquaculture and fisheries activities. The per capita fish consumption rate is 1,512 g/year, which is very low compared to other developed countries. It is probably because the fish production in our country is restricted to inland fisheries and aquaculture because of its land locked nature (Swar, 1998).Three aquaculture systems are in practice in Nepal since 1981 with the investment of Aquaculture Development Project (ADP) with loan assistance from ADB/UNDP (Shrestha and Yadav, 2003). It is reported that 51,000 families are involved in capture fisheries with 899,93 million NRS (Matsya Palan Srinkhala, 1999). Several ethnic communities have taken this profession as full time, in fishing and other water-related activities (Gurung, 2003, 2014). Such ethnic communities who are dependent on wetlands represent about 18% of the total population of the country (IUCN 2004). Mostly, overfishing has been considered major causes of fisheries depletion (Hauge et al. 2009). Paudel et al. (2016) mentioned involvement of 15 ethnic communities in fishing in Koshi Tappu area and same was reported by Gurung and Sah (2016).

During last decades, inlands water bodies of Nepal have been subjected to a range of stress factor caused by direct and indirect human activities such as irrigation, hydroelectric project, etc. associated with siltation, chemical pollution, introduction of exotic species, over and irrational fishing and hydraulic engineering(dams and impoundments, channelization etc.)Fishing activity was reported maximum during autumn and winter seasons and minimum in summer (rainy) seasons (Gachhadar et al., 2004).

In Nepal fisheries, have been practiced for a long time and have a strong tradition in the country. At present the total fish production in Nepal is 64900mt (2013-2014) in which share of reverine fisheries is about 33 % and rest 67% is from aquaculture . As the demand for fish is rising due to rising population and its nutrition security and we need to invest billions of rupees in fish import, we must have to improve the reverine fisheries and pond aquaculture.

1.4 Objectives

1.4.1General objective

To study the fish diversity of Sapta Koshi River, Saptari.

1.4.2 Specific objectives

i) To study the existing different species of fishes, their distribution pattern and frequency.
ii) Analyze the physio-chemical parameters of water.
iii) Identify Fishing implements and techniques used by the local fishermen
iv) To know about socio economic condition of fishermen and their problems.

1.5 Justification

Sapta Koshi river has a very long stretches of cold water fishes in which there are 33 types of indigenous fish speciesare found. It is a good source of Asala , Rohu , Katle , Naini and others production.In the same way Saptari district is rich innumber of ponds where the production of Carp fishes can give good result.Very little efforts have been made to explore the fish diversity in this area.According to the local respondent's fish population is declining but some species was found which was not reported earlier. The present study is to prepare the baseline information regarding fish diversity and its resources

1.6 Limitation of the study

Research studies are not without problems so this study has following limitations.

i) As research for fishery resources are vast in nature, researcher has limited it to Sapta Koshi river including Saptari district.

ii) This academic study has been carried out for the partial fulfillment of the requirements for the Master's Degree in Zoology so research was time constraint.

1.7 Significance of the study

As there is growing demand for fish production, the significance of study can't be over looked. We have to import fishes from India and spend foreign exchange on it. As the riverine fishery, has been over exploited and has many serious problem and pond aquaculture is expensive. Therefore, riverine fishery should be developed with proper management and pond aquaculture should also be extended to fulfill the demand for animal protein in Nepal.

1.8 Scope of the study

As Nepal has abundant water resource with rich ecology and vast aquatic resource including fishery , this subsector must be developed, as tourist trade with boat, rafting and fishing, which will increase our employment and income in one hand and it will support 18% of population of fishermen communities like Bote, Majhi, Tharu , Musahar , Kumale, Dharhi , Chhetri, Gharti, Chepang , Tamang , Pode , Sunha , Badi, Magar , Gurung, Malaha and Kebat (Shrestha, 1990) of Nepal.

2. LITERATURE REVIEW

The fish diversity of Nepal is reported since long time by many ichthyologist like Hamilton (1822) who was probably the first ichthyologist to give authentic information of fishes of Nepal. Day (1886) mentioned the distribution of some fresh water fishes of Nepal in his historical work, "Fishes of India, Burma and Ceylon". Menon (1949, 1954) reported fishes belonging to 11 families comprising 26 genera and 52 species from the Koshi Himalayan region. Taft (1955) prepared a check list of the fishes with 95 species representing 13 families. De Witt (1960) prepared a checklist of 102 species of fishes belonging to 21 families collected during California Himalayan Expedition to Makalu. Swar (1980) estimated that there were about 80,000 fisher populations in the country.

Shrestha (1990) the Koshi river harbor 108 species of fishes and he feared that in long run exotic may replace indigenous species such as Golden Mahseer and Deep-bodied Mahseer and many other species. Shrestha (1999) in her paper stated that 186 species of indigenous and exotic fishes in Nepal. She has reported fifty-nine cold water indigenous and two exotic fishes in Nepal. Among the indigenous species Katle (*Neolessocheilus hexgonolepis*), Snow Trout (*Schizothoraichthys* spp and *Schizothorax* spp.) and Sahar (Tor spp) are the most economically important fish considering their table fish and sport fish values

Shrestha (2001) mentioned that Nepal is blessed by a very high diversity of fresh water fishes with 182 fish species belonging to 93 genera, under 31 families and 11 orders. Gubhaju et al. (2002) have studied on the contribution cold water fishes in the livelihood of mountain people of Nepal. Shrestha (2003) reported 184 fish species belonging to 93 genera, 31 families and 11 orders existing in natural water bodies of Nepal. Recently, Pokharel (2004) reported 42 species of fishes from the lotic and lentic water bodies. Rajbansi (2005) has listed 186 species from Nepal.

Other important ichthyologists namely Jana (2007) and Shrestha et al (2009) described that the native fish decline associated with poor management of water quantity and quality. Cowx (2002), Shrestha (2011), and Gurung & Baidya (2012) indicated that anthropogenic disturbance and ignorance are the most important factor for decline and extinction of fish worldwide. Most fishes are considered as an important natural food resource, worldwide, especially that of animal protein.

The socio-economic status of fisher communities was studied by some workers (Thapaliya, 1988: Kaini, 1996; Gurung, 2003). According to Swar (1980), there were about 80,000 fishers, however, it is estimated that there has recently been a three to five-fold increase in the fishing population due to increasing population and deepening poverty in Nepal. Similarly, Gyawali (1997) also studied about socio-economical aspect of Bote. Swar (2002) has explained that aquatic ecosystem of Nepal offer excellent habitats to at least 186 indigenous and 11 exotic fish species of high economic, environment and academic value. Among the 186-fish species 59 have been considered as cold water fish. He has also given a list of 31 indigenous fishes of Sapta-Koshi River. He

has stated that capture fishery is widely scattered in Nepal but it is not well organized. The fisher men use traditional gears for sport and subsistence fishery at different intensity at different rivers of Nepal. Most of the capture fishes are consumed around the catch sites. Only selected fish species i.e. Silver Carp, Bighead Carp and Grass Carp (not reproducing naturally) and common carp, Sahar and Katle (reproduce naturally) are often stocked.

