CHAPTER ONE
INTRODUCTION

1.1 General background

Earth is known as blue planet due to the presence of about 71 percent water in its surface. Out of which, about 97 percent is present in the sea and only 3 percent exists as freshwater in rivers, lakes, streams, reservoirs, underground water, polar and permanent glaciers, springs etc (Wetzel, 1983). The freshwater resources are not evenly distributed through out the world.

In global context, Nepal is a small landlocked mountainous country lying between China and India at the intersection of two biogeographical realms, the Paleartic to North and the Indo-Malayan in the South. The altitude varies from about 60m above the sea level in the Terai to 8,848m the Mt. Everest. In spite of Nepal being small and landlocked country, it is rich in freshwater resources, which is present in the form of rivers, rivulets, streams, lakes, reservoirs, ponds, swamps, wetlands. These water resources are considered to be the home of many varieties of flora and fauna. Among them, fishes are the most amazing group with great diversity distributed from floor of ocean to high altitude as much as 4000m from the sea level.

1.2 Water resources of Nepal

Nepal is rich in freshwater resources comprising about 816,937 hectare i.e. about 3 percent of total area of country. Out of which, about 401,500 hectare is covered by natural water resources i.e. river, lakes and reservoirs, about 6,337 hectare by ponds, 11,100 hectare by marginal swamps, gholes and about 398,000 hectare by irrigated paddy fields (Table 1). These various forms of inland water resources existing in the country provide a great habitat for the variety of fishes, which gives a great possibility

for the expansion for the fisheries and to uplift our socio-economic condition. Also fishes have a very important part in our cultural, economic, social, food, scientific, aesthetic and recreational value.

Table 1: Estimated Water Surface Area in Nepal.

S.N.	Resource Details	Estimated Area (ha)	Coverage (%)
1.	Natural Waters	401,500	49.15
	Rivers	395,000	48.35
	Lakes	5,000	0.61
	Reservoirs	1,500	0.18
2.	Village Ponds	6,337	0.78
3.	Marginal swamps, gholes, etc.	11,100	1.35
4.	Irrigated paddy field	398,000	48.72
	Total	816,937	100.00

Source: Directorate of Fisheries Development 2005/2006.

1.3 Natural Water Resources of Nepal

The natural water resource of Nepal consists of rivers, lakes and reservoirs. It comprises approximately about 49.15 percent of the total water resources of Nepal (Table 1). Out of 49.15 percent, river covers about 48.35 percent and only about 0.8 percent is covered by lakes and reservoirs.

Rivers

There are about more than 6,000 rivers, rivulets and streams covering about 395,000 hectare. Based on the nature of source and discharge, these rivers can be classified into following groups:

A. Perennial rivers

These rivers originate from Himalayas and carry snow fed waters with significant discharge, even in the dry season. Some of the major perennial rivers of Nepal and their tributaries are as follows:

i. Karnali River System: Mugu Karnali, Humla Karnali, Sani Bheri, Thuli Bheri,

Tila, Budhiganga and Seti.

ii. Gandaki River System: Kali Gandaki, Budhi Gandaki, Seti River, Trishuli River, Modi River, Myagdi River and Marsyangdi River.

iii. Koshi River System: Sunkoshi, Dudhkoshi, Indrawati, Arun, Tamakoshi, Tamar and Likhu.

iv. Mahakali River System: Chamali river and Chavan digad.

B. Perennial rivers with seasonal fluctuations in discharge

These rivers originate from the Midlands or Mahabharat Range of mountains and are fed by precipitation as well as ground water regeneration, including springs. Some of them are: Mechi river, Kankai river, Kamala river, Bagmait river, Rapti river, Babai river, etc.

C. Seasonal rivers

These rivers originate from the southern Siwalik Range of hills and the rivers may or may not contain water flow during the dry season, but characterized by flash flood during the monsoon.

All these rivers flowing south from Nepal form part of the headwaters of the Ganges River Basin (one of the 20 largest rivers in the world), comprising about 40 percent of the main annual flow and 70 percent of the dry season flow of the Ganges.

Lakes

There are several lakes of various size scattered all over the country covering an area of 5,000 hectare (i.e. 0.6 percent) of the total existing water area of Nepal (DOFD, 2001). Based on the origin, these lakes are of three types: Glacial lakes, River-valley lakes and Ox-bow and other lakes. Among these lakes ox-bow lakes are mainly confined to Southern part of the country, which indicates the shift of river course. More than two- dozen of ox-bow lakes are present in Nepal and

most of them are located in Chitwan National Park, Nawalparasi, Bardiya and Kailali (Sharma, 1977). Some of the major lakes of Nepal are: Rara or Mahendra Lake, Phewa Lake, Begnas Lake and Rupa Lake or Rupakot Lake. Some of the minor lakes of Nepal are: Khaptad Lake, Baragon Lake, Tilicho Lake, Phoksundo Lake, Dudhpokhari Lake, Jageswar Lake, Panch Pokhari, etc.

Reservoirs

Reservoirs are built to collect water in order to produce hydro-electricity. So it forms a large water mass that inhabits large variety of fishes. There are numerous small and large reservoirs built at different parts of Nepal, some of which are: Kulekhani water reservoir, Trishuli water reservoir, etc.

1.4 Fish Resources

As we know, Nepal has various forms of water resources inhabiting a variety of fishes. Some of them have a high food value while others have good economic and academic value so their proper study and researches have to be done without discrimination. According to Shrestha (Shrestha 2001), there are 182 species of fishes in Nepal belonging to 93 genera, 31 families and 11 orders. Out of which 89 species are common, 61 species are insufficiently known, 8 species are vulnerable, 1 species is endangered, and 23 species are rare, with none of these being listed in IUCN and CITES list.

Among the indigenous fishes of Nepal, Shrestha (2001) had recommended 10 species to be legally protected.

- *Neolissochilus hexagonolepis* (V),
- *Chagunius chagunio* (V),
- *Tor putitora* (V),
- *Tor tor* (E),
- *Schizothorax richardsonii* (V),
- *Anguilla bengalensis* (V),
- *Myersglnis blythi* (V),
- *Schizothoraichthys progastus* (V),
- *Brachydanio rerio* (V) and

- *Psilorhynchus pseudecheneis* (V).

Beside above indigenous fishes, there are 9 exotic species of commercially valued fishes introduced in Nepal. Among these, *Salmo trutta* and *Onchorhynchus mykiss* are cold water species. *Salmo toutta* did not exist in Nepalese water anymore while *Onchorhynchus mykiss* is being studied in Godawari and Trishuli Research Center under NARC. Now-a-days some private farmers are culturing the *Onchorhynchus mykiss* in Dhunche and Ranipauwa. Among these exotic fish species, most commonly cultured fish are Chinese carps due to their good taste, fast growing and tolerance to warm climate.

Table 2. Exotic fishes cultured in Nepal.

S.N.	**Scientific name.**	**Common name.**
1.	*Cyprinus carpio*	Common carp
2.	*Ctenopharyngodon idella*	Grass carp.
3.	*Hypophthalmichthys molitrix*	Silver carp.
4.	*Aristicthys nobilis*	Big head carp.
5.	*Tilapia sp.*	Tilapia.
6.	*Puntius gonionatus*	
7.	*Clarias gariepinus*	Magur.

In the last few decades inland water have been subjected to a range of stress caused by direct or indirect human activities such as irrigation, hydroelectric projects, urbanization, industrialization, modernization of agriculture, etc. In particular the river basin in Nepal has undergone extensive change thus created adverse effects to aquatic biodiversity specially the native fish fauna (Swar and Shrestha, 1996). Many problems associated with human activities have been identified, i.e. siltation, chemical pollution, introduction of exotic species, over irrational fishing (use of small mesh gillnets, use of explosive, electro-fishing, free access to poison) and hydraulic engineering (dams and

impoundment, levees, canalization, etc.). All these problems have threatened many indigenous species (Shrestha, 1990/1998).

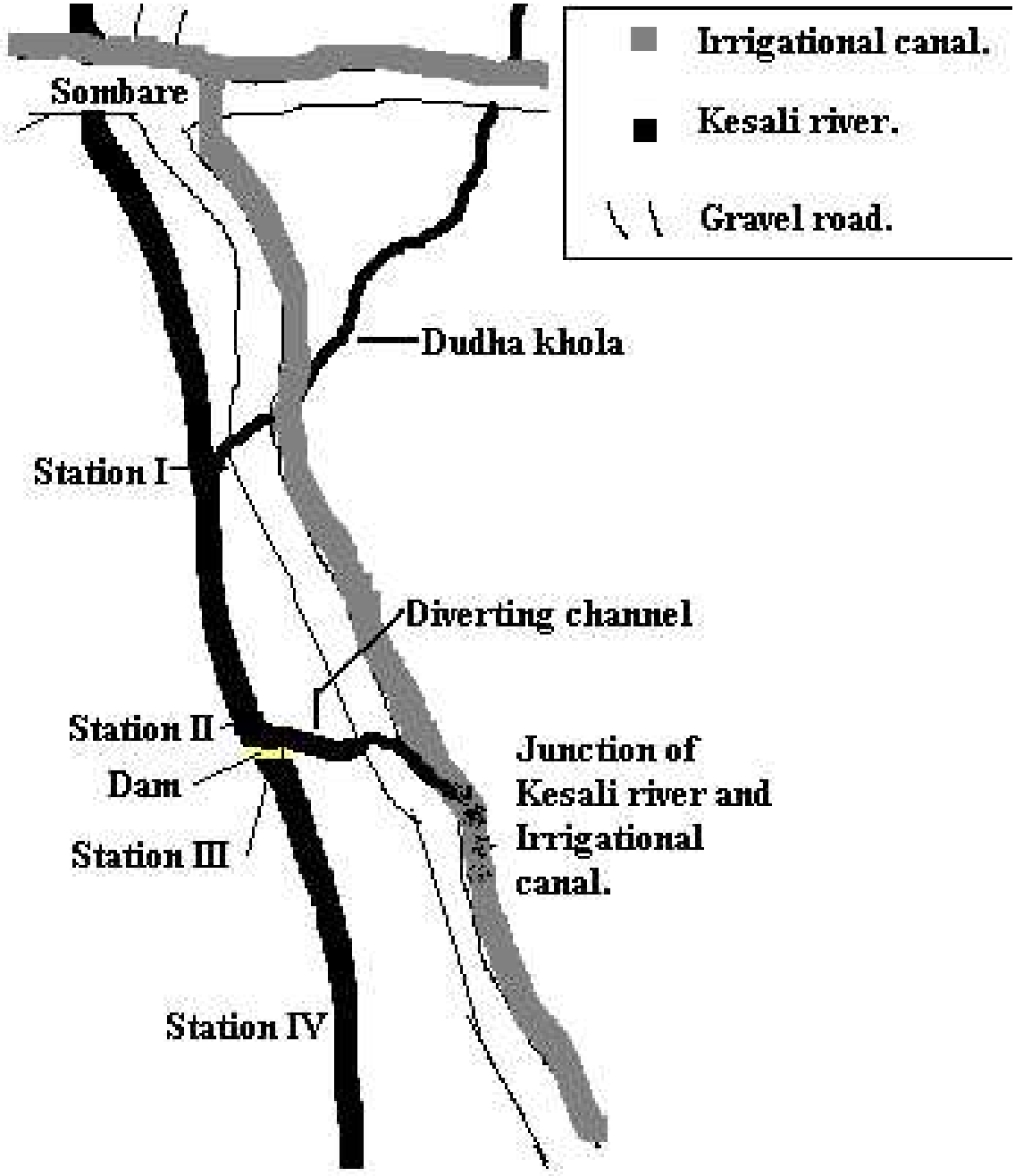
Among above-mentioned problems; construction of dam on the different rivers is one of the important cause for depletion of fish resources. Dams are constructed either for production of electricity or for diversion of water for irrigation purposes which causes many negative impacts such as decrease of water level in lower streams, obstruction on the free movement of migratory fishes, change in the riverine environment by formation of reservoir in the upper part of the dam, etc.

