CHAPTER - ONE

1.0 Introduction

Nepal is a land-locked Himalayan Kingdom with diverse topography located between two bio-geographical realms, the Palearctic realm to north and Indomalyan realm in the South. It is long, rectangular with eastern line shorter than west. It stands on latitude 26°22' to 30°27' and longitude of 80°4' to 88°12' east. The east west length of country is 880km parallel to Himalayan axis and average north-west width is 140km. Its total area is about 147181 sq km and its altitude varies from 60 m in south rising to 8848 m in the north (Sharma, 1980).

1.1 Water Resources

Nepal has vast water resources originated from the glaciers, springs, monsoon rains etc. The inland water which covers 3% of Nepal's land area in the form of natural water bodies like rivers, lakes, reservoirs and man made water bodies like village ponds, marginal swamp and irrigated paddy fields providing a great scope for expanding fisheries (DOFD, 1998).

1.1.1 Natural Water Resources

The natural water resources, in Nepal, constituted rivers, lakes and reservoirs comprising about 48.8% of total water area. The rivers are the major components of it comprising of 48.0% while lakes and reservoirs 0.6% and 0.2% respectively (Table 1).

Table 1. Estimated water surface area in Nepal

S.N.	Water resources	Estimated area	Coverage (%)	Potential for expansion
1.0	Natural Waters	401500	48.8	
	1.1 Rivers	395000	48.0	
	1.2 Lakes	5000	0.6	
	1.3 Reservoirs	1500	0.2	78000
2.0	Village ponds	5964	0.72	14000
3.0	Marginal Swamps/Ghols etc.	11500	1.4	
4.0	Irrigated paddy fields	39800	48.72	
	Total	816954	100.0	92000

Sources: Directorate of Fisheries Development (2001/2002).

a) Rivers

A network of rivers and streams numbering more than 6000 covering total area of 395000 ha flow from north to south in Nepal. There are 3 major river systems each with seven tributaries and are subsequently called (i) Sapta Koshi (ii) Sapta Gandaki and (iii) Sapta Karnali. Besides above major rivers, Mahakali, Bagmati, Kamala, Rapti and Babai are other important rivers of Nepal and drain into the Ganges system India.

(b) Lakes

Several lakes of small to medium size are scattered all over the country covering an area of 5000 (0.60%). These lakes have different origins and can be classified into (i) Glacial (ii) Oxbow and (iii) Tectonic Lakes. Among them, oxbow lakes are mainly confined to southern part of the country. Oxbow lakes are formed by the shift of river course and more than two dozen of the ox-bow lakes are present in Nepal and most of them are located in Chitwan, Nawalparasi, Bardia and Kailali. (Sharma, 1977)

(c) Reservoirs

There are few natural reservoirs in Nepal but most of the reservoirs are man made formed for hydroelectric generation and irrigation. Among the existing manmade reservoirs, Indrasarober reservoir was created for producing hydroelectric power by damming Kulekhani River in the mid-hill region of Nepal. Other existing reservoirs are: Jagdishpur (Barganga, 155 ha), Trisuli (16 ha) Marsyangdi (62 ha), Panauti, Gandak and Sunkoshi. Growth in hydroelectric and irrigation will add 78000 ha of reservoirs area from Gandaki basin (45000ha), Bagmati basin (9000 ha) and Karnali basin (24000ha) (DOFD, 2001/02).

1.2 Fish and Fisheries of Nepal

1.2.1 Status of fish in Nepal

The fishes of Nepal have wide distribution due to the variation in climate and altitude. According to Shrestha (1998), there are 186 indigenous fish species belonging to 79 genera 31 families and 11 orders distributed in different river systems and other forms of water bodies of Nepal.

Table 2. Status of fishes in Nepal

Status Account	IUCN Categories	No. of Species
Common/Occasional		90
Insufficiently known	IK	61+1
Vulnerable	V	9
Endangered	E	1
Rare	R	24
Total		186

Source: Shrestha, 1998

Sixty two fish species (33%) have the status of insufficiently known, 34 (18%) threatened species (vulnerable, endangered and rare species) and 90 species (49%) are common/occasional.

1.2.2 Fish Production form Natural Water

Total natural fish production is 20,100 ton (DOFD, 2006-07). Productivity of fish from rivers and irrigated paddy fields are very low. Lakes, reservoirs and marginal swamps are fairly productive (Table 3). Marginal swamps are highly productive and there is much scope to extract more fish production in future from pen culture/enclosures. Lakes and reservoirs have been highly utilized for cage fish culture.

Table 3. Average coverage and natural production of fishes in Nepal.

S.N.	Particular	Area (ha)	Production (mt.)	Fish Production/ha/kg
1.0	Capture fisheries	811000	20,100	-
1.1	Rivers	395000	7031	17.7
1.2	Lakes	5000	805	160.0
1.3	Reservoirs	1500	364	242.0
1.4	Irrigated paddy fields	398000	6913	17.3
1.5	Marginal swamps/Gholes etc.	11500	4987	448.3

Source: Directorate of Fisheries Development (2006/2007)

1.3 Justification of Study

The Mahakali River is one of the important rivers of Nepal lying in border of Nepal-India in western region. It is originated from the Milan glaciers of India and Lipulekha of Nepal. As it flows south, it is jointed by many tributaries. The biggest tributaties are Chimla and Chavan Digad Rivers. It flows southwest creating numerous oxbow lakes in India. Mahakali River is important from the standpoint of fish biodiversity also; as this is inhabited by large number of different fish species along with reptile like gharials. Due to the variety of reasons such as fish poaching, illegal fishing techniques, heavy flooding and erosion, natural habitat of the Mahakali River is deteriorating and fish population have also declined. Development works like irrigation project, leeves and channelization have created adverse impact on fish fauna of Mahakali River.

CHAPTER - TWO

2.0 Aim and objectives

The main aims and objectives of the present study are following:

- Study of physicochemical and biological parameters of Mahakali River.

- Study of fish diversity, its distribution pattern, frequency occurrence, fish catch and fishing implements used by local fishermen in Mahakali River.

- Study of socio-economic status of the fishermen in the study area.

CHAPTER - THREE

3.0 Literature Review

There are very few literatures regarding the fish fauna of Nepal. The first authentic information about fishes of Nepal was provided by Hamilton (1822) in his work "An account of the fish found in the river Ganges and its branches". It was mainly oriented to the terai region. Gunther (1861) reported some cold-blooded vertebrates including fishes collected by Hodgson in Nepal. Other Ichthyologist such as Beaven (1876), Regan (1907), Boulenger (1907) had also reported some of the fishes of Nepal. Day (1878 and 89) mentioned the distribution of some fresh water fishes of Nepal in his historical work. "Fishes of India, Burma and Ceylon."

Menon (1949) collected fishes from River Koshi and reported 26 genera and 52 species belonging to 11 families and gave an informative description of the zoogeography of the fishes of Nepal in 1949. Taft (1955) made a fishery survey of Nepal and catalogued 94 species of fishes from Kathmandu, Trisuli, Simra, Birgunj and Biratnagar etc. He also studied the Midgalsaki collection which was identified by Hora of the zoological survey by India, Calcutta three years later (1958A.D.). During the Indian Choyal expedition, a new species of fish *Psilorhynchus psendochenis* was described by Menon and Dutta (1961). De Witt (1960) catalogued 102 species without any description of their biology and ecology.