From Koshi River basin *Barilus shacra, Garra annandalei, Psilorhynchoide spseudecheneis, Badis badis, Olyra longicoudata, Tor putitora, Labeo dero* and *Anguillabengalensis* are reported. Edds and Ng (2007) had also added seven fishes from Tamakoshi, Likhu, Bhotekoshi, Dudhkoshi, Arun, Indrawati and their hundreds of small and big tributaries. Thapa (2008) reported 92 fish species from the Koshi River and 81 species were enlisted by Limbu and Subba (2011).

Mallapaty (2013) reported that production of special feed for the fry and development of stress- reducing technologies to improve of eggs during pond transfers targeting national fish production by one percent, and support 1000 marginalized house- hold in ten districts through farmer's group training and will also support a dozen of Ph D graduates to enhance local expertise in fish biology.

Kelkar (2014) looks at the status of riverine fisheries and fisher communities in the Gangetic basin India and highlights the diversity impacts of dams, barrages on water abstraction on this. Its fishing resources support 10-13 million people with 300 fresh water fish species. But fish resources are declining due to large dam's barrages and hydropower projects, severely altered river flows, fragmentation of hydrological connectivity between rivers and wetlands, alarming levels of pollution, riverfront encroachment, rampant sand mining and unregulated over exploitation of fish resources.

Paudal et al (2016) in their article states that the Ganges River Dolphin (*Palatanista ganetica ganetica,* GRD) is one of the most endangered. In Nepal's Narayani, Saptakoshi and Karnali River system, survival of dolphins is being threatened by various anthropogenic activities such as dam construction and interaction with artisanal fisheries. Nepalese fishermen acknowledged that fisheries posed a risk to GRD, but they believed that water pollution and dams, irrigation development were the greatest threats.

House hold woman income problems can be solved by aquaculture. Women's group were projected in this program which results in the development of aquaculture at home for boosting nutrition and generating additional income to women.Gurung (2016) in his article states that fish is a food generally acceptable to all regardless region ,religion, race, gender and age across Nepal. The share of aquaculture and open water capture fishery is about 2% of agricultural GDP. He has estimated Nepal's total fish production 64,900 MT in the year 2013/ 2014 in which share of captured fishery was only 33.17 % and rest 66.83 % was the contribution of aquaculture. This subsector has fasted annual growth rate of 8-9 %. The contribution of fishery can't be ignored as it has big nutritional security perspective to poor and marginalized communities. Fish is the rich source of

animal protein which contains amino acid, folic acid, w-3, vitamins and micronutrients that is useful for heart. Government of Nepal has prescribed 30 g per day fish or animal protein for each man/ woman. In Nepal, where 41 % of children under five suffers from stunning can be minimized by consumption of nutrition rich fish. Fish consumption per capita in Nepal was 125 g in 1975 and increased to 2,060 g in 2013 which is nine times below than the global consumption. The value of per capita fish consumption may be increased if native shell fish, frogs and aquatic plants such as fox nut (*Euryale ferox*) and water chest nut (*Trapa sp*), which are consumed by ethnic communities are added. He has advised support service and innovation for better inland fishery and aquaculture development in the country.

3. MATERIAL AND METHODS

3.1 Study Area

Since the Koshi basin includes a vast area along the river in the plains as well as seven catchment rivers feeding the Sapta Koshi, it was not possible to conduct a study of the whole basin. The study was therefore limited to the river between Hanuman Nagar and Gobardiha which is about 25 km and 30 km respectively from the district headquater, Rajbiraj, Saptari, Nepal. The specific study site includes Koshi River basin in the eastern part of Terai (Fig. 1).Three stations were selected with roughly 1 km distance. The sampling site was visited in the month of February and May 2015.

Fig. 2. Map of Saptari District

3.2 Methods of data collection

Both primary and secondary datawas collectedfor information. Direct observation of thesampled sites was done. Interviews with conservation officer of Koshi Tapu wild life reserve, and fishery development officers of Fishery development office Phatepur and District Agriculture development office, Saptari was done. Interviews with 100 fishermen was recorded on the basis of questionare (Appendix - 1). General survey was done to

compile the different fishing implement used and to assess the socio-economic conditions of fishermen community in the study area.

3.3 Analysis of water parameters

Different physical properties of water were analyzed during the study period after APHA (1976), Adoni, (1985), Trivedi and Goel (1986).

3.3.1 Temperature

Temperature of the surface water of the study area was recorded *C 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.

3.3.2 Transparency

Transparency of water is recorded with the help of a round disc,"Secchi Disc", with different stripes of contrasting colors, white and black. The Secchi disc is first lowered in the water until it became invisible and the distance was noted down. The disc was pulled upward slowly until the metallic copper surface become visible again and reading was noted down.Transparency then calculated by using the following formula:

$$\text{Transparency}=\frac{x+y}{2}$$

Where, x= depth at which disc disappears

y= depth at which disc reappears

3.3.3 pH

A battery operated digital pH meter used to measure the pH value of water. The pH of water was taken at different places at a same stations and mean value was recorded.

3.3.4 Dissolved Oxygen (DO) (Winkler's Iodometric method 1888)

The dissolved oxygen was calculated by titration method using the formula:

$$\text{Dissolved oxygen (mg/1)} =\frac{(MN\times N)of\ Na2S2O3\times 8\times 1000}{V_2\left(\frac{V_1-V}{V_1}\right)}$$

Where,V= volume of $MnSO_4$ and KI added

V_1= volume of sample bottle, and

V_2= volume of the content titrated

3.3.5 Free Carbondioxide (CO_2)

$$FreeCO2 = \frac{(ml * Normality)ofNaOH * 1000 * 44}{V}$$

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

3.3.6 Total Alkalinity

By titration method by using the following equation;

$$\text{Total alkalinity (as } CaCo_3 \text{ mg/1)} = \frac{(B \times N)of\ HCl \times 1000 \times 50}{ml\ of\ sample}$$

Where, B=HCl(ml) used with both (phenolphthalein and methyl orange) indicators.

3.4 Laboratory work

Fishes were brought to Central Department of Zoology, Kirtipur and identified with the help of available literature on fishes of Nepal (Day, 1878-86: Shrestha, 2001 and Shrestha, 2008). The collected fishes were fixed in 10% formalin and preserved in 5% formalin.