1.5 Description of the study area

The Kesali River is a small perennial river. It is one of the important tributary of Lohandra river of Morang district. It has clear water except during flooded season. The water level during the winter and the summer falls to considerable amount but doesn't dry up. Hence, the river is potentially important for aquatic life as well as for the irrigation. A dam had been constructed in Kesali River in 2051-2052 B.S. which diverts the river water to irrigational canal leaving downstream of dam totally dry during large period of the year (usually summer and dry seasons). There is no provision for fish movement and mitigation measures were not adopted to conserve the aquatic flora and fauna of this river. Effect of dam associated with illegal and over fishing, heavy flooding, erosion etc. have spoiled the natural habitat for fish in Kesali river depleting fish population considerably.

It is found that major rivers of Nepal were studied repeatedly but unfortunately the small rivers like Kesali are totally ignored from the point of view of its potential significance, fishery diversity. The present study has been undertaken to gather the basic information on the fish and fisheries of Kesali River, fish diversity and population, impact of dam on the fishes, fishing implements used in this river and surrounding area and socio-economic condition of fishermen. It is believed that the present study will be helpful in developing the management plan for the conservation and development of fishery resources in dam affected rivers of Nepal.

Figure 1: Map of the study area.



CHAPTER TWO

OBJECTIVES OF THE STUDY

The main aim and objective of the present study are as follows:

- To study the physiochemical parameter, fish diversity/population of Kesali River.
- To study the fishing appliances, methods and socio-economic condition of the fishermen of Kesali river.
- To study the impact of irrigational dam on fish diversity.

CHAPTER THREE

LIMITATIONS OF THE STUDY

Some of limitations of the study are as follows:

- Limited resources and facilities.
- Limited time so the study was done four times in the year (detail study to assess changes occurring through out the year could not be done due to time constraints).
- Unable to collect sufficient primary data and relied upon secondary data or information gathered from the informal interviews.

CHAPTER FOUR

LITERATURE REVIEW

McClelland (1839) did an extensive study on fish distribution and taxonomy. As for the literature regarding the fish fauna of Nepal, there are few works done to explore the fish-fauna in spite of huge water resources and great zoo-geographical significance. The earliest record of fish and fishery of Nepal goes back to the eighteen century. The first historical account has been given by Colonel Kirkpatrick, while he traveled Kathmandu in a political mission in the year 1793 AD. He described the fishing methods in the Rapti river of Makwanpur district southwestern Nepal.

However, the credit of first scientific report on fish fauna of Nepal goes to Francis Buchanan (later Hamilton) for his splendid work of 1822 “An Account of the Fish Found in the river Ganges and its Branches”. In his above work he had reported 24 fish species from the river Koshi and 2 fish species from the river Rapti of Nepal.

The first authentic information on descriptive ecology of the Himalayan fishes was furnished by Hamilton (1822) in his work “Fishes of Ganges” which provided the description of 269 species of fish from different water systems of Nepal and India. Gunther published catalogue of the fishes of the British Museum, London in eight volumes. The work contained an account of 6847 species together with the description of another 1682 doubtful species. Boulegner (1907) reported the collection of Nepalese fishes from Western Himalayas. Regan (1907) reported additional species of Nepalese fishes in his publication.

One of the outstanding contributions in this field was that of Hora (1920-1952). Hora (1937) obtained a collection of 158 specimens of fishes comprising 22 species through Colonel Baily from Nepal and published an illustrated account of these fishes.

Menon (1949) described fishes from the Koshi Himalayan region, Nepal which consisted 11 families comprising 26 genera and 52 species and gave an informative description of the zoogeography of the fishes of Nepal. Menon (1955) conducted a fish survey of Nepal and collected 94 species of fishes from Kathmandu, Trusuli, Simara, Biratnagar etc. Menon (1961) collected fishes from the Koshi River and produced a checklist of these fishes.

Taft (1955) conducted a fish survey of Nepal and catalogued 94 species of fishes from Kathmandu, Trishuli, Simra, Birgunj, Biratnagar, etc. Dewitt (1960) listed 120 species of fishes belonging to 21 families. Thapa and Rajbanshi (1963) studied the hill stream adaptation fishes of Nepal.

Majpuria and Shrestha (1968) published a paper on fresh water fishes and fisheries of Nepal. Majpuria (1969) introduced a paper on socioeconomic condition of fishermen of Kathmandu valley.

Majumdar et.al. (1972) recorded some new fishes from Nepal. They collected fishes from the Indrawati River at Dolalghat and the Chatara canal. Of the six species recorded two *Barilius barna* and *Chagunius chagunio* were reported for the first time in Nepal.

Shrestha 1981 described about 120 species of fishes from different water resources of Nepal. Monospecies of *Schizothorax* spp is reported from Syarpu Lake (1372m, Pradhan, 1982). Three species such as *Acrossocheilus hexagonolepis* (katle), *Puntius chilinoids* (karange) and *Schizothorax* (asala) were recorded by from Indrasarobar Reservoir (Pradhan and Swar, 1987).

Jha and Shrestha (1986) had given a report on fish fauna of Karnali River. They had described the occurrence and distribution of the fishes in the various sections of the Karnali River. Joshi (1988) studied of fishery resources of Sun-Koshi River with particular reference to dam and its impact.

Shrestha (1991) reported 59 cold-water fish species from the natural water bodies of mountains and Himalayan region. Sapkota (1992) studied fishery ecology of swamplands of Koshi River. Shrestha (1995) again described the status of fish species in Nepal and enumerated 185 indigenous fishes found in Nepal. Later in 1998 with the finding of Puntius phutunio, she has reported 186 species of indigenous fishes.

Few studies on Biodiversity of fast flowing river had been reported in Nepal. Fisheries Development Directorate had carried out extensive studies on limnological/biological aspects of Sunkoshi River and Trisuli River (Yearly Progress Report, FDD, Balaju, 1998/99).

A numbers of workers like Khadka (1989), Shrestha (1991) and Shah et. al. (1992) had explored the lower stretch of Arun River Koshi at Saptari District. Sharma (1996) studied on the fish biodiversity and the fishery resources of the Tinau Rivers Subha and Ghose (1996) had reported a new record of the pygmy barb, P*untius phutunio* (Ham) from Koshi Tappu wild life Reserve's low land catchments area.

Smith et al (1996) studied on the Aquatic biodiversity in the Karnali and Narayani River basins and a total of 121 and 135 fish species have been reported from the Karnali and Narayani River basins respectively, below and within the Himalayan foothills.

Yadav (2001) had reported 93 species of fishes in plains of Koshi River. A study on Bheri-Babai Hydroelectric Project reported 40 fish species of which 21 species reported from river Bheri and 19 species from Babai.

Shrestha (2001) published a paper entitled "Taxonomic Revision of fishes of Nepal" in which the thorough taxonomic revision of 186 fish species reported earlier (Shrestha, 1998) with their nomenclature and systematic position according to new

classification after Jayaram (1999). A total number of 182 species belonging to 93 genera under 31 families and 11 orders are listed.

There is a couple of EIA report on Dudh Koshi (1998), Kali Gandaki A (1996), Kulekhani (1997), Melamchi (1999), West Seti (2000), Upper Karnali (1997) etc. containing biodiversity studies with possible impact of damming for hydropower developments and mitigation measures. Upadhyaya and Shrestha (2002) had described the impact of Kali Gandaki 'A' Hydropower and also discussed about different mitigation measures.

Malla (2004) studied fish diversity and distributional pattern in Daram Khola, Baglung and recorded 21 fish species. Gandaki Hydropower Development Company (2004) did EIA study describing the different ecological habitat and fish diversity of the upper Mardi Khola Small Hydropower Project. Gaurav Integrated Development Association (2004) had done an extensive study about the fish biodiversity and management in Sunkoshi River (Phase I. A total of 15 species of fishes were caught in cast net in Phase I at different stations of Sunkoshi. While a total of 22 fish species were recorded from Indrawati and Dollaghat in an extensive study about the fish biodiversity and management in Sunkoshi River (Phase II) done by AEFIM Consult Pvt. Ltd. AEFIM (2005) had also carried and extensive study of whole Koshi System from Chataraghat to Dollaghat and recommended to involve fisher communities in conservation management for sustainable utilization of fishery resources in Koshi System for this purpose, this consultancy firm had established four different 'Fish Conservation Groups' in Chataraghat, barahachhetra, Tribeni and Dolalghat.