Thapa and Rabjbanshi (1968) studied the ecology of hill stream fishes of Nepal. Majpuria and Shrestha (1968), Shrestha (1981, 1992), Rajbanshi (1982) worked on bibliography of fish and fishes of Nepal and had listed 330 reference. The

study on biological and limnological aspects of lake and natural waters in Pokhara valley was done by Ferro and Swar (1978) with reference to existing fish population their feeding habits and biology.

Bhatta and Shrestha (1973) gave and account of 57 fishes in his book "The Natural History and Economic Botany of Nepal". Hatter and Pillay (1971) gave an account of fishes of Nepal in their report "Rain of fishes in Shilong", Meghalaya. Shrestha and Pradhan (1979) described the aquatic ecology and fishery potential of Bagmati River. Ferrow (1980-81) gave a list of 120 species of fishes in his book "Wild life of Nepal.

Shrestha (1990) reported 74 species of fishes from Karnali River, 108 species from Koshi, 34 from Trisuli, 102 species from Narayani and 69 species from Mahakali River in his pioneer work "Resource Ecology of Himalayan Water". Shrestha (1991) studied the spawning ecology and biology of migratory fishes in upper Arun. Yadav (1994) worked on the water quality and benthic fauna of the feeding river, Palung, Thudo and Chitlang of the Kulekhani reservoirs. Luitel (1994) gave a guideline of water quality monitoring work for Kathmandu Valley Rivers.

Wernick *et. al*. (2004) assessed the effect of water and sediment quality upon benthic composition. The water bodies in vicinity of mine water reported to be enriched with metals and metalloid (arsenic, gold, iron, zinc etc.). Mokaya et.al (2004) recorded the influence of anthropogenic activities on water quality of 3 major rivers in Kenya.

Mancini et. al (2005) stated that water quality in running water streams in urban areas was strongly altered by the impact of human activities. The study

emphasized multidisciplinary approach necessary to address pollution pressure on water of urban water bodies. The presence of buffer zones in urban green areas did not minimize the impact as the surrounding urban areas contribute pollutants.

Karycinska et. al. (2006) studied biotic factors of the Liwiee River by using physiochemical parameters and micro-invertebrate/macro-invertebrate analysis. The water quality was classified on the basis of physical and chemical parameters and biodiversity index in Liwiee River. Charkhabi et.al. (2006) assessed spatial variation of water quality parameters in the most polluted wetland of northern Iran.

CHAPTER – FOUR

4.0 Methodology

4.1 Study period

The field study was carried out far 10 months from September 2007 to 2008 July. Each sampling station was visited once in the month of October, January April and July for sample collection representing four different seasons.

4.2 Mahakali Irrigation Project

The Mahakali Irrigation Canal is a contour canal running from west to east. It starts from the Sarada Barrage at Indian Territory. Mahakali Irrigation Project (MIP) is supplied with water from Sarada Barrage in the Mahakali in accordance with water sharing agreement made in 1920 between Government of Nepal and the Government of India. Project implementation commenced in 1971 with the design and construction of the main canal by Department of Irrigation (DOI), Nepal with a capacity of 13m^3/s and the distribution system of irrigation facility to an area of 5000 ha. The work was completed in 1988.

4.3 Study Sites and Sampling Stations

Station I: First sampling station was established near the bridge at India and Nepal border in Mahakali River.

Station II: It was near Badaipur village where leeves installed at its both side to protect from flooding. As flooding is common in this region during rainy season.

Station III: It laid Near Dodhara village where destruction of fish was noted high due to illegal fishing and flooding in rainy season.

Station V: It laid at the eastern side of Mahakali river. It lies 5 km east and human encroachment had decreased fish population here.

4.4 Source of Data Collection

The primary or basic data was collected by direct field observation, photography and questionnaires for the information like changing pattern of the river, fish diversity and distribution in Mahakali River.

4.5 Water Quality Parameters

4.5.1 Physical Parameters

4.5.1.1 Temperature

The air and water temperature was recorded by using a standard mercury thermometer dipping directly in the water far two minutes to record the water temperature while the air temperature was recorded by holding the thermometer in the air avoiding the direct sunlight. The result was expressed in degree celsius.

4.5.1.2. Depth

For measuring depth, a long stick was used. This long stick was dipped in water at 5 different places in each station and water level was marked, which was later measured using measuring tape and average depth was calculated in each sampling station.

4.5.1.3. Transparency

A secchi-disc method was applied to measure the transparency of Mahakali River. Transparency is the depth of the point where white secchi disc of 20cm diameters disappears from view at lowering and reappears at raising. The value was calculated by applying the following formula.

Transparency (D) = $\frac{(A + B)}{2}$, Where, A : Depth at which secchi disc disappear

B : Depth at which secchi dis disappears

4.5.1.4 Water Velocity

The velocity of water was measured using float and stopwatch. The velocity was calculated five times at different places in each station and average velocity was calculated.

4.5.2 Chemical parameters

4.5.2.1 Hydrogen ion concentration (pH)

An electric pen-pH meter was used for it.

4.5.2.2 Total Alkalinity

Total alkalinity was measured by titrating the water sample (50 ml) with a strong acid Hcl (0.1 N) first to pH 8.3 using phenolphthalein as an indicator. The alkalinity was expressed in mg/l and calculated by using following formula:

$$\text{Total alkalinity as } CaCO_3 \text{ (mg/l)} = \frac{\text{m. Y Normality of HCL} \times 50 \times 100}{\text{ml. of sample used}}$$

4.5.2.3 Total Hardness

Total hardness was measured by titrating the water sample with titrating reagent after mixing the buffer solution and the result was obtained in mg/l as carbonate, which was equal to the number of drops of titrating reagent needed to bring color change from pink to blue.

Total hardness was calculated by using the following formula:

$$\text{Total Hardness (mg/l)} = \frac{\text{ml. of EDTA Used} \times 1000}{\text{ml. of sampled used}}$$

4.5.2.4 Dissolved Oxygen

The water samples were collected from each sampling site in stopper BOD glass bottle by allowing the water to overflow the bottle to avoid air bubbles. Dissolved oxygen was measured by Wrinkler's Iodometric method following precaution given by Boyd (1979). Then D.O concentration was calculated by using following formula:

$$\text{D.O (mg/l)} = \frac{(\text{ml} \times \text{n}) \text{ of titrant} \times 8 \times 100}{V_2(V_1 - V)/V_1}$$

Where, V = Vol. of $MnSO_4$ and KI added

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

V_2 = Vol. of the contents titrated

4.5.2.5 Free Carbon-dioxide (CO_2)

Free carbon-dioxide (CO_2) can be measured by titration using phenolphthalein as indicator and calculation was done by using the following formula.

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

4.5.3 Biological parameters

4.5.3.1 Planktons

Planktons were studied of two types: Phytoplankton and Zooplanktons

For the plankton collection, the plankton net (Wisconsin's plankton net of mesh size 75 μ and 20 cm diameter) was used and the samples was preserved first in 5% formalin. The planktons were qualitatively analyzed under compound microscope, 10 × 15 magnification in the laboratory of Central Department of Zoology. The identification of planktons was done using Edmondson keys (1965).

4.5.3.2 Macro-invertebrates

The macro-invertebrates were collected by using Peterson Grab Sampler and the macro-invertebrates were preserved in 10% formalin in polythene bags. The macro-invertebrates were identified in the laboratory of Central Department of Zoology. The identification of macro-invertebrates was done using Edmondson guidelines (1965).

4.5.3.3 Fish Sampling and identification

The fishes were collected from each sampling sites separately in different seasons, which might represent the average fish abundance and distribution in Mahakali River. Fishes were collected by using cast net in each station and preserved in 10% formalin. The collected fishes were brought to laboratory of

Central Department of Zoology for identification and further investigation. The collected fish samples were identified after Shrestha (1981) and Jayaram (1999).