3.5 Statistical Analysis

The coefficient of correlation between some important physio-chemical parameters of water with fish diversity in four different seasons were calculated by using formula given by Karl-Pearson as referred by Gupta (1988).

$$\text{Coefficient of correlation (r)} = \frac{N\sum XY - \sum X.\sum Y}{\sqrt{(N\sum X2 - (\sum X)2)(N\sum X2 - (\sum X)2)}}$$

$$\text{Probability Error (P.Er.)} = \frac{1-r2}{\sqrt{N}} \times 0.6745$$

4. RESULTS

4.1 Physicochemical parameters

4.1.1 Temperature

The temperature of the water in the Saptakoshi River was found ranging between 24ºC to 32ºC in February and May respectively (Table 3 and fig 3).

Table 3. Seasonal variation in temperature (ºC) at different stations -2015

Months	**Stations (**Temperature)			**Average**	**Max**	**Min**
	I	II	III			
February	24	25	25	25	25	24
May	28	32	30	30	32	28

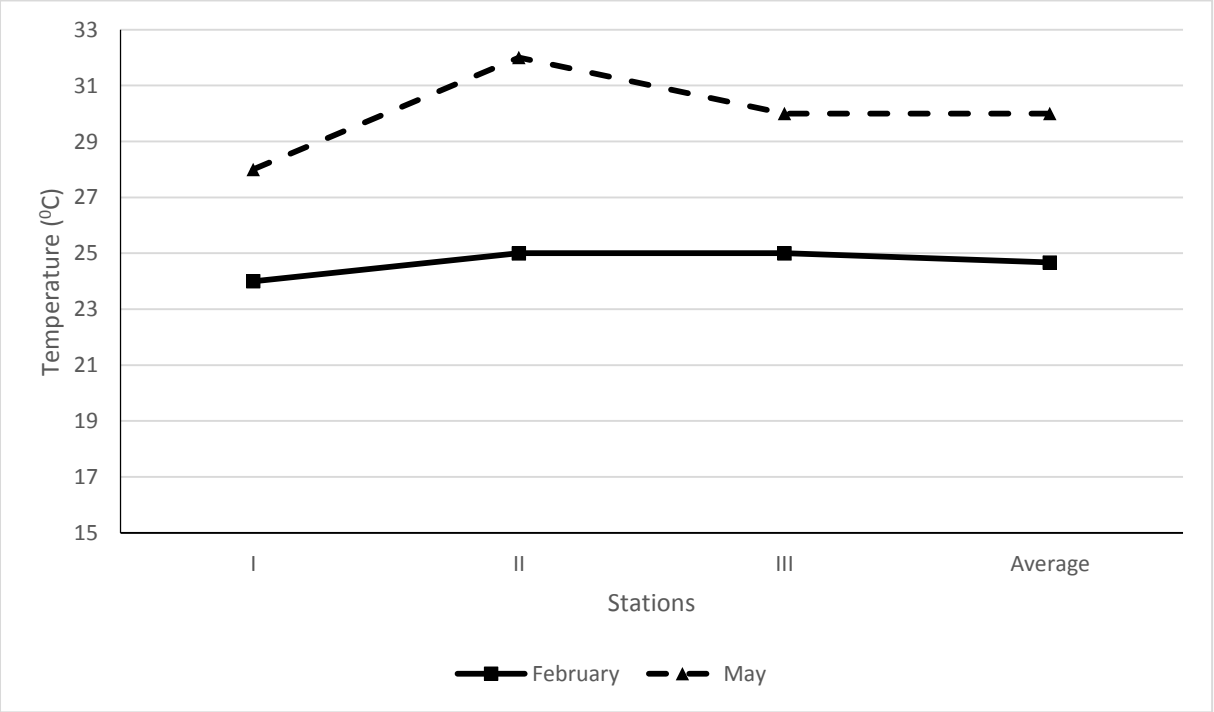

Figure 3. Seasonal variations in temperature (ºC) at different Stations 2015

4.1.2 Transparency

The transparency of Sapta Koshi River recorded during the study period ranged from 10.6 cm to 34.5 cm. The maximum value 34.5 cm was recorded at station I in February, while the minimum value of 10.6cm was recorded at station II in May (Table 4 Fig. 4).

Table-4 Seasonal variation in transparency (cm) at different stations 2015

Months	**Stations**			**Average**	**Max**	**Min**
	I	II	III			
February	34.5	22.1	30.3	29	34.5	22.1
May	15.5	10.6	15.2	14	15.5	10.6

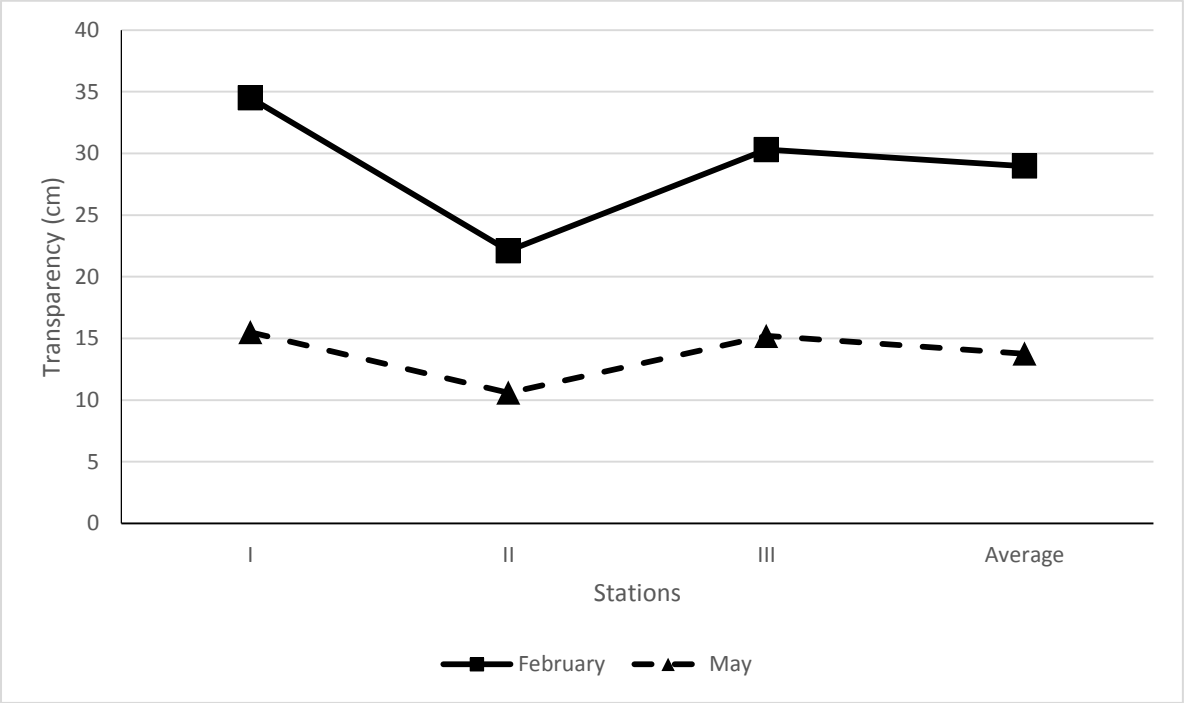

Figure 4 Seasonal variation in transparency (cm) at different stations2015

4.1.3 pH

The pH was found to be varied between 6.5 to 7.8 (Table 5 Fig.5)