CHAPTER FIVE

MATERIALS AND METHODS

5.1 Study period

For the present study, the field work was conducted form November 2006 to August 2007, during which the field was visited once in every three months to cover four different seasons. Each sampling stations were visited four times during the study period in the months of November, February, May, and August for sample collection.

5.2 Study area

The study was carried out in “Kesali river” a tributary of Lohandra river, which is located at the Morang district, Koshi zone. It originates from the forest area near Lachimarga, bottom area of Mahabharat range. It flows south for about 40 km and merges to Lohandra, which flows across the border to India. Kesali River is a perennial river with clear water, except during monsoon season when the water colour becomes grayish (muddy) due to heavy flooding. It consist of sand, gravel, and pebbles on the bed and green vegetations at its banks. A number of villages like Tilkuri, Sombare, Pulaha, etc. are situated near the bank of Kesali River. Water resources of Kesali River have been utilized for drinking, washing, bathing and irrigation purposes. In 20051/52 B.S., Government of Nepal with the help of India under the supervision of Nepali Engineer built a dam across the Kesali river to divert the river water to the irrigational canal. This irrigational canal comes under Chatara Canal System, Secondary 16 (Bariyati Section) built in 2026 B.S. and was handed over to Nepal Government at 2032 B.S. This canal section irrigates about 7000 hectare of land. For the management of dam a consumer committee is formed with Mr. Mohan Shrestha as a president to regulate the closing and opening of sluice gate of dam.

During construction of dam, no rule of minimum discharge during dry season was mandated so no measures were followed for the conservation of aquatic flora and fauna of river, except for prevention of soil erosion. It was found in practice that all the river water is diverted to irrigational canal during dry seasons leaving downstream of the river totally dry or very small quantity of water. But during monsoon or flood season sluice gate is fully opened allowing the water flow in downstream. During its course a small river named Dudha Khola confluence with it about one km north from the dam. Usually this river adds very less amount of water because it is one of the major water sources for irrigation to the land areas surrounding it.

5.3 Range of study area

The study of whole river from the origin to end point is very difficult, so the present study is particularly confined to dam area, and about one km upstream and downstream from the dam. The whole study area is centered at the Kesani V.D.C., Morang district. But for the sample collection for fish diversity, study fishing implements and fishing technique in river, certain other regions of the river were also visited.

5.4 Selection and description of sampling stations

A preliminary survey has been made, prior to field study, to select the sites. The selection of sampling stations is based on the physical characteristics, human settlements, confluences of tributaries, location of dam, diversion of water, etc. In the present study four sampling stations were selected which are as follows.

Station I

The sample station I has been selected about one km upstream from the dam area, which is situated at the meeting point of Kesali river and Dudha khola. At this station, river is surrounded by rice field and dense vegetation at the river bank. River basin bears mixture of gravels, pebbles, sand and mud, and the width of the river at this station is about 5m.

Station II

The sampling station II has been selected at the upper part of the dam. It acts as reservoir and usually had turbid water. From this station a diverting channel joins the Kesali river with irrigational canal. Depth of water in this station is always more than in other stations. This station had a deposition of mud and heavy vegetation growth at the banks. Bamboo and Sisoo trees were present at the embankments of the dam area.

Station III

The sampling station III has been selected at the lower part of the dam. At this station, large stones, rubbles, gravels, pebbles and sand are present at the river bed. Embankments of dam and river are protected by stones woven in wire baskets. A deep groove is present in front of the sluice gate formed by water current. This portion forms water pockets during dry season when the downstream of the river get dried due to diversion of river water to the irrigational canal.

Station IV

The sampling station IV has been selected about one km downstream from the dam. At this station, pebbles, gravels and coarse sand is present at the river bed. It has rice fields at the east side, while Sisoo trees on the west side of the river. The width of river in this station is nearly about 4m.

5.5 Source of data collection

The primary or basic source of data collection is based on the direct field observation, sampling, photography and other information gathered from fishermen. To meet the objectives of current study the informal interviews were conducted with the fishermen, villagers and engineers to collect the information concerning the history of

fishing, fish population, fish diversity, changes which takes place throughout a year, history of dam, cause for the construction of dam, impact of dam on the fish diversity and population, etc.

5.6 Analysis of Water Quality

During present study, some physical and chemical parameters of water were analyzed following methods given by APHA (1978), Adoni (1985) and Trivedy and Goel (1986).

5.6.1 Analysis of physical parameters

Some of the physical parameters studied are as follows:

a) **Water Colour**

For determining the water colour, a simple method was used. First a beaker full of river water was taken and placed over a white sheet of paper to determine the colour of the water.

b) **Water Temperature**

For recording water temperature, a mercury thermometer was dipped in the water for about 10 minutes and recorded the value at each station.

c) **Depth**

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

d) **Transparency**

The transparency of water was measured by using Secchi Disc which is a metallic device. For measuring the transparency, the Secchi Disc was

lowered in the water till it is invisible and the depth of water was noted. Next time Secchi Disc was totally merged in the water till it totally disappears and the disc was gradually pulled up and the depth of water when the disc reappears is noted. Then the transparency was calculated by applying the following formula:

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

Where, A = Depth at which Secchi Disc disappears.

B = Depth at which Secchi Disc reappears.

e) **Water velocity**

For measuring the velocity of water a float and a stopwatch was used. The velocity of each station was measured five times and the average velocity of water was calculated.

5.6.2 Chemical parameters

a) **Hydrogen Ion Concentration**

For determining the pH of the water, an Electric Digital Pen-pH meter was used.

b) Dissolved Oxygen

For measuring the dissolved oxygen, at first BOD bottle of capacity 200ml were filled with river water, then 2ml of $MnSO_4$ and 2ml of KI solution were added respectively through the wall of the BOD bottle, with the help of pipettes, shaken well and allowed to settle down until the precipitate was settled down. After that, few drops of concentrated H_2SO_4 was added and shaken well until the precipitation was completely disappeared. Than 50ml of the solution was taken in a conical flask and added 4 drops of starch indicator and was titrated against the Sodium thiosulphate solution. Then the dissolved oxygen concentration was calculated using the following formula:

Dissolved Oxygen (mg/l) = $\frac{(\text{ml} \times \text{N}) \text{ of titrant} \times 8 \times 1000}{}$

$$\frac{V_2 (V_1 - V)}{V_1}$$

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

V_2 = Volume of sample bottle after placing the stopper

V_1= Volume of the contents titrated.

N = Normality of titrant.

c) **Free Carbondioxide**

For measuring the free Carbondioxide, first 100ml of river water was taken in a conical flask and few (4-5) drops of phenolphthalein indicator were added to it. If no colour change occurs then it was titrated with 0.05N NaOH with regular shaking until a pink colour appears. Then the free carbondioxide was calculated using the following formula:

$$\text{Free } CO_2 \text{ (mg/l)} = \frac{(V_1 \text{ x N) of NaOH x 1000 x 44}}{V}$$

Where, V = Volume of water sample.

V_1= Volume of NaOH.

N = Normality of NaOH.

5.7 Collection of Fish Sample

The fish samples were collected by two methods, which were as follows:

5.7.1 Sampling of fishes using cast net

For collection of fishes, fishing was done for one hour in every sampling station at the area of about 50m using cast net. Local fishermen were employed for the collection of fish samples. Number of different fish species was noted and the total weight in each sampling station was taken.

5.7.2 Collection of fishes for fish diversity study

Collection of the sample of the fish species present in the Kesali River with the use of cast net was not possible. So, fish samples were also collected from the different places and from different fishermen who use different fishing gears.

The colouration and morphometric characteristics (size, length, etc.) of the collected fishes were noted down at the field. The measurement of weight of individual fish was not possible so the gross weight of total catch in every station was taken. The collected fishes were preserved in 5% formalin.

The larger fishes were given longitudinal incision along the abdomen whereas the small fishes were directly put in the container containing formalin. The fishes were kept in the container with the tail pointing upwards so as to avoid any damage to the caudal fin. The preserved specimens were identified in the laboratory of Central Department of Zoology using standard method of taxonomy after Shrestha (1981), Jayaram (1981) and Shrestha (1994).

5.8 Socio-Economic Condition of Fishermen

Basic information about the socio-economic condition of fishermen was collected by conducting different sets of informal interviews among the different groups of fishermen and villagers.

5.9 Fishing Appliances and methods used in Kesali River

Fish appliances used in Kesali River were studied through direct field visit and information about them was collected by interview with local fishermen. In every visit, photographs and information about the fishing practices, different gears and appliances were collected.

5.10 Impact of irrigational dam on the Kesali River

Impact of irrigational dam on the Kesali river were studied through direct field visit and information collected by informal interview with local people and fishermen.