4.5.3.4 Fish Catch Composition and Catch per Unit Effort (CPUE)

Fish sampling was done four times in a year in the month of July, October, January and April to cover four seasons. Data collection was also made with the help of local fishermen from different habitats (pool, runs, riffles and shallow). Catch per unit effort was determined.

CHAPTER - FIVE

5.0 Observation and Results

5.1 Water Quality

Physical and chemical parameters were studied and recorded (Table 4).

5.1.1 Physical parameters

5.1.1.1 Water temperature

Water temperature was recorded between 8 to 21°C with an average water temperature of 13.79°C.

5.1.1.2 Water Velocity

The maximum velocity was recorded 2.6 m/s in April in Site IV and lowest 0.25 m/s in January at Site III. The average velocity of Mahakali River was 1.48 m/s.

5.1.1.3 Water Depth

Lowest depth was recorded to be 0.55 m in January at Site II and the highest was 4.0 m in July at Site III and IV.

5.1.1.4 Transparency

The water was noted transparent and clear throughout study period except in heavy flooding during July. The average transparency of water was about 1.23 m.

5.1.2 Chemical parameters

5.1.2.1 Dissolved Oxygen (DO)

The range of dissolved oxygen concentration in Mahakali River was 9.5 mg/l to 12.78 mg/l. The concentration of DO was recorded highest in July at all sites and found gradually decreasing thereafter with lowest DO in January and the concentration of DO gradually rising from April. The average concentration of DO was 11.3 mg/l.

5.1.2.2 Free Carbon Dioxide

Free CO_2 was found nil during October and January but during April and July, the concentration of free CO_2 ranged from 5.1 to 7.0 mg/l.

5.1.2.3 pH

pH showed the water of Mahakali alkaline all throughout study period. pH was found ranging from 7.00 to 9.5. The average pH value recorded was 8.48.

5.1.2.4 Total Alkalinity

The minimum total alkalinity recorded was 15 mg/l minimum and the highest was 100 mg/l and average total alkalinity was 33.51 mg/l. Total alkalinity was more or less similar from January to July but the concentration was recorded highest at October.

5.1.2.5 Total Hardness

Hardness ranged from 35 to 80 mg/l with an average hardness of 51.69 mg/l. The highest total hardness was found at January and the hardness was more or less similar in other seasons (Table 4).

Table 4. Water quality parameters of Mahakali River from September – July, 2007/08.

S.N	Parameters	October				January				April				July				
		Site I	Site II	Site III	Site IV	Site I	Site II	Site III	Site IV	Site I	Site II	Site III	Site IV	Site I	Site II	Site III	Site IV	Average
1.	Temperature (0^0C)	16	17	19	20	8	9	7	8.5	8	10	12	14	16	18	21	17	13.78
2.	Water Velocity (m/s)	1.5	0.75	0.84	1.0	1.0	0.5	0.25	0.75	2.5	1.8	1.5	2.65	1.5	1.5	1.7	2.0	1.43
3.	Water Depth (m)	1.5	0.85	2.5	3.0	0.75	0.55	2.0	1.9	0.75	1.5	1.25	1.5	1.5	2.7	4.0	4.0	1.9
4.	Transparency (m)	1.5	1.2	0.45	0.8	1.0	0.75	2.0	2.05	0.85	0.5	1.8	1.5	0.6	1.2	1.05	1.2	1.17
5	Dissolved Oxygen (mg/l)	11.0	10.5	11.5	12.6	10.0	9.5	11.1	10.5	11.0	12.7	10.0	9.9	12.0	12.8	12.6	12.6	11.3
6	Free $C0_2$ (mg/l)	nil	-	-	-	-	-	-	-	5.7	5.9	6.0	6.7	5.1	7.0	-	-	
7	pH	8.05	9.0	8.0	9.5	9.5	8.25	9.0	8.75	9.0	7.5	7.25	8.25	7.0	7.25	8.0	7.75	8.48
8.	Total Alkalinity (mg/l)	60.0	80.0	80.0	100.0	16.0	16.0	20.5	20.0	21.0	21.5	20.0	16.0	16.0	15.0	20.0	15.0	33.51
9.	Total Hardness (mg/l)	42.0	43.0	55.0	58.0	76.0	71.0	76.0	80.0	45.0	44.0	41.0	35.0	60.0	42.5	38.5	40.0	51.69

Water Quality at Different Sites in Different Months of Mahakali River (October-July, 2007/2008)

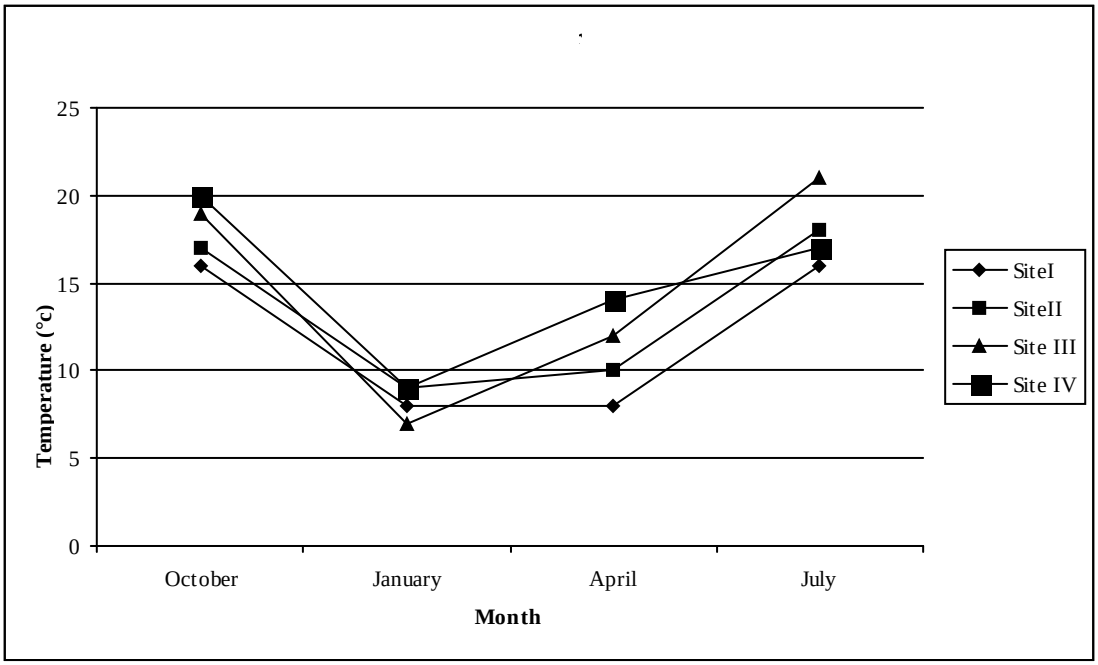

Fig 1. Variation in Surface water temperature at four sampling stations.