Table 5 Seasonal variation in pH at different stations 2015

Months	Stations			Average	Max	Min
	I	II	III			
February	7.2	7.1	7.1	7	7.2	7.1
May	7.8	6.5	7.3	7	7.8	6.5

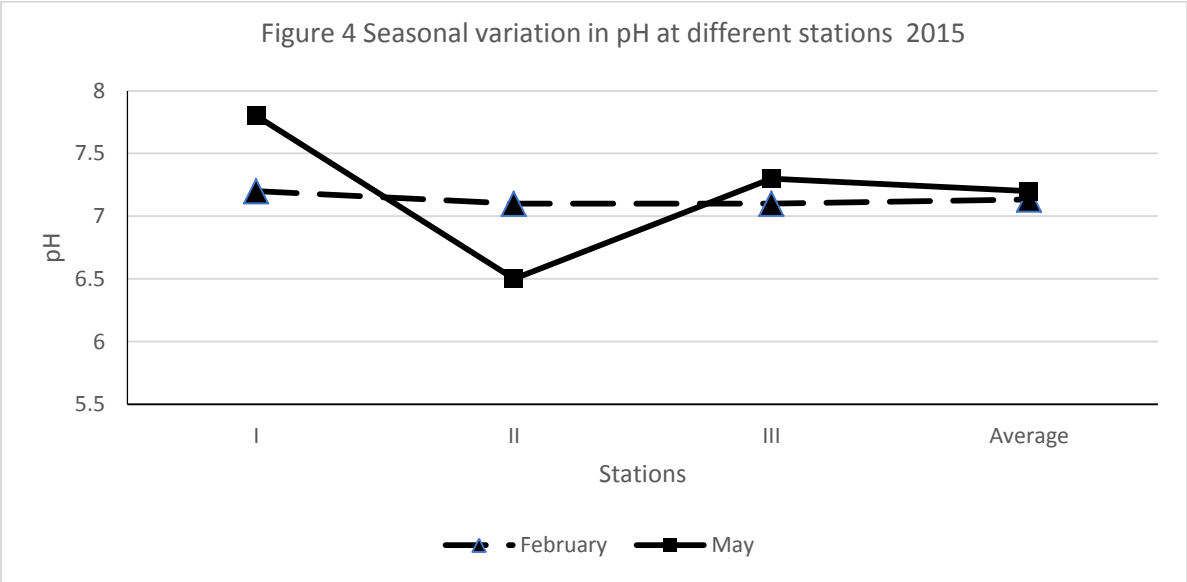

Figure 5 Seasonal variation in pH at different stations 2015

4.1.4 Dissolved Oxygen (DO)

The dissolved oxygen content in the sample was found to be ranged from 3.9 mg m/l to 9.2 mg/l. The DO was found minimum at the station II during May and maximum at the station III during February (Table 6, Fig 6).

Table 6 Seasonal variation in dissolved oxygen(mg/l) at different stations 2015

Months	Stations			Average	Max	Min
	I	II	III			
February	9.1	4.3	9.2	8	9.2	4.3
May	6.8	3.9	6.7	6	6.8	3.9

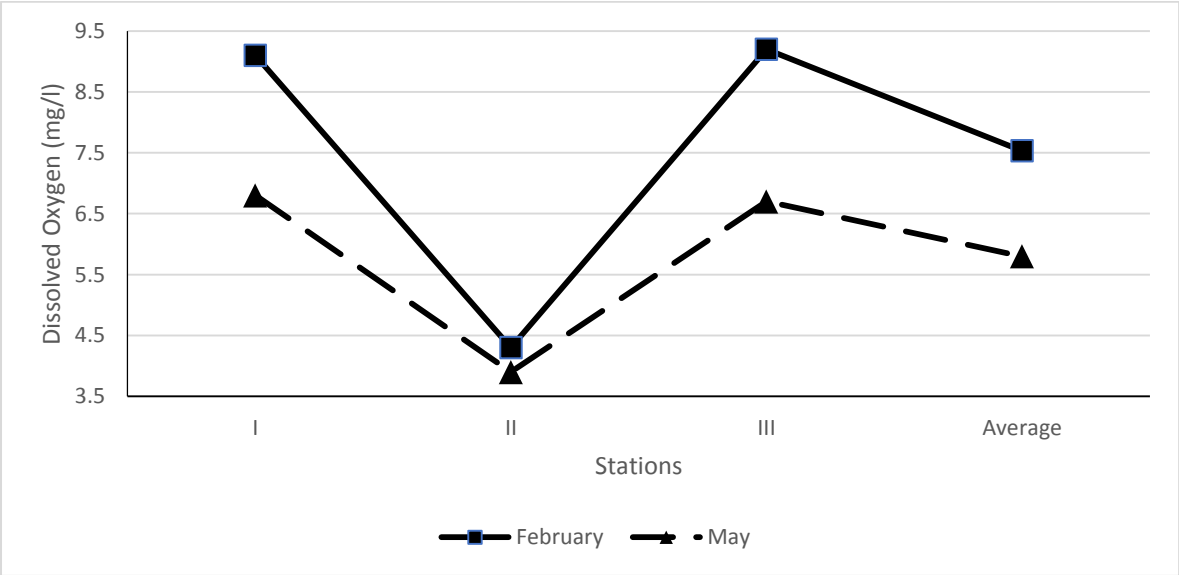

Figure 6 Variation in Dissolved Oxygen (mg/l) at different stations 2015

4.1.5 Free Carbon Dioxide

The carbondioxide was found to be ranging from 5.5 mg/l to 8.2 mg/l. The maximum value of 8.2 mg/l was observed at the station II in May and minimum value 5.5 mg/l at the station III in the February (Table 7 Fig 7).