CHAPTER SIX

OBSERVATION AND RESULT

6.1 Analysis of water quality

6.1.1 Physical parameters

a) Nature of Day

Generally day was clear, calm and sunny during February and May but it was cloudy during the August. During November, day was cold and foggy at the morning and was cleared at the day time. At month of August, at first the day was clear and sunny but rained for about two hours from 11:00 am.

b) Water colour

The river water was clear throughout the year except during monsoon when the water colour became grayish (muddy) due to heavy flooding. But in station II due to the accumulation of mud and growth of heavy vegetation, water usually remained grayish throughout the year. (Table 3)

c) Water temperature

The surface water temperature ranged from 19.8^{o}C to 32.2^{o}C with an average of water temperature of 25.2^{o}C. The highest temperature was recorded 32.2^{o}C in August and lowest temperature 19.8^{o}C in May. (Table 3)

d) Depth

The depth of Kesali River varied in all sites at different seasons. Depth, ranged from 25 to 157cm. The depth was recorded less varying in Station II but high variation in depth noted in the station I, III & IV. During November and February, station III & IV was totally dry due to the diversion of river to irrigational canal leaving only some pockets of water in some places. The minimum depth 25cm was recorded at station IV during May and maximum depth 157cm was recorded at station II during August. (Table 3)

e) Transparency

The water was almost clear throughout the year except in rainy season. The transparency ranged from 29.5 cm to 46 cm. The highest transparency was 46 cm recorded in February and the lowest transparency 29.5 cm recorded in August. Transparency of station I during November and February and station IV during May were not recorded as the depth was very less. Transparency of station III & IV during November and February were not mentioned because these stations were totally dry. (Table 3)

f) Water velocity

The water velocity was nearly equal in all stations. The velocity ranged from 9.0 to 15 m/s. The maximum velocity of 15 m/s was recorded during August and the minimum was recorded during February. (Table 3)

Figure 2: Temperature variations at different stations and seasons.

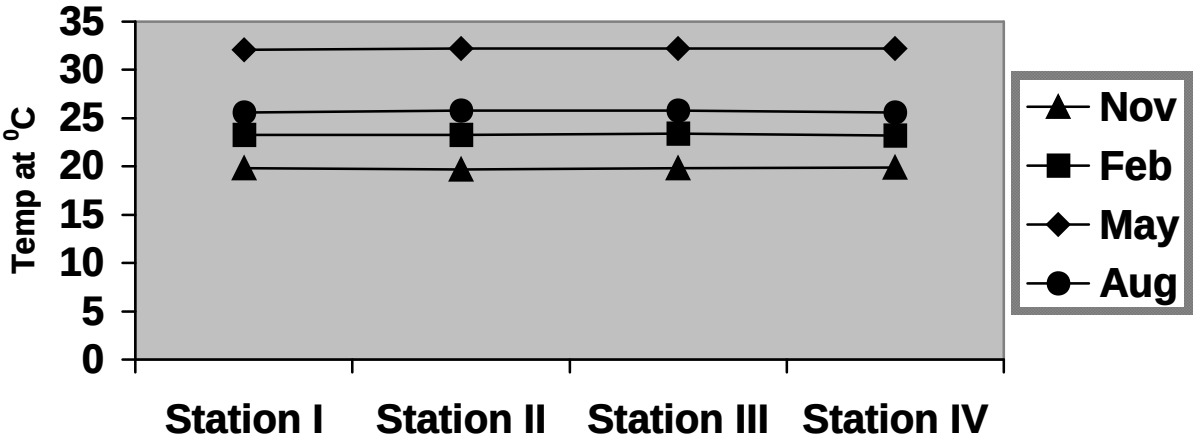


Figure 3: Depth variations at different stations and seasons.

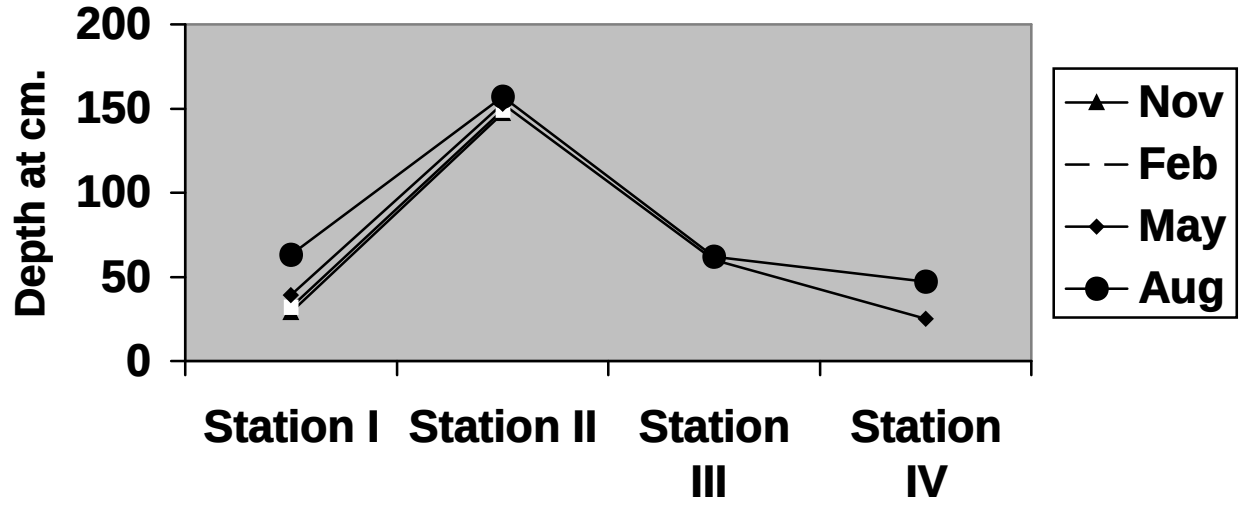


Figure 4: Transparancy variations at different stations and seasons.

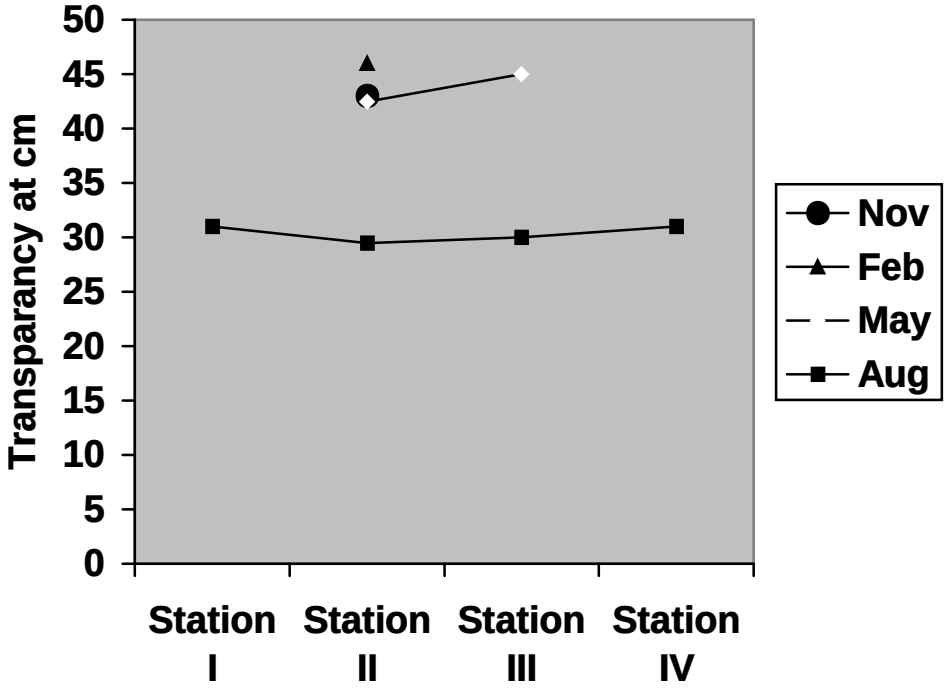
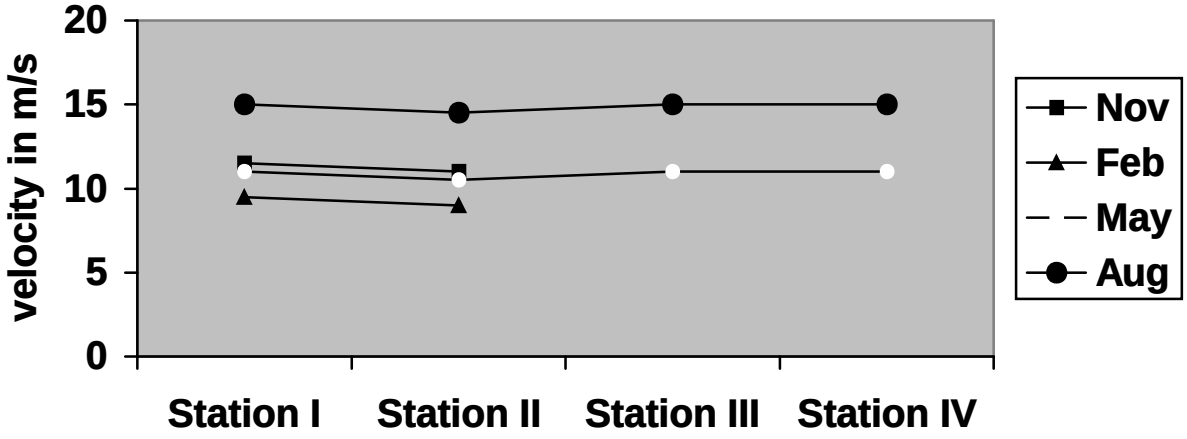


Figure 5: Velocity variations at different stations and seasons.



6.1.2 Chemical parameters

h) Dissolved Oxygen

The dissolved oxygen ranged from 6.8 to 8.9mg/l. The maximum dissolved oxygen concentration was recorded during August and the minimum in February. (Table 3)

i) Free Carbon-dioxide

Free Carbon dioxide ranged from 13 to 18mg/l. The maximum value of 18mg/l recorded during May at station II and lowest 13mg/l during November at stations I and II**.** (Table 3)

g) Hydrogen Ion Concentration (pH)

The pH ranged from 6.5 to 7.6. The maximum pH was recorded in May and the minimum in November. (Table 3)

Figure 6: Dissolved Oxygen variations at different stations and seasons.