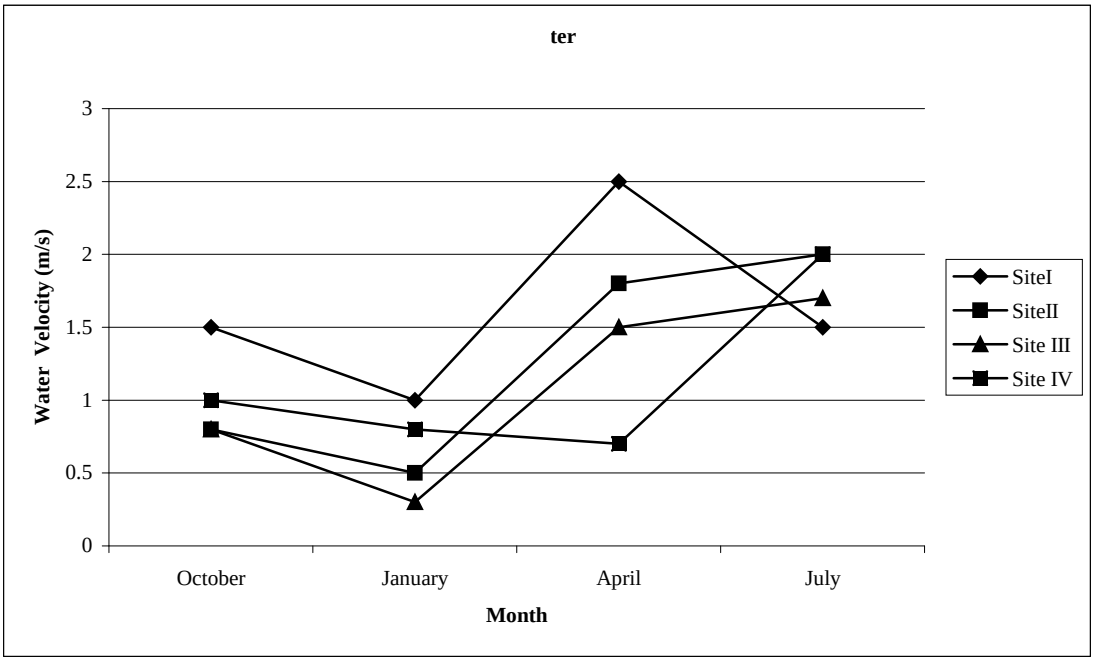

Fig 2.Variation in water velocity (m/s) at four sampling stations.

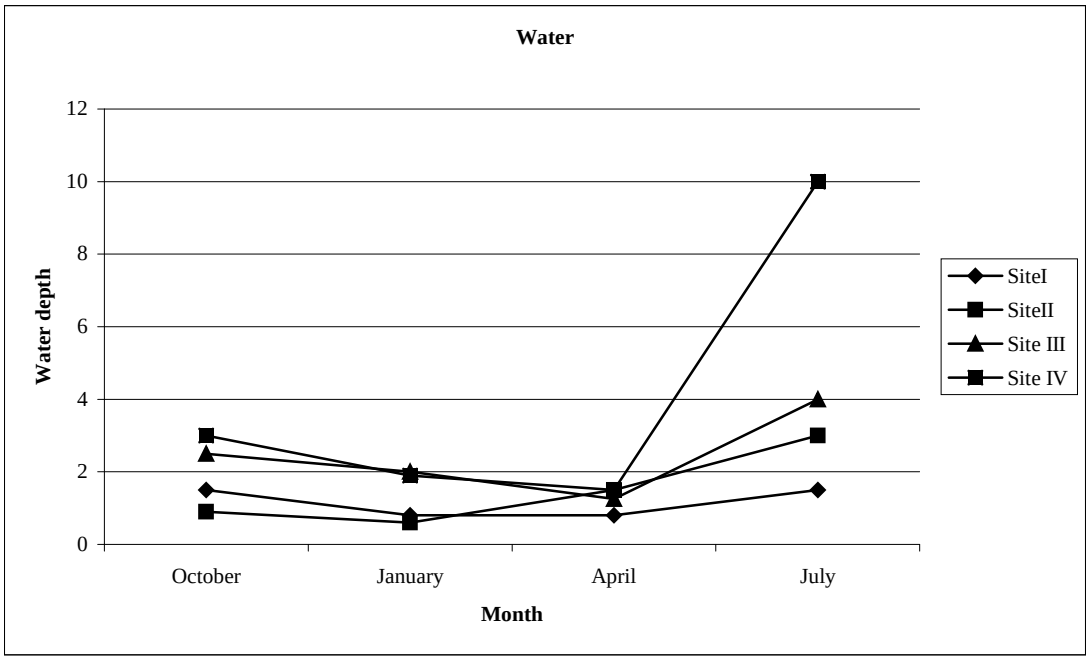

Fig 3. Variation in water depth (m) at four sampling stations.

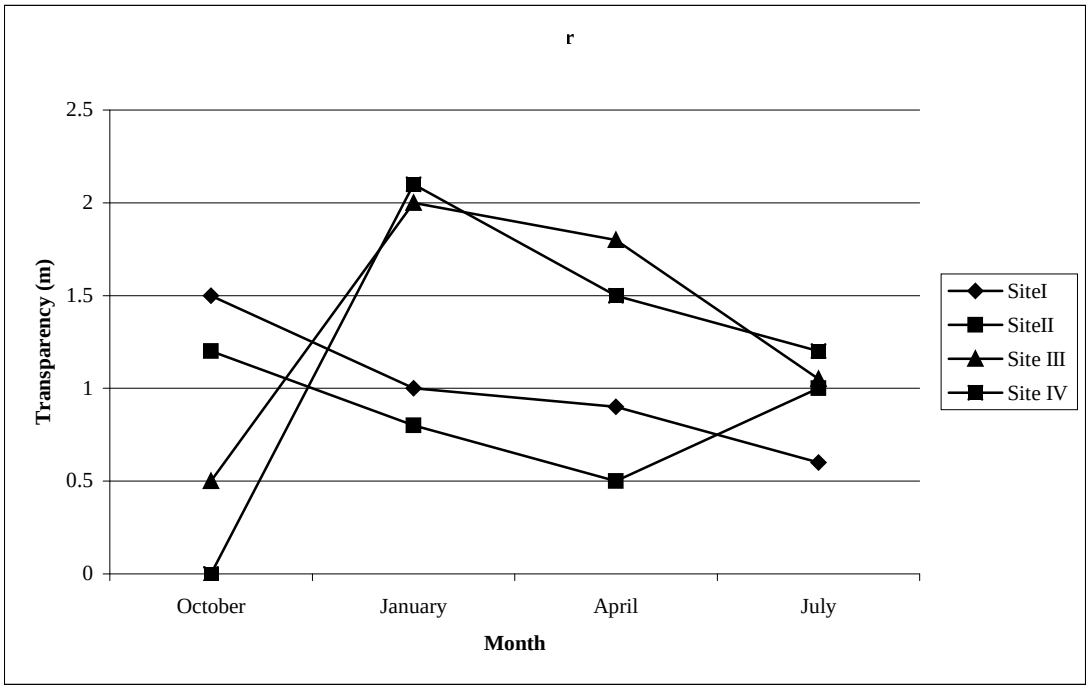

Fig. 4. Variation in water transparency (m) at four sampling stations.