Table 7 Seasonal variation in free carbon dioxide (mg/l), 2015

Months	Stations			Average	Max	Min
	I	II	III			
February	6.5	6.2	5.5	6	6.5	5.5
May	6	8.2	7.5	7	8.2	6

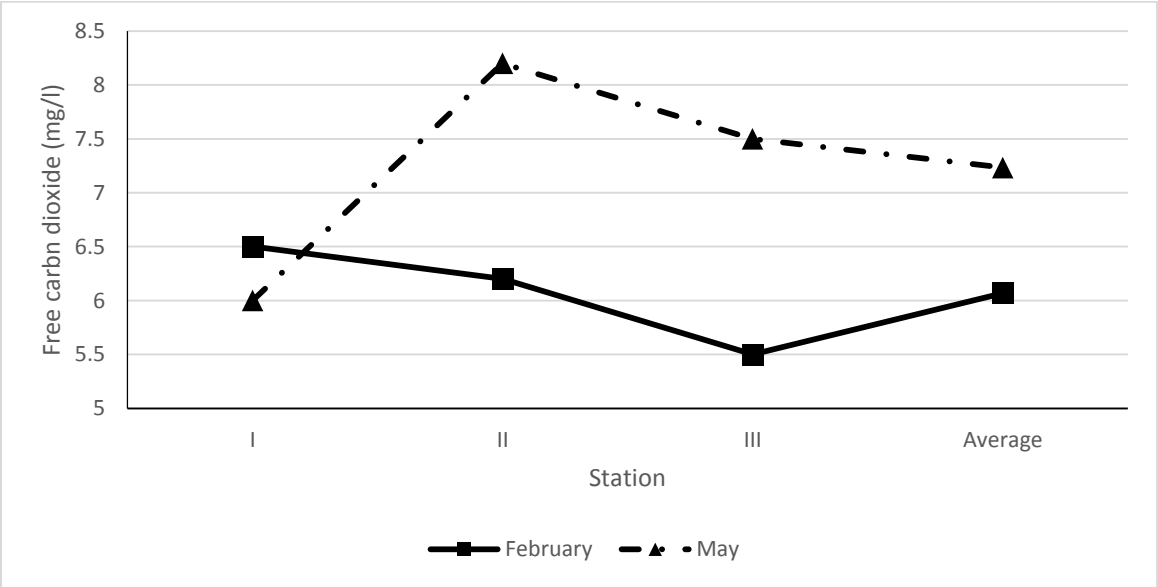

Figure 7 Seasonal variations in free carbondioxide (mg/l) at different stations2015

4.1.6 Total Alkalinity:

The value of total alkalinity was ranged from 30.7 mg/l to 45.8 mg/l. The maximum value 45.8 mg/l was recorded at station II and minimum value 30.7 mg/l at station I in summer (Table 8 Fig8).

Table 8 Seasonal variation in total alkalinity (mg/l) at different stations 2015

Months	Stations			Average	Max	Min
	I	II	III			
February	30.7	40.5	45.8	39	45.8	30.7
May	33.2	40.2	34	36	40.2	33.2

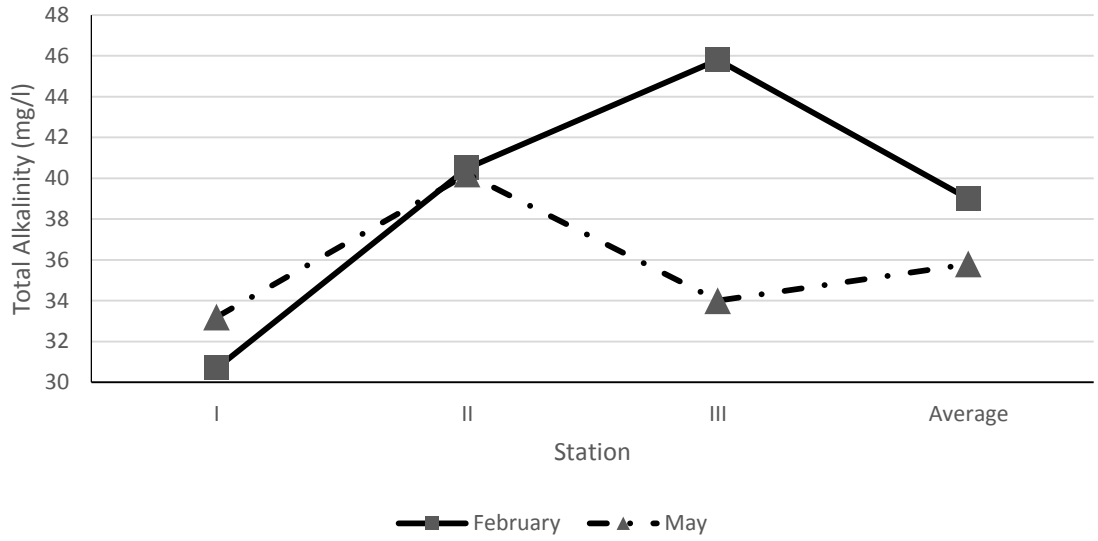

Figure 8 Seasonal variations in total alkalinity (mg/l) at different stations 2015

4.2 Fish Diversity in Sapta Koshi River

Sapta Koshi River was found to be distributed with diverse fresh water fishes. A total of 22 fish species was recorded belonging to 6 orders, 10 families and 17 genera during the present investigation. *Aspidoperia morar,Clupisoma garua, Labeo dero*, *Puntius sophore, Mystus tengra* were the most abundant fishes in the Koshi River. *Labeodero* are caught abundantly during February while *Aspidoporia morar, Clupisoma garua* are caught abundantly during May (Table 9).

Table 9: List of fishes found and its frequency in the Koshi River

S.N.	Scientific name	Local name	Stations			Total	Frequency
			I	II	III		
1.	*Anguilla bengalensis*	Raj Bam	+	-	-	5	1.73
2.	*Catla catla*	Catla/Vakur	+	+	+	15	5.20
3.	*Cirrhinus mrigala mrigala*	Mrigal/Naini	+	+	+	15	5.20
4.	*Labeo angra*	Thed	+	-	+	10	3.47
5.	*Mystus tengra*	Tengri	+	+	+	50	17.36
6.	*Puntius conchonius*	Sidre	-	+	+	8	2.77
7.	*Puntiussophore*	Pothi	+	+	+	25	8.68
8.	*Puntius terio*	Pothi / one spot barb	+	_	+	16	5.5

S.N.	Scientific name	Local name	Stations			Total	Frequency
			I	II	III		
9.	*Puntiusticto*	Two spot barb	+	_	+	10	3.47
10.	*Chela labuca*	Deduwa	+	+	+	9	3.12
11.	*Danio dangila*	Pothi	-	-	+	5	1.73
12.	*Botia lohachata*	Baghi, loach	+	+	-	7	2.43
13.	*Gadusia chapra*	River Shad/Suiya	+	-	-	5	1.73
14.	*Esomus danricus*	Dedhawa	+	+	+	8	2.77
15.	*Aspidoparia morar*	Karangi	+	+	+	10	3.47
16.	*Mastacembelus pancalus*	Kathgainchi/ Bami	+	_	+	10	3.47

S.N.	Scientific name	Local name	Stations			Total	Frequency
			I	II	III		
17.	*Channa punctatus*	Garai	+	+	+	6	2.08
18.	*Labeo dero*	Pausi	+	_	_	3	1.04
19.	*Clupisoma garua*	Jalkapur/potasi	+	+	+	23	7.98
20.	*Clarias batrachus*	Mangur	+	+	+	9	3.12
21.	*Heteropneustes fossilis*	Singhi	+	+	+	20	6.94
22.	*Labeo rohita*	Rohu	+	+	+	19	6.59
			Total			288	

Field Survey 2015

4.2.1 Systematic Position of Fishes

The collected fishes were identified and classified(Table 11) based on classification after and Jayaram (1999) and Shrestha (2008).