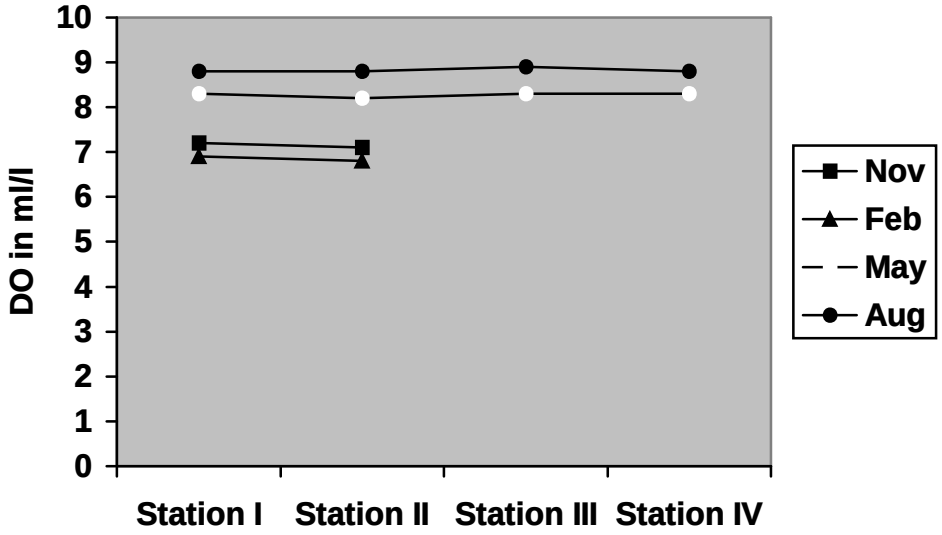


Figure 7: Free CO2 variations at different stations and seasons.

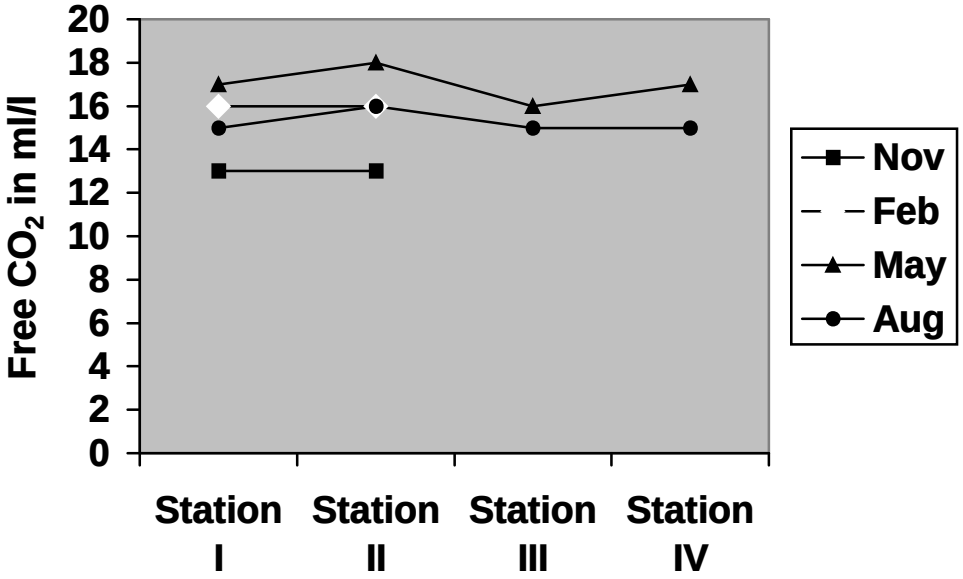


Figure 8: pH variations at different stations and seasons.

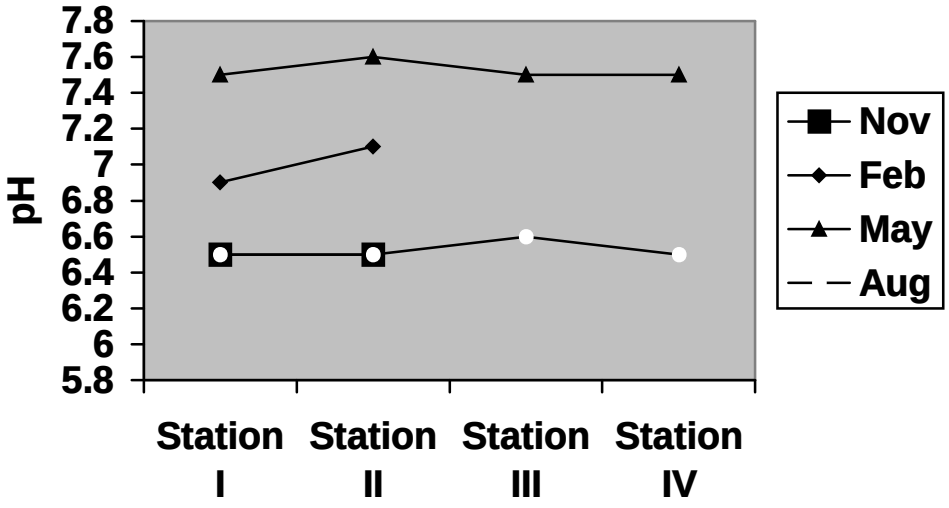


Table 3

Variation of Physico-chemical Parameter of Kesali River, Morang

(From November 2006 to August 2007)

S. N.	Stations.	Station I				Station II				Station III				Station IV				Max.	Min.	Avg.
	Parameters.	Nov.	Feb.	May.	Aug.	Nov.	Feb.	May.	Aug.	Nov.	Feb.	May.	Aug.	Nov.	Feb.	May.	Aug.			
1.	Temperature	19.8	23.3	32.1	25.6	19.7	23.3	32.2	25.8	19.8	23.4	32.2	25.8	19.9	23.2	32.2	25.6	32.3	19.7	26
2.	Depth	29	32	39	63	146	149	153	157	NW	NW	60	62	NW	NW	25	47	157	25	91
3.	Transparency	-	-	-	31	43	46	42.5	29.5	NW	NW	45	30	NW	NW	-	31	46	29.5	37.75
4.	Velocity	11.5	9.5	11	15	11	9	10.5	14.5	NW	NW	11	15	NW	NW	11	15	15	9	12
5.	Dissolved Oxygen	7.2	6.9	8.3	8.8	7.1	6.8	8.2	8.8	NW	NW	8.3	8.9	NW	NW	8.3	8.8	8.9	6.8	7.85
6.	Free Carbondioxide	13	16	17	15	13	16	18	16	NW	NW	16	15	NW	NW	17	15	18	13	15.5
7.	pH	6.5	6.9	7.5	6.5	6.5	7.1	7.6	6.5	NW	NW	7.5	6.6	NW	NW	7.5	6.5	7.6	6.5	7.05

6.2. Fish catch and diversity

6.2.1 Fish Catch

The maximum fish catch per hour effort was 350 gm in the station III on August and the minimum catch was 50 gm in the station II and station IV during November and May respectively. Generally, maximum fish catch was found on August and the minimum on November. In the month of November and February, river water was diverted to irrigational canal leaving the downstream totally dry, so the fish sampling at the stations III and IV was not possible during these seasons. Fish catch was consistent (250 gm) and higher in station I all throughout the seasons except 300 gm in August; similarly catch was consistent (100 gm) and low in station II. During water flow, the fish was recorded highest in station III. (Tables 4 to 7)

Table 4: Fish catch per hour effort in the month of November.

S.N.	Name of species	Station I	Station II	Station III	Station IV	Total Fish Number
1.	*Barilius barna*	4	-	N.W.	N.W.	4
2.	*Barilius bendelisis*	3	-	N.W.	N.W.	3
3.	*Esomus danricus*	2	-	N.W.	N.W.	2
4.	*Garra annandelai*	3	-	N.W.	N.W.	3
5.	*Puntius sarana*	5	1	N.W.	N.W.	6
6.	*Puntius sophore*	12	3	N.W.	N.W.	15
7.	*Lepidocephalicthys guntea*	2	5	N.W.	N.W.	7
8.	*Nemacheilus botia*	-	-	N.W.	N.W.	-
9.	*Channa punctatus*	-	-	N.W.	N.W.	-
10.	*Colisa fasciatus*	1	3	N.W.	N.W.	4
11.	*Glossogobius giuris*	-	-	N.W.	N.W.	-
12.	*Mastacembelus armatus*	-	-	N.W.	N.W.	-
	Total weight (gm)	**250**	**50**			**44**

N.W.= No Water

Table 5: Fish catch per hour effort in the month of February.

S.N.	Name of species	Station I	Station II	Station III	Station IV	Total Fish Number
1.	*Barilius barna*	3	-	N.W.	N.W.	3
2.	*Barilius bendelisis*	2	-	N.W.	N.W.	2
3.	*Esomus danricus*	1	-	N.W.	N.W.	1
4.	*Garra annandelai*	5	-	N.W.	N.W.	5
5.	*Puntius sarana*	6	3	N.W.	N.W.	9
6.	*Puntius sophore*	9	4	N.W.	N.W.	13
7.	*Lepidocephalicthys guntea*	-	2	N.W.	N.W.	2
8.	*Nemacheilus botia*	2	-	N.W.	N.W.	2
9.	*Channa punctatus*	-	-	N.W.	N.W.	-
10.	*Colisa fasciatus*	3	2	N.W.	N.W.	5
11.	*Glossogobius giuris*	1	-	N.W.	N.W.	1
12.	*Mastacembelus armatus*	-	-	N.W.	N.W.	-
	Total weight (gm)	**250**	**100**			**43**

N.W.= No water.

Table 6: Fish catch per hour effort in the month of May.

S.N.	Name of species	Station I	Station II	Station III	Station IV	Total Fish Number
1.	*Barilius barna*	2	1	-	1	4
2.	*Barilius bendelisis*	-	-	-	-	-
3.	*Esomus danricus*	3	-	-	-	3
4.	*Garra annandelai*	6	-	3	1	10
5.	*Puntius sarana*	4	2	3	1	10
6.	*Puntius sophore*	9	6	7	3	25
7.	*Lepidocephalicthys guntea*	1	-	3	-	4
8.	*Nemacheilus botia*	-	-	2	1	3
9.	*Channa punctatus*	1	-	2	-	3
10.	*Colisa fasciatus*	2	3	5	-	10
11.	*Glossogobius giuris*	-	-	2	-	2
12.	*Mastacembelus armatus*	-	-	1	-	1
	Total weight (gm)	**250**	**100**	**300**	**50**	**75**

Table 7:Fish catch per hour effort in the month of August.