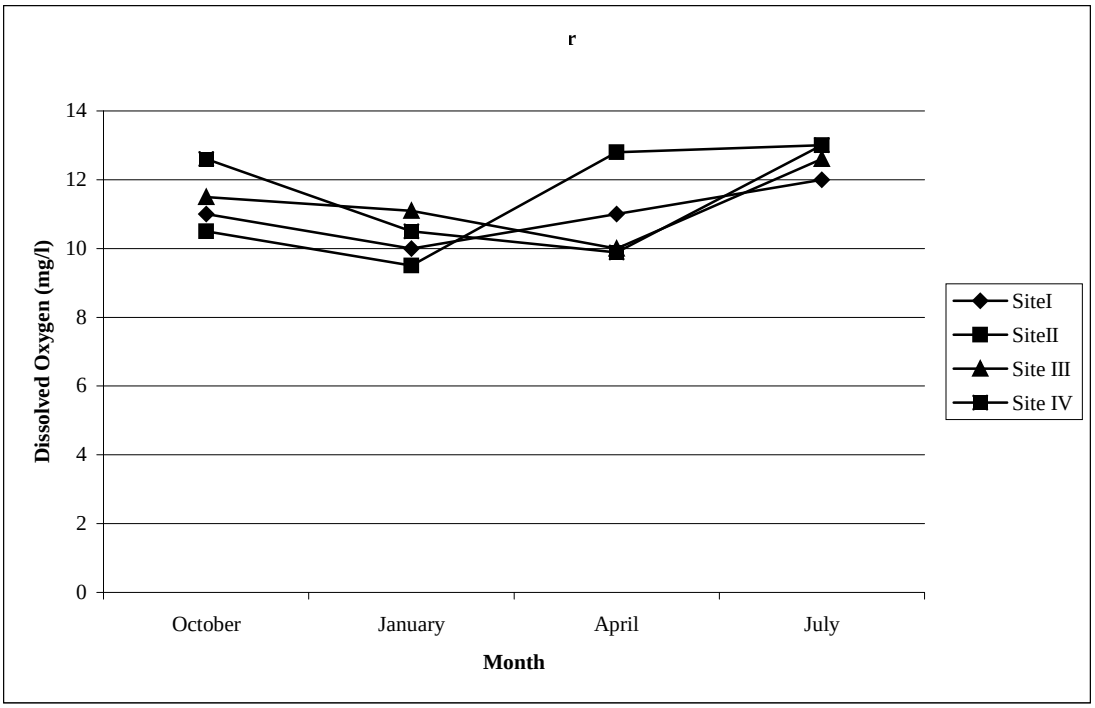

Fig. 05: Variation in water Dissolved Oxygen (mg/l) at four sites.

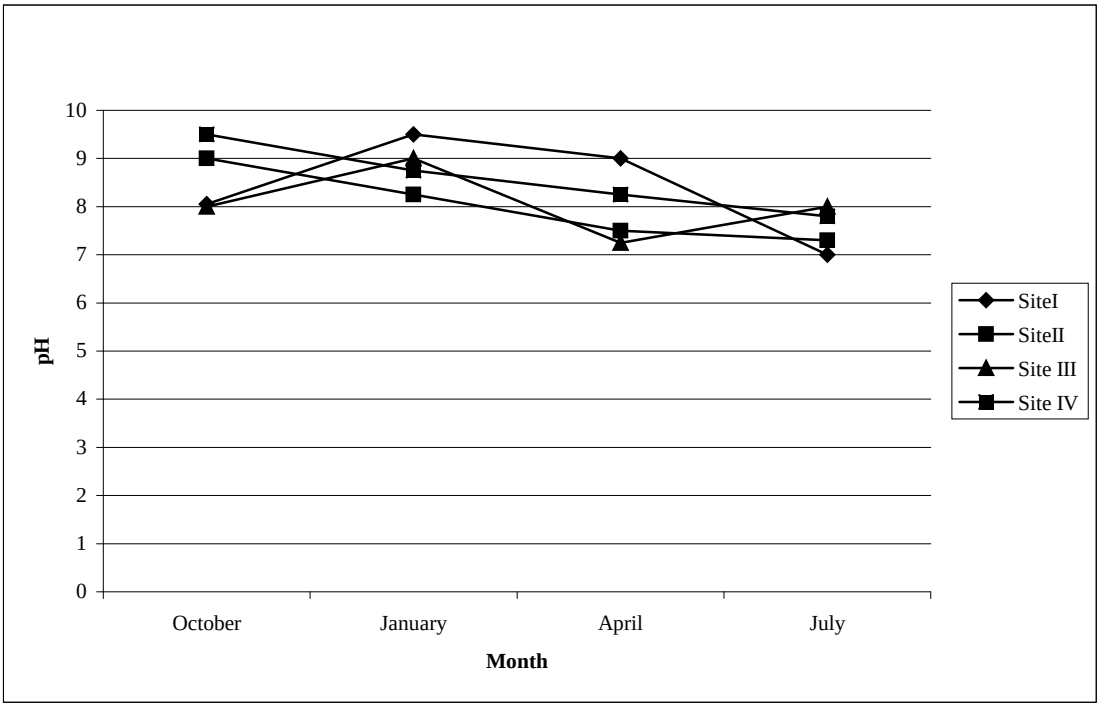

Fig. 6. Variation in pH at four sampling stations.

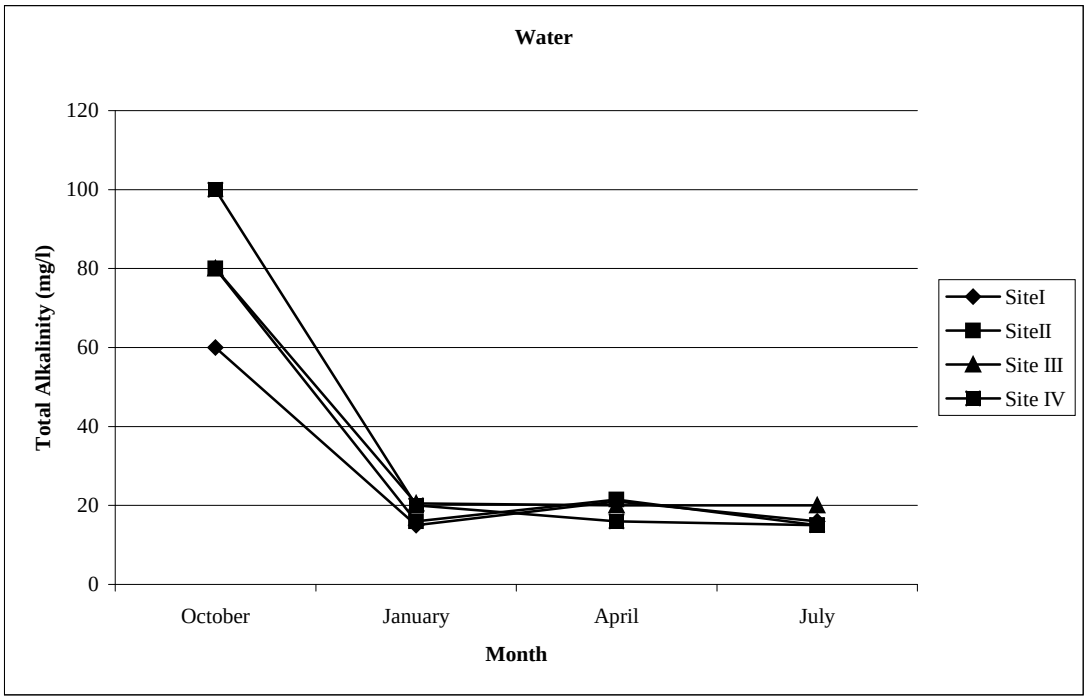

Fig. 7.Variation in Total Alkalinity (mg/l) at four sampling stations.

5.2 Biological parameters

5.2.1 Planktons

Planktons like phytoplankton and zooplanktons were studied as follows:

5.2.1.1 Phytoplankton

During present investigation, a total of 13 genera of phytoplankton under four families were recorded. *Cladophora* and *Navicula* were recorded all the stations and found dominant all throughout the seasons.