Table 10. Systemic position of Fishes

Order	Family	Genus	Species
Anguilliformes	Anguillidae	*Anguilla*	*bengalensis* Day1878
Clupeiformes	Clupeidae	*Gadusia*	*chapra* Misra 1976
Cypriniformes	Cypinidae	*Aspidoperia*	*maror*Hamilton-Buchanan 1822
		Catla	*catla*Jhingram 1966
		Puntius	*sophore*Hamilton-Buchanan 1822 *conchonius* Hamilton-Buchanan 1822 terio Hamilton-Buchanan 1822 *ticto* Hamilton-Buchanan 1822
		Chela	*labuca*Hamilton-Buchanan 1822
		Labeo	*rohita*Day,1877 *dero* Hamilton-Buchanan 1822 *angra* Day 1877
		Cirrhinus	*mrigala mrigala*Hamilton-Buchanan 1822

		Danio	*dangila*Hamilton-Buchanan 1822
		Esomus	*danricus*Hamilton-Buchanan 1822
	Cobitidae	*Botia*	*lohachata* Chaudhuri 1912
Siluriformes	Bagridae	*Mystus*	*tengri*Hamilton-Buchanan 1822
Synbranchiformes	Mastacembelidae	*Mastacembelus*	*pancalus*Hamilton -Buchanan 1822
Perciformes	Channidae	*Channa*	*punctatus* Bloch 1793

4.3 Community structure of fishes

4.3.1 Order wise fish composition

Fishes belonged to different orders like-Anguilliformes(1.73%), Clupeiformes (1.73%), Cypriniformes (48.95%), Siluriformes(35.41%), Synbranchiformes (3.47%) andPerciformes(2.08%) of fish species out of 288 fish catch(Table 11 and fig. 9).

Table 11. Order wise fish composition

Order wise fishes	Percentage
Anguilliformes	1.73%
Clupeiformes	1.73%
Cypriniformes	48.95%
Siluriformes	35.41%
Synbranchiformes	3.47%
Perciformes	2.08%

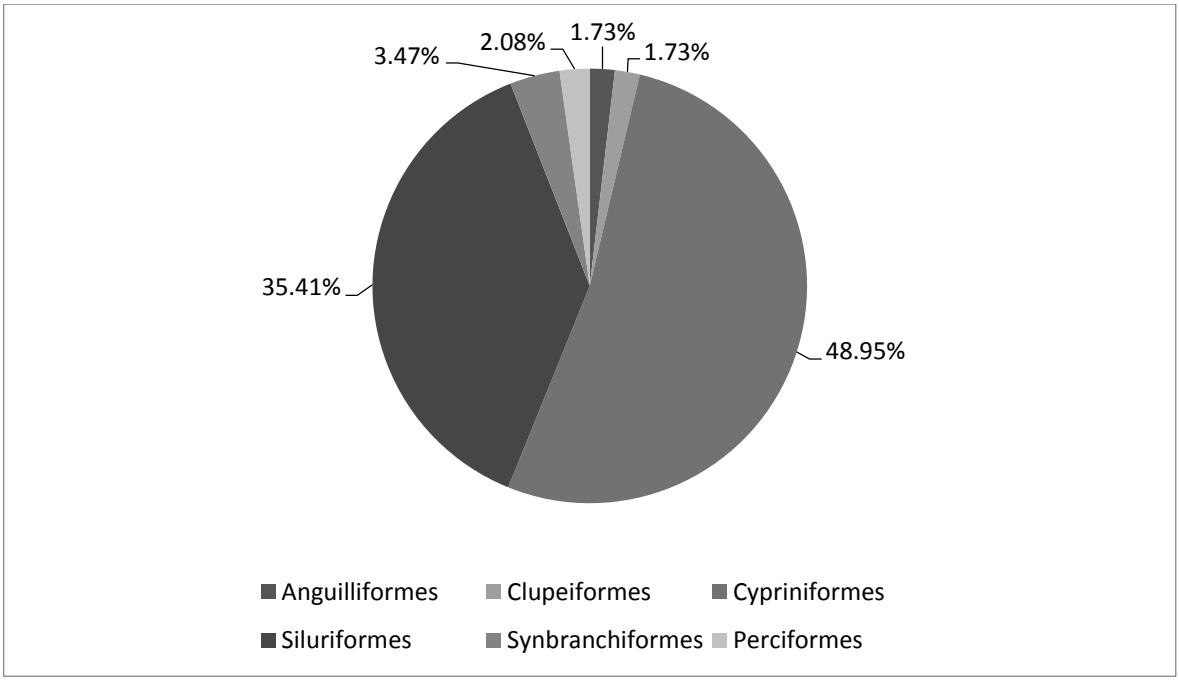

Figure 9. Order wise fish composition

4.3.2 Family wise fish composition

Fishes belonged to different families like- Anguillidae(1.73%) , Clupeidae (1.73%)), Cypinidae (46.52%) , Cobitidae(2.43%), Bagridae(17.36%) , Schilbeidae (7.98%) , Clariidae (3.13%), Heteropneustidae (6.94%) , Mastacembelidae (3.47%) and Channidae (2.08%)of fish species out of 288 fish catch (Table 12 and fig. 10)

Table No. 12. Family wise fish composition

Fishes Family	Percentage
Anguillidae	1.73%
Clupeidae	1.73%
Cypinidae	46.52%
Cobitidae	2.43%
Bagridae	17.36%
Schilbeidae	7.98%
Clariidae	3.13%
Heteropneustidae	6.94%
Mastacembelidae	3.47%
Channidae	2.08%