S.N.	Name of species	Station I	Station II	Station III	Station IV	Total Fish Number
1.	*Barilius barna*	3	-	2	2	7
2.	*Barilius bendelisis*	1	1	-	-	2
3.	*Esomus danricus*	2	-	1	-	3
4.	*Garra annandelai*	5	-	2	4	11
5.	*Puntius sarana*	2	-	1	1	4
6.	*Puntius sophore*	9	5	11	8	33
7.	*Lepidocephalicthys guntea*	-	3	2	1	6
8.	*Nemacheilus botia*	2	-	1	2	5
9.	*Channa punctatus*	-	-	2	1	3
10.	*Colisa fasciatus*	2	1	2	3	8
11.	*Glossogobius giuris*	1	-	2	-	3
12.	*Mastacembelus armatus*	-	-	3	-	3
	Total weight (gm)	**300**	**100**	**350**	**200**	**88**

6.2.2 Diversity of fish species of Kesali river

A total of 21 different fish species belonging to 15 genera, 10 families and under 5 orders were recorded in Kesali River from fishermen employing different fishing gears (Table 8). The most common fish found in Kesali River in present study, was *Puntius* species. Other common fishes were *Garra annandelai, Barilius* species*, Lepidocephalicthys guntea, Nemacheilus botia, Mastacembelus armatus, Channa* species *and Colisa fasciatus.* Fishes like *Amphipnous cuchia* is very rarely found here. Local fishermen reported Wallago *attu* (Buhari)*, Channa striatus* (Saura) etc caught rarely during flood.

Figure 9: Composition of different families

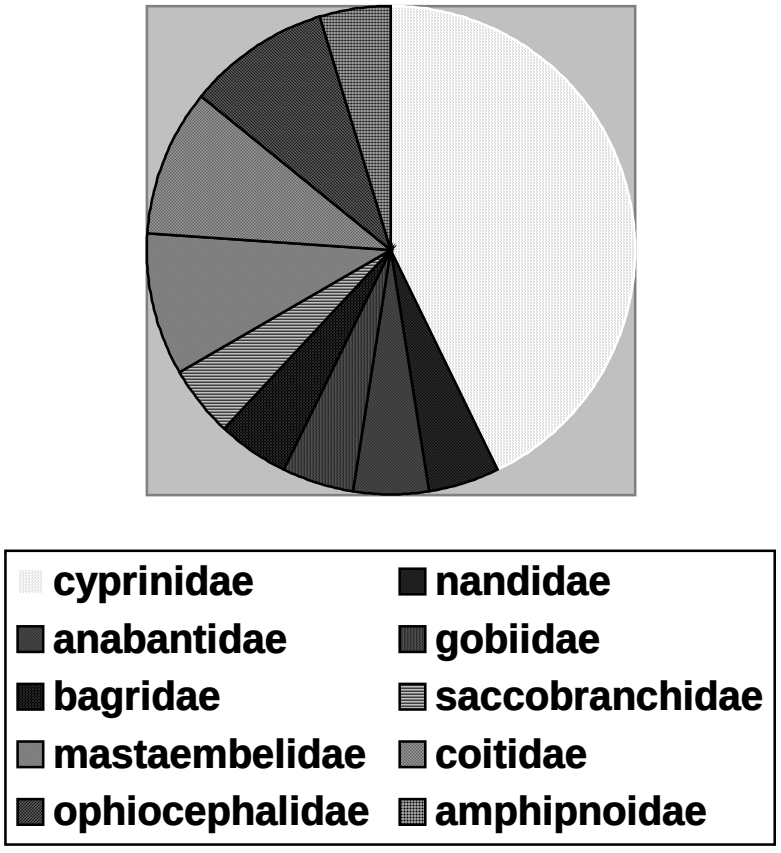


Table 8: Classification of the fish species collected from the Kesali river.

TS. N.	Name of species.	Order.	Division.	Family
1	Barilius bendelisis	Cypriniformes	Cyprini	Cyprinidae
2	*B. barna*	’’	’’	’’
3	*B. bola*	’’	’’	’’
4	*Esomus danricus*	’’	’’	’’
5	*Garra annandalei*	’’	’’	’’
6	*Puntius conchonius*	’’	’’	’’
7	*P. sarana*	’’	’’	’’
8	*P. sophore*	’’	’’	’’
9	*Rasbora elanga*	’’	’’	’’
10	*Mystus bleekeri*	’’	Siluri	Bagridae
11	*Heteropneustes fossilis*	’’	’’	Saccobranchidae
12	*Lepidocephalicthys guntea*	mastacembeliformes		Cobitidae
13	*Nemacheilus botia*	’’		’’
14	*Mastacembelus armatus*	’’		Mastacembelidae
15	*M. pancalus*	’’		’’
16	*Channa gachua*	Ophiocephaliformes		Ophiocephalidae
17	*C. punctatus*	’’		’’
18	*Colisa fasciatus*	Perciformes		Anabantidae
19	*Glossogobius giuris*	’’		Gobiidae
20	*Badis badis*	’’		Nandidae
21	*Amphipnous cuchia*	Symbranchiformes		Amphipnoidae

Table 9: Common name and status of fishes found in the Kesali River.

S.N.	Name of species.	Local name	Status
1	*Amphipnous cuchia*	Andha bam	Uncommon
2	*Barilius barna*	Nau dargi	Common
3	*B. bendelisis*	Tila macha	Common
4	*B. bola*	-	-
5	*Esomus danricus*	-	-
6	*Garra annandalei*	Pathar chatta	Common
7	*Puntius sarana*	Pothi	Common
8	*P. sophore*	Pothi	Common
9	*P. conchonius*	Pothi	Common
10	*Rasbora elanga*	-	-
11	*Badis badis*	Kalo macha	-
12	*Lepidocephalicthys guntea*	Paiya	Common
13	*Nemacheilus botia*	Raja paiya	Common
14	*Mystus bleekeri*	Tengra	Common
15	*Heteropneustes fossilis*	Singhi	Common
16	*Channa gachua*	Hile	Common
17	*C. punctatus*	Garai	Common
18	*Colisa fasciatus*	-	Common
19	*Glossogobius giuris*	Bulla	Common
20	*Mastacembelus armatus*	Kaichi bam	Common
21	*M. pancalus*	Kaichi bam	Common

6.3 Socio-Economic condition of Fishermen:

The socio-economic conditions of fishermen of Kesali River were studied in the vicinity of river by direct observation and informal interview. Most of the villagers from different communities residing close to the river were found engaged in fishing. But these people had not taken fishing as a profession or full time job. The real fishing community of Kesali River is locally called “Jalari”. In general, fishermen of Kesali river could be classified into three different categories:

a) Full time fishermen

Only few full time fishermen were recorded from the study area. They were known as “Jalari” and mostly they were Indian nationality belonging to the different caste like Sahani, Mukhia, etc. Fishermen used different types of fishing implements in different seasons depending upon the nature and behavior of different fishes. Most of their catches were sold in the close local market and sometimes the catch was consumed by themselves when it is very low. According to them, they caught 1-3 kg fish per day in an average depending upon the water level and the season. Besides fishing in river, these fishermen supply fingerlings to different fish farmer in certain season and also buy the cultured fishes from the farmers to sell in city market or supply to bulk collector. They also harvest marketable fishes from ponds on wage.

b) Part time fishermen

Most of the fishermen of this area fall under this category. People like Chaudhary, Tharu, Dhimal, etc. come under this category. They own land and engaged in the agriculture during farming seasons. They go to fishing in groups or alone during free time. Their main profession is agriculture and fishing is only part time profession. They usually consume their catches and only rarely sell it. They use all types of fishing implements.

c) Occasional fishermen

The occasional fishermen are active in fishing activities when their agriculture load becomes low. Most families from the villages around Kesali River turn into occasional fishermen in summer. Most of the village boys and girls are engaged in fishing during flooding. They usually use hook and lines, and chanki in small canals of the river. Most of the occasional fishermen are students, when they get leave or free time they go to river. Usually this group was found fishing for recreation and pleasure.

6.3.1 Fishing and economic condition

Fishing activities continue throughout the year. During the survey it was found that both men and women along with young boys and girls are involved in the fishing. Men usually uses cast net while women and children uses chanki net for fishing. The fishing pressure increases during monsoon due to increase in the large sized fishes along with the increase in the water.

Economically, fishermen inhabiting along the Kesali River are not so poor. They have their own land for agriculture and do agriculture as their major profession. Majority of fishermen are living in small houses made up of bamboo and mud wall and have thatched roof (rice straw).

6.3.2 Education

Mostly the older generation is illiterate but younger generation is aware about the education and attracted towards it. It was found that the fishermen of this area are very much interested to give education to their children and sending their children to school. They are aware of facilities available of free education in the government school.

6.3.3 Family Size

Majority of fishermen are having the family of 5-10 members. Mostly the older generation is not aware about family planning, but younger generation is more educated and aware about the family planning and has taken benefit from it. Old generation thinks that there is no need of family planning because children are the blessing of God and helps in work and look after them at their old age.

6.4 Fishing appliances and methods used in Kesali River

From the general study it was found that there are different kinds of fishing implements and methods used in Kesali River for catching fishes by local fishermen. These fishing methods can be mainly grouped into two categories as follows:

a) Conventional fishing methods

Conventional fishing method includes most of the traditional fishing practices like use of different types of nets, hook and lines, trapping devices, etc. as well as fishing with hand. Followings are the conventional fishing appliances and methods used in Kesali river area:

1. **Cast net**

It is locally known as “Phakna jal”. Cast net is a round shaped net with pieces of iron or lead attached along the circumference, which makes the net sink in water. A long rope is tied to the center of the net which is used to handle the net. While fishing this net is thrown with a jerk and allowed to settle to the bottom of the river which traps the fishes, when the net settles at the bottom it is pulled with the help of rope tied in the middle of the net. It is used throughout

the year in Kesali river. It is more efficient for catching fish in low water upto 50 cm depth.