5.2.1.2 Zooplankton

During present investigation, few zooplanktons were recorded belonging to Trichoptera, Cladocera, Copepoda and Rotifera. Quantitative study and identification of zooplankton could not be done.

Table 5. Distribution of planktons at different stations in Mahakali River.

S.N.	Family	Planktons	Sampling Stations				
			A	B	C	D	E
I	**Phytoplankton**						
	Cyanophyceae	*Nostoc sps.*	-	-	+	+	-
		Oscillataria sps	+	-	+	-	-
		Anabaena sps.	-	+	-	-	-
		Rivularia	+	-	-	-	+
	Chlorophyceae	*Spirogyra sps.*	-	-	+	-	-
		Cladophora sps.	+	+	+	+	+
		Chara sps.	-	+	+	-	-
	Bacilliariophyceae	*Navicula sps.*	+	+	+	+	+
		Synedra sps.	-	-	+	-	-
		Cymbella sps.	-	+	-	-	+
		Fragillaria sps.	+	+	-	-	+
	Desmidiaceae	*Closteridium sps.*	-	-	+	+	-
		Cosmarium sps.	+	+	-	-	+
II	**Zooplanktons**						
	Cladocera		+	-	+	+	-
	Trichoptera		-	+	+	-	-
	Copepoda		+	+	-	-	+
	Rotifera		+	-	-	+	-

5.2.2 Macro invertebrates

During present investigation, macroinvertebrates were collected belonging to three different phyla - Arthropoda, Annelida and Mollusca. Among them, Arthropoda was found to be dominant comprising three classes and 10 orders while only one genus from Annelida and Mollusca recorded like *Pheretima* and *Limax* respectively. There was recorded a total of 113 invertebrates; out of which 17 were larvae of *Culex* sp. and recorded as most common in Mahakali River followed by velvet ant comprising 16 in number. Similarly, larvae of damselfly and dragonfly were 12 each and that of *Dystiscus* sp 11. Similarly, there was 9 recorded each of *Belostoma* sp and stonefly followed by 8 number of crabs. The larva of *Melanopus* sp was recorded only 3 as least common species of Mahakali River. The number of *Limax* was 10 and that of annelid 6 only.

Table 6. Distribution of macro-invertebrates at different stations.

Phyla	Macroinvertebrates	Numbers recorded
Arthropoda	Culex	17
	Velvet ant	16
	Dragonfly	12
	Damselfly	12
	Dystiscus	11
	Belostoma	9
	Stonefly	9
	Crab	8
	Melanopus	3
Mollusca	*Limax*	10
Annelida	Annelid	6

5.2.3 Fish diversity

A total of 21 species belonging to 15 genera and 7 families were recorded during the study period. The different fish species, local name and classification are given below:

Table 7. Different fishes of Mahakali River.

S.N.	Scientific Name	Local Name	Order	Family
1	Tor pitutara	Mahsheer	Cypriniformes	Cyprinidae
2	Crossocheilus latius	Kharat	Cypriniformes	Cyprinidae
3	Schizothorax plagiostomus	Asla	Cypriniformes	Cyprinidae
4	Labeo dero	Chippan	Cypriniformes	Cyprinidae
5	Rasbora elonga		Cypriniformes	Cyprinidae
6	Rasbora daniconius	-	Cypriniformes	Cyprinidae
7	Garra gotyala	Buduna	Cypriniformes	Cyprinidae
8	Garra annandalei	Buduna	Cypriniformes	Cyprinidae
9	Glyptothorax pectinopterus	Chal	Cypriniformes	Sisoridae
10	Oxygaster bacaila	Bhur	Cypriniformes	Cyprinidae
11	Botia lohachata	Bhur	Cypriniformes	Cobitidae
12	Puntius sarana	Chitre	Cypriniformes	Cyprinidae
13	Puntius sophore	Chitre	Cypriniformes	Cyprinidae
14	Nemachelus botia	Gadela	Cypriniformes	Cobitidae
15	Nemacheilus beavani	Gadela	Cypriniformes	Cobitidae
16	Clupisoma garua	Jalkapoor	Cypriniformes	Schilbeidae
17	Psedeutropius murius matrepsis	Jalkapoor	Cypriniformes	Schilbeidae
18	Channa gachua	Bhote	Channiformes	Channidae
19	Channa punctatus	Bhote	Channiformes	Channidae
20	Channa maurilius	Saul	Channiformes	Channidae
21	Mastacembelus armatus	Gaichi	Mastacembeliformes	Mastacembelidae

Ecological behavior of some important fish species

Tor putitora (Hamilton-Buchanon) 1822

Tor putitora is an important food and game fish, which is locally known as 'Mahseer". 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. Mahseer generally inhabits the deep pools of many 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 Spirogyra, Oscillatoria, larva of insects or adults of mayfly, stone fly etc.

Labeo **(Cuvier)**

Labeo dero was captured from Mahakali River. Most of them were distributed in all stations. These fishes are regarded as very tasty food fish. The average size of the captured fish ranged form 10-23 cm. These fishes breed during the month of June-July at gravel bottom breeding ground. *Labeo dero* locally known as Gardi which breeds in the month of June-July and the breeding ground comprises of gravel beds. It is herbivorous and detrivores feeding on algae, vegetable, matter, detritus and mud.

Schizothorax plagistomus

It is locally known as "Asla". Body elongated and slender attains a size of 309mm. Its weight was recorded up o 1kg. Body colour was grayish black on dorsal with belly sides silvery. A few black dots often scattered on whole body and fins. Fins except dorsal had reddish tinge.

Garra Gotyala

It is a small hill stream fish with cylindrical body commonly known as Buduna. General body colour black with greenish tinge. A black dot is behind gill opening and a dark band on caudal fin.

Fish composition and frequency distribution study in fish catches revealed cyprinids as major fishes and *Chrossocheilus latius* and *Oxygaster bacailla* as most dominant species. The sampling record showed fish diversity was high close to bridge near Nepal and India border but low in other stations.

5.3 Socio-economic condition of fishermen

5.3.1 Types of fishermen

There were different types of fishermen recorded in the study area. During study period only few fishermen were found as full time. Fishing in done throughout year but best time is from October to July. But, during months of August and September, it was very difficult for fishing due to the high volume of water and use of cast nets and gill nets became very difficult.

Full Time Fishermen

The full time fishermen are mostly involved in this large Mahakali River. Government gave permission for fishing on contract to Nepali citizen. At the side of river, there were many people living small hut and they take their large gill net during night in river and large numbers of fishes were collected by the morning. Indian Bengali fishermen came here for fishing purpose. The interview with these revealed that they did not fish small sized, if by chance, small fishes caught, they threw them back into river.

Part-time fishermen

Part time fisherman belonged to Tharu, Pahadi, Magars, Kami, Damai, Sarki etc. For fishing, they use all type of implements. The fishing activities of part time fishermen were higher during spring and summer due to low water level. Some people used poisons and dynamite also. Fishing intensity became low during the harvesting of crops in November and December.

Occasional Fishermaen

The occasional fisherman's in Mahakali river used to start fishing for their livelihood soon after food grains was harvested. Most of the families of the villagers were occasional fishermen in summer and spring. They generally used mesquite net for fishing. The catch was reported to be consumed for their own family. Tharu, Magar, Gurung, Chhetri peoples are involved in fishing.

Table 8. Different types of fishermen communities in Mahakali River.