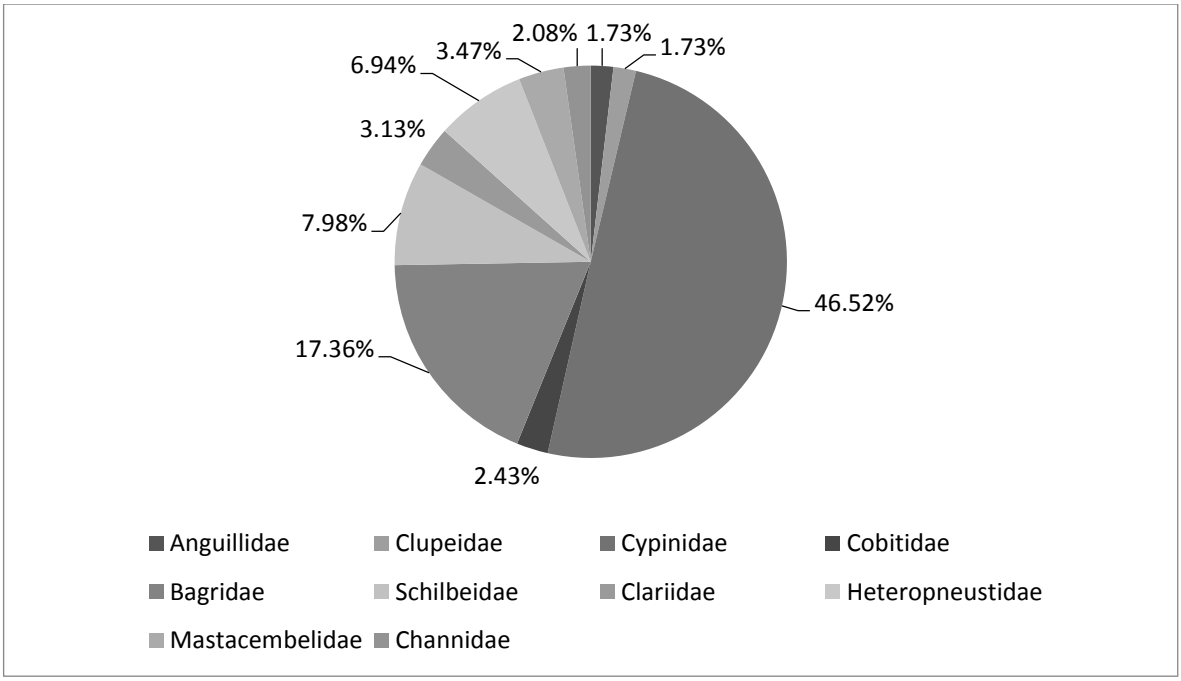

Figure 10. Family wise Fishes Composition

4.4 Correlation between water quality parameters and fish diversity

The correlation between transparency and fishdiversity was found to negatively correlated in station I(– 0.98)andpositive in station II & III (0.75 and 0.60 respectively). Water temperature and fish diversity showed positive correlation in both months all the stations. The coefficient of correlation between free carbon dioxide and fish number showed positive at stations I and II but negative at station III(Table 13)

Table 13. Show the correlation value of the physio-chemical and fish density.

S.N.	Correlation between water variants and fish number	Station I	Station II	Station III
		Coefficient of correlation and Probable error (P.Er.)	Coefficient of correlation and Probable error (P.Er.)	Coefficient of correlation and Probable error (P.Er.)
1.	temperature and fish number	0.93 ± 0.045	0.44 ± 0.038	0.59 ± 0.024

S.N.	Correlation between water	Station I	Station II	Station III
3.	transparency and fish number	-0.98 ± 0.03	0.75 ± 0.06	0.60 ± 0.23
4.	pH and fish number	-0.10 ± 0.38	-0.99 ± 0.007	0.91 ± 0.06
5.	DO and fish number	-0.59 ± 0.25	0.22 ± 0.37	-0.41 ± 0.32
6.	CO_2 and fish number	0.58 ± 0.25	0.49 ± 0.29	-0.84 ± 0.11

4.5 Fishing implements

There were different methods implied by the fishermen like -

a) Nets (Jaal)

Various kinds of nets are used for fishing, viz., Cast net, Scoop nets and Hook. **a) Cast net -**It is a large casting type of net , made up of cotton or nylon thread and its body is bell shaped. The mesh size of the net ranges from 1.5 cm- 2.5 cm.

b) Scoop net

It consists of a rectangular wooden or steel-frame which is supported by a short handle of wood. The rectangular frame carries an oval net which is made of jute or mosquito net.

c) Fishing-Rod (Hook-Line)

Fishing rods are locally known as Balchhi hanne which consist of a lone and slender rod slightly curved at the tip. Fine cotton or nylon thread is tied at the curved tip of rod and a hook in the distal end of thread. Bait generally consists of earthworms, small fishes, insects or maize etc. Stout rod with thick string and a bait of small fishes is generally used for catching fishes like *Channa punctatus* etc.

d) Electric fishing

Electric fishing was done usually at station II at night and early morning.Non-targeted and juvenile fishes becomes victim of this method thus, contributing towards loss of fauna.

4.6 Socio economic status of fishermen

Fishermen, locally known as Majhi and Mallah generally inhabits the places near the bank of the river. They are deprived group. This community is poor and most of them are illiterate. They are most of the time dependent on fishing but during monsoon get engaged in agricultural activities. During the present study, only 20% was found fulltime, 32% as part time and 48% as occasional fishermen during pre- monsoon because that was the best time to catch fishes.

Fishermen are found living small huts made up of bamboo and Khar and some have their houses made up of brick wall and have roofs of tiles.Few houses made with stone walls Khar and Zinc plates roof was foumd.

They sell about 90 percent of the total catch composition of fishes at local markets at the rate of Rs. 100/- to 350/- per kg depending upon the species of fishes. The rest catch will be consumed by the family as there was no place for preservation. The monthly income is about Rs.1500-Rs. 3000 per month depending upon fish size and season. In festive season like marriage ceremony and others income is high but in Kartik it gets low.