2. **Chanki**

It is made of two bamboo flanks crossed each other and tied at the mid point. A square nylon net or locally prepared net is loosely tied at the four ends of bamboo flanks. Generally village boys and girls use this device for fishing. While fishing this net is dipped in the water and taken out after sometime with the help of bamboo flanks. It is only used to catch small fishes like *Puntius sp.,Colisa sp.*, shrimps, etc.

3. **Dhadiya**

It is with a wide mouth and tapering body. Mouth is covered with bamboo sticks except in one side where there is a small opening. Once the fish go inside they cannot come out. It is usually used in dam area and small canals made to irrigate rice fields.

4. Hook and line

Fishing with rod and line is locally known as “Balchhi Khelne”. It consists of a long and slender rod, nylon thread and hook. One end of the nylon thread is tied at the tip of the rod and another end of the nylon thread is tied with the hook. The hook is baited with pieces of earthworm.

5. **Fishing with bare hand**

It is a common ancient practice of fishing without gears. In this method, fishermen dip his hands quite slowly into water and searches fish in the crevices and aquatic vegetation and grasp the fish. This method is used to capture small and moderate sized fishes, crabs and molluscs.

6. **Draining water mass**

It is another common and ancient practice of fishing without gears. This method is practiced mainly during dry season when the water level is very low. In this method, small mass of water is separated building embankment and water is drained out manually, and when the area becomes dry fishes and other aquatic animals are caught by hand.

b) Non-conventional fishing methods

Non-conventional fishing method includes those which are recently developed fishing practices like used of explosive, use of chemical poisons, etc.

7. **Use of explosive**

It is commonly known as “Gola-hanne”. In this method explosive is wrapped in thick cloth or plastic and tied in the stone and thrown to river instantly after igniting. As it explodes the fishes are killed and floats which are collected by hands or net. This practice is very rarely used by local people.

8. **Use of poison**

It is commonly known as “Bikh halne” and one of the most harmful non-conventional fishing practice used in Kesali river. While fishing with poison, appropriate amount of poison is calculated and applied to the river, which either kills or paralyse the fish and these fishes are collected by hand or net. It not only kills the fish but also all the large and small animals and insects without discrimination. Usually poison extract from plants like Khirro (*Sapium insignes*), Sihudi (*Euphorbia royleana*), Ketuke (*Avage americana*), Mahuwa (*Madhuca indica*), Pire sanewar (*Polygonum hydropiper*), etc. are used. Beside plant poison, some chemical poisons like Malathion, DDT (Dichloro Diphenyl Trichloroethane), etc are also used.

6.5 Impact of irrigational dam on the Kesali river:

During the study it was found that the irrigational dam had caused adverse/negative impact on the Kesali River by changing the nature of the river ecology.

6.5.1 Reservoir formation with heavy growth of vegetation

It had changed the upper part of the dam into a small reservoir, where there is a heavy growth of vegetation due to the accumulation of mud and other organic matters.

6.5.2 Dry out condition on downstream

It was also observed that the impact of irrigation dam was less in the upper region of river above the dam in comparison to the down stream of the river. Usually during the dry seasons, it was found that the water of the river is totally diverted to the irrigational canal leaving the down stream of the river totally dry, which has the negative impact on the plants and animals of the river living downstream. In such season pockets of water were found in the different parts. Some fishes present in the pockets were caught by both human and birds.

6.5.3 Obstruction in the of movement of migratory fishes

Construction of irrigational dam in the Kesali River had caused inconvenience in the free movement of the migratory fishes. Even during the monsoon season when the river is flooded free movement of the fishes was not possible because of the high current water flowing through the open sluice gate and lack of fish ladder.

6.5.4 Occurrence of cultivated and local fishes not found locally

Along with the local fishes, different new fishes were found in the river coming from the canal of Koshi River. The most prominent fishes recorded here and

reported by local people were *Xenentodon sp.* and cultivated carps passed from pond to the canal finally reaching the river.

6.5.5 Other problems affecting fishes of Kesali River

21 species of fishes were recorded in the present study and most of them belonged to cyprinidae family. The Kesali River was found to support diverse ichthyofauna. Besides irrigation dam, fishes of Kesali River faced serious problems due to the lack of any measures adopted for the fish conservation and management. There is no management or conservation activities (like riverine habitat management, release of hatchery reared fishes etc.) so far adopted in Kesali River. Some of the major problems, which have been identified for the declination of fish population in Kesali River, are as follows:

a. **Destruction of natural habitat by floods**

Flood affects river ecology severely. Usually during flood, river changes its course and the area close to the river is swept away. Due to soil erosion, composition of river bed is disturbed.

b. Deforestation, sand and stone mining

Deforestation at the head area of Kesali River had decreased water level since last decade decreasing the population and number of good-sized fishes (version of local people). Sand and stone mining had spoiled fish habitat and breeding ground.

c. **Pollution**

Human activities are visibly disturbing the environment. People wash clothes using soap and detergents in river. Farmers were found to use pesticide like Aldrin, Thiodine, BHC and Malathion, and chemical fertilizers along the riverside fields which not only adversely affect the aquatic life but threaten

human health. Besides these garbage and sewage were also found disposed in the river causing pollution in river.

d. Use of Destructive Fishing Methods

In Kesali River, some of the fishermen operated destructive fishing methods like use of poision, draining water, use of explosive, etc. Such activities affect whole aquatic ecosystem. This fishing method kills all sized fishes along with other aquatic organisms.

e. **Lack of Awareness**

Lack of awareness about the importance of riverine fishery in the local inhabitants was responsible for the destruction of riverine fishes. Uneducated local fishermen do not understand the destructive nature of fishing method and the importance of natural habitat of fishes. People of this area are not concerned about the fish fauna except the agriculture. Even the staffs of the “Sunsari Morang Irrigational Project” took natural fish fauna casually and undermined the importance of fish population and did not give enough attention in the protection and conservation of aquatic fauna.

CHAPTER SEVEN
DISCUSSION

Nepal is a small kingdom rich in fish biodiversity due to its spectacular topography, geography, climatic contrast and vast water resources. Different developmental works like hydropower development, irrigation projects, disposal of sewage, industrial effluents and agro-toxic chemicals have altered the water quality drastically affecting fish diversity to a considerable extent. The present study is an attempt to study the impact of irrigation dam on fish and fishery of Kesali River.

Diversity of aquatic organism in the water is determined by several factors, which includes physiochemical parameters as well as altitudinal variation. According to Hynes (1970), physical factors of the environments are more important to the diversity and distribution of fishes. The colour of water indirectly affects the fish population by blocking the sunlight and decreasing the plankton production. Transparency is another important physical factor which determines the productivity directly or indirectly. Transparency is a measure of water turbidity allowing the penetration of light and photosynthetic activities. During the present study period, water remained highly transparent all throughout the year except in rainy season due to rainfall and high flood. The transparency of Kesali River ranged from 29.5 cm to 46 cm.

It is well known that all the aquatic organisms have well defined limits of temperature tolerance that includes fishes also. All metabolism and physiological activities and life processes such as feeding, reproduction, growth rate, movement and distribution of aquatic organisms are greatly influenced by water temperature. For example, the places with boulders, pebbles, gravels and fine sandy substrate with water temperature 15^0C to 18^0C and current velocity 3 to 9 m/s are dominated by sucker headed fishes like *Garra* sp. (Shrestha, 1990).

The depth of water is an important physical parameter which directly or indirectly affects the fish species diversity. During study, it was observed that small fishes were found distributed in shallow habitat and large sized fishes were recorded in higher depth. The depth of Kesali River varied in different seasons due to rainfall and flood. The depth of Kesali River ranged from 25 to 157cm in the present study. The depth of the river decreased due to absence of rain fall in winter and spring while it starts increasing from late summer when rainfall start and reaches peak in July/August. Due to the increase in water volume and depth, large sized fishes were observed during rainy season.

Water velocity plays a major role in the determination of habitat and abundance of flora and fauna in a river by grading the river bed and maintenance of high level of dissolved oxygen (Whitton, 1975). The water velocity was noted to have a great significance in distribution of fish species in the river as *Barilius sp, Garra sp* were distributed in fast flowing water whereas *Channa sp, Lepidocephalicthys sp* were distributed in slow water current. The velocity ranged from 9.0 to 15 m/s. The maximum velocity of 15 m/s was recorded during August and the minimum was recorded during February. The water velocity is found high in rainy season in all the stations due to high volume of water.

The pH of natural water is an important environment factor, the variation of which is linked with the species composition and life process of animal and plant community (Jhingran, 1991). Under natural conditions, small variation of pH value has little effect on fishes as they can tolerate the normal daily pH range (Whitton, 1975). According to Welch (1952), the current of lotic environment tends to keep pH uniform over considerable distance. According to Jhingran (1991), fish dies at pH 11. Generally, alkaline water up to 9.5 is suitable for fish growth. Acidic water is unsuitable for fish and other aquatic invertebrates as it not only reduces the appetite of fish but also growth and tolerance to toxic substances. The pH ranged from 6.5 to 7.6. The maximum pH was recorded in May and the minimum in November. Present study of Kesali River revealed that the water of the river was slightly acidic with average pH of

6.9. It was observed that the pH of water decreases during May and gradually increases in August, November and February.

The most important chemical parameter, which affects the distribution of fish species, is the concentration of dissolved oxygen of water. Dissolved Oxygen (DO) above 5.0 mg/l is suitable to support diverse biota (APHA, 1978). The average DO in present study was 8.03 mg/l and the value of DO varied from 6.8 mg/l at the sites II during February to 8.9 mg/l at site III in August respectively.

The distribution of Carbon dioxide in surface water varies both seasonally and vertically. Most of the carbon dioxide in the water comes from the decomposition of organic matter and from respiration of organism. Carbon dioxide stands at the threshold of all production (Cole, 1975). Free carbon dioxide in the present study varied from 13.0mg/l in November from site I and II to 18.0 m/l in May from site II. The average free carbon dioxide in Kesali River was 15.58 mg/l.