S.N	Fishermen	October				January				April				July			
		I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV
1	**Tharu**	+	+	+	-	+	-	-	+	-	+	-	-	+	+	-	-
2	**Magar**	-	-	+	+	-	-	+	-	-	-	-	+	-	-	-	-
3	**Gurung**	-	-	+	+	-	-	+	-	-	-	+	-	-	-	-	-
4	**Chhetri**	-	+	+	+	-	-	-	-	-	-	+	-	-	-	+	-
5	**Bengali Contractor**	-	+	+	+	-	+	+	+	-	+	+	+	-	+	+	+
6	**Pahadi**	-	+	+	+	-	-	-	-	-	-	+	+	-	-	-	-
7	**Indian**	+	-	-	-	+	-	-	-	-	+	-	-	+	-	-	-
8	**Kami**	-	+	+	+	-	+	+	-	-	-	+	+	-	-	-	+
9	**Damai**	-	+	+	+	-	+	-	-	+	-	+	+	-	-	-	-
10	**Sarki**	-	+	+	+	-	-	-	+	-	-	-	+	+	-	-	-

5.3.2 Socio economic condition of Fishermen

Mahakali River has good fish resources and there is great scope for fish production and conservation. In Mahakali River population of fishermen were different types belonging to Magar, Gurung, Tharu, Chaudhary, Sunuwar, Luhar etc. by cast. Fishermen lived at bank of river in villages like Badaipur, Dodhara Chadani etc. Fishermen were found to make different types of fishing implements/gears or nets made usually of nylon strings. Fishing is done at night and in the early morning and rarely at day time.

Literary: Only few fishermen members can read and write and literacy rate was found about 5%. The children are school going, however, they were not showing any keen interest in education and no one was found to complete above class 8.

Family Structure: Generally it was found that all households were nucleus type. The general practice is the separation of married son from the family. But, new resident is made very close to parents.

Housing Condition: Most houses of fishermen were huts with thatched roof. The house does not have the facility of electricity except few. Most depend upon kerosene for light.

Land Holding: Most of the fishermen were found landless and made their houses at the bank of river/stream. About 15% of total fishermen were landless

and those had land possessed an average land holding of 2.0 Katha (i.e. 0.07 ha.).

Occupations: Fishing and boating was noted their main profession. According to the fishermen, fishing is not enough to maintain their livelihood nowadays and most fishermen had shifted to new occupation as field workers of landlord or labor etc.

Family size: They were poor with 4-5 children so their head of family have difficult to fulfill their basic need likewise they were socially, backward, illiterate. They did not educate their children and unaware of the importance of family planning.

5.3.4 Fish Market

The condition of local fish market is not good here. Few fishermen carried fishes home to home in villages for sale in bicycles kept in baskets and sacks. Some took fishes to market 4-5 km away from river. They carried fishes in a basket to market by Tempo, Rickshaw and Tanga.

5.3.5 Fishing practices and fishing implements

The following different conventional and non-conventional fishing methods/techniques had been observed during study period in the Mahakali River.

5.3.5.1 Conventional fishing implements

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. Its one side has floating device and other side has fixed sinking devices like iron nails, or pieces of iron wire. The net remains float vertically to trap fishes like small *Tor* spp, *Labeo spp*. It is not being used in rainy season.

Castnet

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. During rainy season, fishermen uses cast net from boat.

Hook and line (Balchi Hanne)

Balchi is refer to the hook and is prepared generally by the fishermen from the rim of umbrella. Readyman hooks from the market are using the line or thread is attached to the thread. Different types of baits (living or nonliving) are fixed to the hooks eg. earth worth, insects, and wet wheat floor are the common bait in this area.

Use of hammer/hammering

The fishes hiding under the stones on the river banks of the river are hammered force fully creating a great sound and vibration then the fish loose their balance and become paralyzed. Children along the riverbank throughout river bank use this method.

Fishing with bare hand

Ancient fishing practice without gears. Fishermen dip his hand quiet slowly into water and searches fish in the crevices.

5.3.5.2 Non-conventional fishing methods

Electrofishing

Electricity is applied to catch fishes from small shallow river and streams of the Mahakali river. Electric current is applied not only kill the targeted aquatic fauna as well as whole organism.

Poisoning

Number fish poisons are reported to be used in fish kill. 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 also found used for fish killing in shallow and stagnant water. All these products are applied in water to paralyze fishes for easier large catch. Generally a group of people are involved in poisoning and electro-fishing. Explosives used in road construction projects are also misused in killing fishes. The present insurgency political situation had, however, controlled the use of explosives to great extent. Electro-fishing still carried during night. All these illegal means of fishing are responsible for indiscriminate kill of fry and fingerlings along with brood fishes.

Use of Explosive

It is commonly known as "Gola hanne" explosive is wrapped in thick cloth or plastic and tied in the stone and throw river instantly after igniting. The fishes killed and floats which are collected by hands or net.

6.0 DISCUSSION

Mahakali River is one of the largest rivers lying in the western border of Nepal. There is a considerable differences noted in water currents, depth, volume and substrate and the change in different physical and chemical parameters have given diverse habitats/ecology in a running water system to be inhabited by a wide variety of fishes (Whitton, 1975).

The physicochemical parameters in an aquatic environment exhibits as influencing linmological factors affecting the quantity and diversity of total biota and their life process directly/indirectly. The existing climatic condition and chemical parameters regulate the physical properties of aquatic ecosystem.

6.1 Physical parameters

The transparency, directly or indirectly determined the productivity of the river by controlling the penetration of solar radiation. During present investigation, water was transparent throughout the year except rainy season in during flooding.

Temperature has an important role on other physicochemical parameters and physiological activities of aquatic living organisms. A rise in water temperature leads to the decrease in solubility of oxygen and amplifying the taste and odors. The water temperature of Mahakali River was found ranging from 4 to 21°C.

Depth of Mahakali river water ranged from 0.55-4.0m. The depth was recorded generally high in stations III and IV and lowest in station II. Similarly, the depth was found highest in July during rainy season followed by October. The depth of water directly or indirectly affects the fish species diversity. During present

investigation small fishes like *Garra* and *Nemacheilus* sps were found distributed in shallow water habitat and large sps like *Tor* and S*chizotharax* sps were caught in deeper pool habitat. Larger fishes were caught during rainy season.

The velocity of water of Mahakali River ranged from 0.73 m/s to 2.6 m/s with an average velocity 1.48 m/s.

6.2 Chemical parameters

The most important chemical parameter is the concentration of dissolved oxygen, which affects distribution of fish species. Dissolved oxygen should be above 5.0 mg/l to support diverse biota (APHA, 1976). The average dissolved oxygen in Mahakali River was recorded 11.3 mg/l in all the stations during present study.

Natural water may be neutral, acidic or alkaline. It is an important environmental factor influencing the metabolism of all the animals and plants in habiting it. According to Khanna (1989), the pH of water is not constant but varies in relation to the other chemicals present in water. The hydrogen ion concentration has little effect on fishes as the current of water in lotic environment tend to keep pH uniform over a considerable distance, and fish can tolerate the normal pH range (Welch, 1952 and Whitton, 1975). Generally, alkaline water up to 9.5 pH is suitable for fish growth and pH value above 9.5 is unsuitable due to lack of sufficient carbonate compounds (Swingle, 1967). According to Jhingram (1991), fish could not survive at 11 pH. During present investigation, pH was about 8.48 mg/l in all stations.

The total alkalinity of water was recorded 15.0 mg/l to 100 mg/l in Mahakali River. The correlation between total alkalinity and fish catch showed positive

correlation at all the stations. The free CO_2 was recorded nil in January and October ranging from 5.1 to 7 mg/l.