5. Discussion

The physio-chemical parameter of an aquatic environment exhibit influencing factor for the quantity of aquatic life. A survey of the site (a ranging of 2.5 km) during the month of February and May 2015 in the Koshi River indicated a total account of 22 fishes species from 6 orders namely Anguilliformes(1.73%), Clupeiformes (1.73%), Cypriniformes (48.95%), Siluriformes (35.41%), Synbranchiformes (3.47%) and Perciformes(2.08%) of fish species out of 288 fish catch recorded 10 families and 17 genera. The most abundant family within catch was Cyprinidae. *Aspidoperia morar*, *Clupisoma garua* were the most abundant fishes in all the study sites during the month of May.Occurrence of Cyprinidae in Koshi River as dominant species which favours the result ofNepal (Shrestha, 2008; 2013; Rajbanshi, 2012). Shrestha et al (2009), Saund et al (2012) and Gautam et al (2016) had also found that Cyprinidae as common family in Tamor, Mahakali, and Rupa. They reported 86 Cyprinidae (Shrestha,2008) from the Koshi River. *Labeo rohita, Puntius sophore, Mystus tengra* were the most abundant fishes in all the study sites during the month of February. During the month of February, a total of 103 fish species were recorded and observed family wise where the maximum number was 9 of *Labeo rohita*and minimum number was 1 of *A. morar*. Similarly the highest frequency occurrence was for *M.tengra* (17.36%). Fishes belonged to different families like- Anguillidae (1.73%), Clupeidae (1.73%), Cypinidae (46.52%), Cobitidae (2.43%), Bagridae (17.36%) , Schilbeidae (7.98%) , Clariidae (3.13%), Heteropneustidae (6.945) , Mastacembelidae (3.47%) and Channidae (2.08%)of fish species out of 288 fish catch.Here, occurrence of Cypriniformes - *Labeo spp. Cirrhinus*comprises the dominant group. One species belonging to Heteropneustidae family in the Koshi River during this investigation but *Anguillabengalensis*, *Labeo dero*, which were not reported from Koshi River(Rijal et al. 2014) were reported in the present study. During the month of May, a total of 185 fish species were recorded and observed family wise where the maximum number was 45 of *M. tengra* and minimum number was 1 of*Labeo dero* and 10 of *H. fossilis*. According to the local Mallaha, the catch frequency of occurrence of the local fishes such as *Clupisoma garua* and *Heteropneustes fossilis* are decreasing day by day. On the basis of interviews with fishermen and personal observations catch statistics from the Koshi River was estimated as 1 kg/ha/day to 1.5kg/ha/day in all the seasons but 2 kg/ha/day to 3kg/ha/day in the month of May to July and September to November on fishing about one kilometer. The total population was estimated to be approximately 350 in around 70 households in Hanuman Nagar and Gobidha, of which 65 households are solely dependent on the fishing which is similar to Yadav (2001) the total population was estimated to be 2937 in 484 households in all ten villages, of which 445 households are solely depend on fishing in the Koshi River Basin which showed decline. The rest of the families have source of income from government job and foreign employment. All of them depend basically on the capture fishery. The socio-economic status of the fishermen communities is the lowest in the society. These families contain 2-15 members among Mallaha. In most cases, the head of the family is the eldest active male of the household with great responsibility of the family. On the basis of age distribution data shows that the economically most active group at the age of 15-25 years and they support the rest of the family members by fishing. At present most of the Mallaha

community are sending their children to the school for education and thus, it was found that the highest percentage of Primary education. Illiteracy, high population growth, low risk bearing capacity and unskilled youth in the community bind them to go on with their traditional occupation even if it is no longer beneficial. They manage their every social need by fishing and marketing the catch.

Number of fish species was recorded higher in stations I and III and lower in station II. The diversity of all aquatic organisms including fish was determined by several factors. The richness of fish species in stations I and III could be correlation with increase transparency. Physico-chemical factor of water not only affected the distribution patterns and abundances of species but they also plays an important role in species richness.

Ecological factor such as substratum, temperature transparency dissolved oxygen of running water system are interdependent on ecological niche of fishes.In the present study, the temperature was recorded to decrease in February station I and increase in May. Water temperature showed the positive correlation with fish density.This showed increase fish species composition with the rise in water temperature in a few months.

The correlation between transparency and fish density was found negative at station I and positive at II and III. The transparency was change in the water depth and human activities.

The depth of water is important physical parameter which directly or indirectly affects the fish species diversity.

Physical and chemical analysis of water has attained great importance for the ecological studies of aquatic habitats. The chemical parameters of water also show effect on Among the chemical factor, the concentration of distribution oxygen as water is the most important factors and dissolved oxygen above 5 mg/l is suitable to support diverse biota (APHA, 1976)the dissolved oxygen of Koshi river range from 6.8-9.2 mg/l. The DO showed the negative correlation with the fish density at station I and III but station II showed positive correlation..

According to Roule, (1930) the largest fish crops are usually produced in water which is just on the alkaline side of neutrality between pH 7.0 and 8.0. The limit above or below which pH has a harmful effect is given as 4.8 and 10.8 Ohle (1938). Shrestha (1990)reported that pH around 8.0 in Karnali river of Nepal. Paudel (2002) also studied the Karmaiya in Sarlahi district pH value was 8.3. During my study period pH range from 6.5-7.8. The pH. Showed the positive correlation with fish density at station III, and negative correlation at station I and II. Though carbon dioxide(CO_2) is readily soluble in water very little CO_2 is in simple solution because of the small amount of it being present in the atmospheric air. Most of the carbon dioxide in the water is formed by the decomposition of organic matter and from respiration of organism The coefficient of correlation between free carbon dioxide and fish number showed positive at stations I and II but negative at station III. 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.

The causing of decreasing of rate were becomes of heavy harvesting using all type of available nets and measures, illegal method of poising, killing the immature fry fishes before lying eggs and sweeping the fishes away to India with eggs in flooding season. The fishes cannot back to their habitat.

The demand for fish has been sizably rising in Nepal as the people becoming more conscious about health and nutrition. Fish is a healthy food low in calories and cholesterol level but rich in protein and cheap to produce.Fisheries has been an important occupation in many parts of Nepal. In spite its significance and the institutional efforts the contribution of fisheries to employment, national income and exports has been far from satisfactory. Government fisheries institutions have been able to make estimates of fish catches in some fresh waters and have studied the people involved in it.

6. CONCLUSION AND RECOMMENDATIONS

The "Fish diversity of Koshi River in Saptari" were studied for the period of two months from February and May 2015 covering the different three stations. Information was collected on species composition local names, location of catch and fishing methods used to catch different species from all stations. Along with the physio- chemical parameters and managements consideration of Koshi River was studied. The information also showed that the composition and abundance of fish in the rivers studied vary according to the season.

A total number of 22 species fish was collected from the different stations of Koshi River belonging to 6 order, 10 families and 17 genera. Fish were not uniformly distributed but influenced by the water temperature, dissolved oxygen, free CO_2, pH, etc. Present fish record included common fish species, economically important fishes like *Mystis,Chela Labeo etc* .

The study showed riverine environment undergone degradation due to various natural landslide, soil erosion and manmade activities like road construction alongside of the river bridge, construction, over fishing, illegal fishing, use of soap and detergent, stone extraction etc.

Improvements of fisheries of natural waters offer a great opportunity for self –employment and income generation among poor people living along the rivers. But no work had been done so far for the conservation of fish fauna, as a result, there is a decline in density and diversity of riverine fish species. Therefore, for successful conservation and management of indigenous fish species following recommendation are suggested.

Nepal government has to take immediate look in the local resources, to harvest and conserve the resources for effective and sustainable management and as biodiversity including fish diversity is a part of global common this work should supplement the knowledge at international level.

The recommendations were; to provide enough water, adequate natural flow in all rivers , ban on destructive fishing practices, poverty alleviation and social security , define fisher rights and responsibilities , reduce pollution and mass fish kills , alternative livelihoods , fishery co-operatives , ensure compliance of fisher towards biodiversity conservation and monitoring , use of food security act rural labor program , restoration of native riverine fish communities and adaptive management of water tenure in fishing areas.

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