The bottom substratum is an important factor to fish as well as invertebrates as it serves a habitat for them. Although sand and gravel dominate the bottom substratum of Kesali River, there is some difference in composition among the four sampling stations. The dominant bottom substratum in stations I, III and IV is gravel and sand, where as in station II it is sand, gravel, mud and other organic matters.

The principal fish species of Kesali River are *Puntius sophore* and *Puntius sarana* which are locally known as 'Sidra macha'. Other common fishes are *Barilius barna* (Nau dargi), *B. bendelisis* (Tila macha), *Garra annandalei* (Pathar chatta) etc. It was found that fish capture was high in May and August months while it was low in November and February months. Station I and II are situated at the upstream of river while station III and IV lie at the downstream of river from the dam. The fish capture and fish species distribution was high in sampling station III and least in station II. The sampling revealed that the population of fish species is higher in the downstream of the dam in comparison to the upper stream during high water flow (Table 5-6).

Majority of the fish species collected from the Kesali River belonged to the order Cypriniformes. In present study cyprinid fishes were most common fishes in Kesali river comprising about 52 % of the total fish species. Family cyprinidae consists of about 42% of total fish species. According to local fishermen the fishes like W*allago attu* (Buhari) and *Channa striatus* (Saura) were also found during the heavy flood. The seasonal catch composition of fish species in Kesali River revealed that the catch per hour effort is high in the month of August. As the water volume increases number and big sized fishes also increases. The catch per hour effort decreased in the month of November and February due to decrease in water volume.

Fishing implements and practices used in Kesali River were also studied in present study and revealed fishermen, of this area, still following the traditional methods and implements. In Kesali River fishermen used both conventional and non-conventional fishing methods. The fish capturing methods in the Kesali River are similar to those of the other parts of the Nepal. Most of the fishing appliances used in Kesali River is seasonal and only cast net and hook and line are being used throughout the year. Non-conventional fishing methods include poisoning, dynamiting in pools and use of small mesh sized net. Non-conventional fishing practices kill non target fishes, small fishes and other unrelated aquatic organisms. Draining of water is another harmful fishing practice generally employed in Kesali River.

Twenty-one fish species recorded in the present study, none of them were vulnerable, endangered or protected species as mentioned to be threatened and merit in Red Data Book of Nepal (Shrestha, 2001). An attempt was made to identify the fish predators of the Kesali river area. During study some predators of fishes were noted from observation and local fishermen. Duck, kingfisher, heron, large fishes and water snakes were the major predators. The natural fish habitat is being destroyed in Kesali river due to large number of environmental factors such as soil erosion, floods, silt deposition and human activities such as irrational fishing, use of pesticides in a near by fields, construction of dam, etc. however, among them construction of irrigational dam and deforestation in the origin area of Kesali river are the most serious and important cause of fish depletion.

The socio-economic condition of fishermen at the study area was found to be normal, as most of them own land. They are part time or occasional fishermen as they were involved in fishing when agricultural load became minimum. Fishermen from India were found to be full time fishermen and take the fishing as their main profession. The family size of fishermen varies from 5 to 10 members in each family. They live in a small house made up of bamboo or mud wall with thatched roof. Sharma (1996) and Malla (2004) had reported poor economic condition of the fishermen in Trishuli and Daram Khola respectively.

Fishermen of older generation are illiterate but younger generations are literate and interested to educate their children. The fishermen in the study area are aware of the available facilities of free education programs in government schools and send their children to school.

The market system in the area is very poor. However, the main market of this area is “Neta Chowk” and “Som Bare” where fish and vegetables were sold. Fishermen sell the catch at Rs.80-120/kg. The fishermen are not getting good return to the effort due to lack of proper fish market system. Shrestha (1994) also reported the marketing system of Nepal is not well organized and lack of separate market for fish in Nepal.

CHAPTER EIGHT
CONCLUSION AND RECOMMENDATIONS

8.1 Conclusion

The present study entitled "**Study on impact of Irrigation Dam on fish and fishery of Kesali River**" was conducted for a period of 10 months (from November 2006 to August 2007) covering four different seasons. This study dealt with physicochemical parameters, fish diversity, population, socio-economic status of fishermen, fishing implements and impact of irrigational dam on the Kesali River.

Physicochemical parameters showed fluctuating throughout the year with average water temperature of 25.0^{o}C, average depth of 80.16 cm, average transparency of 37.5 cm, velocity of 12.0m/s, average dissolved oxygen of 8.03 mg/l, average free carbon dioxide of 15.58 mg/ l, and average pH of 6.9.

A total number of 21 species of fish fauna were collected from the different sampling stations of Kesali River belonging to 5 orders, 10 families and 15 genera. Fishes were collected mainly with the help of local fishermen using cast net. The distribution of fishes in Kesali River was found influenced by the physical (velocity, depth, etc) and chemical parameters.

Establishment of irrigation dam had affected fish diversity and population especially in dry season due to the total diversion of river water. Dam had also affected free movement of migratory fishes due to the lack of fish ladder. Invasion of cultivated fishes and other natural fishes not found here locally was another remarkable change noticed here.

The study showed that the riverine environment undergo degradation due to various natural and man made constructions like land slides, erosion, erosion, dam construction, bridge construction, over fishing, illegal fishing, etc. The main reasons for

such activities are lack of education and awareness. People are unaware of the importance of ecosystem and environment.

The present study on the fish diversity and fishery resources of Kesali river showed that the Kesali river is an important tributary of Lohandra river and important for ecological and fishery point of view. Good management of Kesali River will help to increase the total production of capture fishery and protection of local fish fauna.

8.2 Recommendations

Improvement of fisheries in natural waters offers a great opportunity for self-employment and income generation among poor people living along the rivers. But no work has been done for the conservation strategy of fish fauna in Kesali River by any sector so far. Due to the absence of such priority on the conservation and management in this river, there is a degradation of riverine fisheries. Therefore, for successful conservation and management of indigenous fish species in Kesali River, following recommendations can be made.

- Inappropriate fishing practices like use of fine mesh sized cast net not only catch the target fish population but also non-target fish juveniles. Hence, these harmful methods must be checked and totally banned for proper conservation and management of fish diversity.

- Many non-conventional methods of fishing like poisoning, dynamiting, etc. are being used in Kesali River. Such methods not only kill the large fishes but also destroy many small fishes and fingerlings including other aquatic organisms along with their habitat. Therefore, such fishing methods should be stopped immediately.

- Different species of fish breed in different seasons and different habitat. Thus their habitat should be protected, and mining of sand and gravels from the river should be banned.

- Most of the fishes living in the down stream are greatly affected by the drying of down stream by the diversion of water to the canal. So, the rule of Riparian flow rule should be followed.

- Construction of fish ladder in the dam area should be done to facilitate the easy movement of the fishes. Regular training and awareness program should be conducted in local level for the conservation of river and biodiversity through environmental conservation education at school level, public meeting and adult literacy classes from governmental as well as non-governmental organization.

- In Nepal, very few research activities have been conducted in small river from fishery and aquatic resources point of view. Therefore, it should be necessary to increase the research activities on fishery in small rivers by encouraging researcher.

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PHOTO SECTION

Station I

Station II

Station III

Station IV

Picture showing the dam at Kesali river.

Fisherman fishing at the low water area.

PHOTO SECTION

Local fishermen with his fishing gears.

Fishermen showing cast net.

Fishermen throwing cast-net.

Fishermen using cast-net.

Fishermen collecting fishes from cast-net.

Hundi, Bhar and weighing balance.

PHOTO SECTION

Fishing using cast-net.

Fishing using Chanki-net.

Fishing by draining water mass.

Fishermen selling fish in local market.

Dry fish at local market.

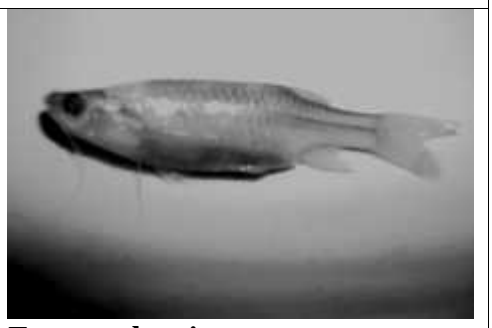
Sun drying of small fishes.

PHOTO SECTIO

Barilius bendelisis

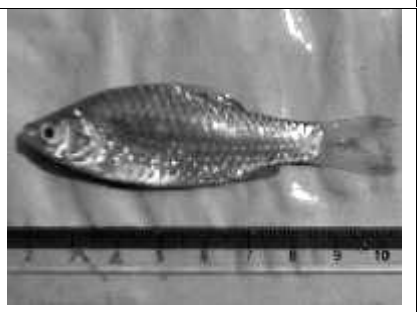
Barilius barna

Barilius bola

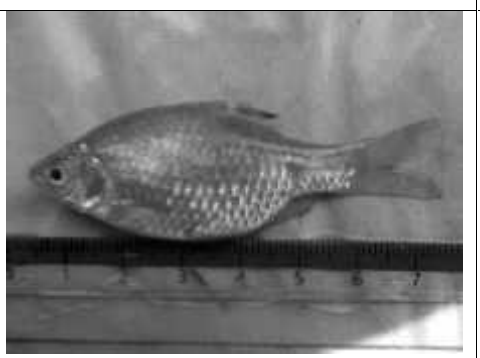


Esomus danricus

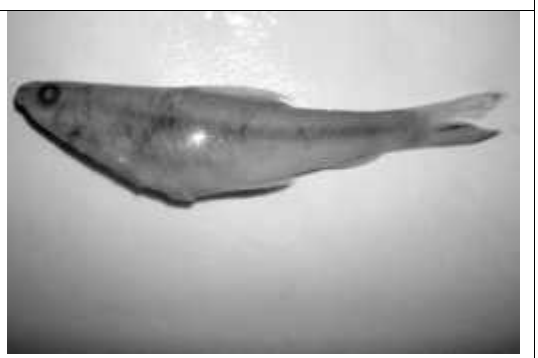
Garra annandalei



Puntius sarana



Puntius sophore



Rasbora elanga