Hardness ranged from 35 to 80 mg/l with an average hardness of 51.69 mg/l. The highest total hardness was found at January and the hardness was more or less similar in other seasons. The concentration of alkaline earth metals (Ca^{++} and Mg^{++}) contributes the total hardness in natural water.

6.3 Biological Parameters

During present investigation study, quantitative analysis of planktons were done and a total of 13 genera of phytoplankton and 4 species of zooplanktons were recorded along with the collection of 113 invertebrates belonging to three different phyla. The phytoplankton consisted Nostoc sps, Oscillataria sps, Anabaena sps. Rivularia, Spirogyra sps. Cladophora sps. Chara sps, Navicula sps, Synedra sps. Cymbella sps. Cymbella sps. Fragillaria sp, Closteridium sps.

and Cosmarium sps. under four families Cyanophyceae, Bacilliariophyceae and Desmidiaceae. Cladophora and Navicula were recorded in all the stations and found dominant all throughout the seasons. During present investigation, few zooplanktons were recorded belonging to Trichoptera, Cladocera, Copepoda and Rotifera. Quantitative study and identification of zooplankton could not be done.

During present investigation, macroinvertebrates were collected belonging to three different phyla - Arthropoda, Annelida and Mollusca. Among them, Arthropoda was found to be dominant belonging to three classes and 10 orders while only one genus from Annelida and Mollusca recorded like *Pheretima* and *Limax* respectively. There was recorded a total of 113 invertebrates.

A total of 21 fish species belonging to 15 genera and 7 families were recorded during the study period. Although, physicochemical parameters are the primary factors for distribution and catch composition of fish community in the water body, various other factors such as ongoing ecological changes of the aquatic ecosystem and physiological nature of biotic community might have effected on the distribution and catch composition of the fish fauna diving present investigation period. The seasonal catch composition of fish species in Mahakali River recorded increased from March to June than decreased in September to December and the highest catch was recorded during June. Fish composition and frequency distribution study in fish catches revealed cyprinids as major fishes - *Chrossocheilus latius* and *Oxygaster bacailla* as most dominant species. The sampling record showed fish diversity was high close to bridge near Nepal and India border but low in other stations.

Local fishermen around Mahakalli River were found to be involved in fishing as part time fisherman; but, Bengali fishermen from India were found to be involved in fishing throughout the year. Both conventional and non-conventional fishing methods were noted to be used in Mahakali River. Fish diversity and population is decreasing due to the impact of leeves, irrigation dam, non-conventional fishing methods, pollution and natural calamities like heavy flood and erosion.

6.4 Fishermen and socio-economics

There were three types of fishermen found in the study area - full time, part-time fishermen and occasional fishermen. In the study area, fishermen belonged to Magar, Gurung, Tharu, Chaudhary, Sunuwar, Luhar etc. by cast. Fishermen lived at bank of river in villages like Badaipur, Dodhara Chadani etc. Fishing is done at night and in the early morning and rarely at day time. Most houses of

fishermen were huts with thatched roof. Most of the fishermen were found landless and made their houses at the bank of river/stream. About 15% of total fishermen were landless and others with land had average land holding of 2.0 katha. According to the fishermen, fishing is not enough to maintain their livelihood nowadays. Fishing and boating was noted their main profession. Only few fishermen members can read and write and literacy rate was found about 5%. Most fishermen had shifted to new occupation as field workers of landlord or labor etc. Generally the households of fisher communities were found nucleus type. The general practice is the separation of married son from the family. But, new resident is made very close to parents.

6.5 Fish Market

The condition of local fish market is not good here. Few fishermen carried fishes home to home in villages for sale in bicycles kept in baskets and sacks. Some took fishes to market 4-5 km away from river. They carried fishes in a basket to market by Tempo, Rickshaw and Tanga.

The fish marketing system, if contractor than they should fishes keeps on basket and transported by Tampoo, Rikshan or Taanga. If other fishermen than market is some far away it and they take into there by bicycle or door to door in their basket on which they sold them.

6.6 Fishing implements and adverse impacts of illegal fishing methods and irrigation canal.

Fishing implements used in Mahakali River included indigenous fishing devices like gill net, cast net, hook and line (balchi) hammering etc. But sometimes fishermen were found to use improper mesh-sized nets leading to the indiscriminate fishing/killing of small fry. Besides these fishing practices,

unconventional/illegal fishing practices like blasting, poisoning, electrofishing, blocking the fish by making impoundments were also found to be used in this river.

The presence of irrigation canal in the river is beneficial in one hand by providing water in agriculture field and also has harmful adverse impact upon aquatic biota. Before the establishment of dams, migratory species like *Anguilla begalensis* was also reported below, but the catch of this fish is almost nil thereafter. Though there was established fish ladder but it did not work properly as large fish species could not pass through fish ladder due to its narrowness and some other technical faults. There is no monitoring system to evaluate its effectiveness. There was also established leeves in Dodhara regions creating adverse impacts upon aquatic biodiversity.

Government permit fishing in Mahakali River to the contractor and the contractor allowed fishermen to do fishing on monthly payment to contractor. There is system charging NRs. 5,000.00 as punishment to those caught involved in illegal fishing.

7.0 Conclusion and Recommendation

The main conclusion of present study is the rapid depletion of fish diversity and population. The main problems identified are overexploitation, illegal fishing, land slides, regular flooding, sand mining, formation of leeves etc. Access to fishing opportunity should be easier to poor people and their involvement also is required to be applied in the conservation and management of fish diversity, control of illegal fishing etc by participatory community approach.

The important management recommendations for the betterment of Mahakali River are listed below:

- Mahakali River should be designated as protected area implementing strict rules and regulations to promote biodiversity conservation programs.
- Regular training and awareness programs should be conducted at local level, school level etc for conservation and management of river and biodiversity with the joint efforts of governmental, non-governmental organization and local public.
- Aquatic Animal Protection Act (AAPA) should be implemented effectively from the concerned governmental agencies.
- A detailed inventory study of the endangered, rare and common fish species should be done to prepare database for better resource management in the future.
- Many non-conventional fishing methods like poison, dynamite, electrical current and small mesh sized nets should be stopped immediately.
- Indiscrimination fishing and catching of brood fish during breeding season should be strictly throughout river.

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APPENDIX –I

A questionnaire for interview with fishermen of Mahakali River to study socio-economic condition

1. Name of Fishermen
2. Age: ..... 3. Sex: .....
4. Caste of fishermen : .....
5. Zone: 6. VDC:
7. District: 8. Ward No.:
9. Village:
10. How many members are in your family?

    Male: ..... Female: ..... Total: .....
11. Are you literature? Yes/No

    If yes level: .....
12. Are you giving school education to your children?
13. If no then why?
14. Do you know about family planning?
15. How many fisherman come to fishing at this site?
16. Is fishing your own profession?

    Yes: ..... No:.....
17. If yes in which category do you fall?

    a) Full time fisherman b) Part time fishermen

18. What do you do with captured fish?

    a) Consume b) Sell c) Both

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

Place	Market/Village	Distance from Home

20. How much fish do you captured per month/year?

21. What type of fishing gear do you use different time of the year?

22. Which fish species are abundant/uncommon in this river?

Name of Fish	Abundant	Common	Uncommon	Remarks

23. How many species are there in the river in your opinion?

    .....

24. Which season is best for fishing?

25. Persons who included in other works are also come to fishing there? If yes, what is the effect in your business?

    .....

26. If population of fish declining in river? If yes,

    Causes .....

27. Any suggestion would you give for the improvement of fishing of the Mahakali River?

    .....