CHAPTER ONE

INTRODUCTION

1.1 GENERAL BACKGROUND

Nepal is a small country with an area of 1,47,181 square kilometer. It is surrounded by India in the south, east and west and China in the north and stands between the latitude of 26°22' to 30°27' North and longitude of 80°4' and 88°12' East. It extends 885 km along the East-West with an average width of 193 Km along the North-South. Within this limited area, there exists a remarkable altitudinal variation ranging from the plain in the south with hot subtropical climate to the mountain region of temperate climate and very cold alpine climate in Himalayan region. The southern Terai region is an extension of Indo-Gangetic plain, on its north lies the Churia range. Its elevation ranges between 300m to 500m, which at places reaches about 1800m (Rao and Gupta, 1998).

In Nepal rainfall occurs due to the south west monsoon, which lasts from the month of June to September. The humid monsoon air streams blowing from the Bengal are forced to rise as it meets the Himalayan, as a result heavy rainfall occurs. Based on rainfall records collected by the Department of Hydrology and the Metrology, Nepal receives about 1500 mm rainfall during a good monsoon regime.

Nepal has rich freshwater resources, which constitutes snow fed rivers, lakes, ponds and torrential hill streams. The water of Koshi, Gandaki, Karnali and Mahakali river systems provide suitable habitat for a number of fish species. The water surface area of Nepal covers 0.1% of the total world water and the diversity is 0.21% of the global fish diversity (Shrestha, 1995).

Nepal is endowed with rich biological diversity. Among different natural flora and fauna, the king of aquatic system is the fish which lives in water throughout its lifetime. Nepal has only freshwater habitats covering an area of 7,45,000 hectors (5% of total area) that includes rivers, lakes, ponds, wetlands, reservoirs and irrigated fields.

A fundamental feature of the earth is an abundance of water, which covers 71% of its surface to an average depth of 3800 m. Of the total water about 97% remains in the

seas as salt water amnd remaining 3% exist as fresh water in rivers, lakes, streams, reservoirs, underground water, polar caps and permanent glaciers etc (Wetzel, 1983).

1.2 WATER RESOURCES OF NEPAL:

Nepal's chief source of exploitable energy remains as waterpower in the form of wetland ecosystem and the second richest country of the world for possessing about 2.27% of the worlds water resources.

Nepal is endowed with several types of wetlands. The total estimated wetland resources consist of permanent fast flowing rivers to seasonal streams, high altitude glacial lakes to low land oxbow lakes, ghols to swamps and marshy lands, river flood plains to paddy fields and man made reservoirs to village ponds.

Table 1: Estimated Water Resources of Nepal

Resource Details	Estimated Area (ha)		Percent Coverage	Potential Area (ha)
Natural Water	Rivers	3,95,000	48.34	
	Lakes	5,000	0.61	
Reservoirs		1,500	0.18	78,000
Village Ponds		6,500	0.80	14,000
Seasonal Water	Marginal Swamps	11,100	1.36	
	Irrigated Rice Field	3,98,000	48.71	
Total		8,17,100	100	92,000

Source: Directorate of Fisheries Development, 2007

1.3 RIVER SYSTEM OF NEPAL:

Nepal, a Himalayan country, is blessed by nature with a vast network of rivers and streams. Rivers in Nepal can be classified into three categories in terms of their sources of dry season discharge. Generally, responses of all rivers follow the rainfall pattern.

The first group of rivers has its sources in the snow and glaciers in the dry season. The Mahakali, the Karnali, the Gandaki and the Saptakoshi are the four rivers in the first category. The second group of rivers originates in the middle mountains, which is mostly rain fed and low dry season flow. Bagmati, West Rapti, Mechi, Kankai, Kamala and Babai are the rivers in the second category. Rivers in the third categories originates in the Churia, southern face of the Mahabharat or in the Terai. These rivers have small catchment areas. In dry season, the discharge of these rivers becomes

nominal while several rivers dry up. Tilawe, Sirsia, Manusmara, Hardinath, Sunsari, Banganga are some of the rivers in this group. All these large and small rivers give rise to about 6,000 rivers totaling about 45,000 Km in length. Approximately, 1000 of these rivers are more than 10 km. long and about 100 of them are longer than 160 km (Sharma, 1977).

There are four major river system in Nepal, which drains out the country, Saptakoshi in the east, Saptagandaki in the Centre, Karnali in the west and Mahakali in the far west. Out of the four, the three i.e. Saptakoshi, Saptagandaki, Saptakarnali originates from the Tibetian Plateau and crosses the Himalayas. Each river system has several tributaries, which are fed by snow and glacier, melt from the Tibetian Plateau and the Himalayas. Thus these river systems are separately called as the Saptakoshi, Saptagandaki and Saptakarnali.

Map 1: Nepal with its river system.

1.3.1 The Saptakoshi River System

From the point of view of drainage area, the Koshi is the greatest river system in Nepal. It is said that it is as big as Indus and the Brahamputra rivers of India. It flows particularly in the eastern Nepal in the east by Gosaithan and west of Kanchanzanga area. The seven tributaries of Koshi river system are:-

i.The Arun Koshi ii.The Dudh Koshi
iii.The Indrawati iv.The Likhu
v.The sun Koshi vi.The Tama Koshi and

vii.The Tamor

1.3.2 The Saptagandaki River System

The Gandaki River rises from the Muktinath area. It flows between Dhaulagiri and Gosainthan. Budhi Gandaki, Marsyangdi, Seti and Trishuliganga join it in the mid-land part. It flows through the churiya hill making its way at Tribeni ghat and appears in the plains forming the Narayani River. The seven tributaries of gandaki river system are:-

i.The Budhi gandaki ii.The Kali Gandaki
iii.The Madi iv.The Marsyangdi
v.The Myagdi vi.The Seti and
vii.The Trishuli

1.3.3 The Saptakarnali River System

The Karnali rises in the Tibetian region of China near Lampiya Dhura pass between India and the Tibet. It flows south easterly through the Tibetian Plateau and then enters Nepal in a gorge through the Lipa Lekh. It is said to be the major river system in the western Nepal. The seven tributaries of Saptakarnali riverv system are:-

i.The Budhi Ganga ii.The Humla Karnali
iii.The Mugu Karnali iv.The Seti Karnali
v.The Sani Bheri vi. The Thuli Bheri and
vi.The Tila

1.4 THE KALI GANDAKI RIVER:

Kaligandaki is the main river in the Sapta-Gandaki River System and is considered to be the main stem of the Narayani River. It rises in the Mustang Bhot area. It is called Muktinath or Mustang Khola in the upper reaches and Kaligandaki from the North of Chhukgaon area onward. It flows to South from Mustang through a deep gorge flanked on the West by Dhaulagiri and Annapurna Himal. Various feeder streams and Khola join the Kaligandaki river at different zones like the Myagdi Khola at Beni Bazaar, the Modi Khola near Kusma, the Barigad Khola at Barighat and the Riri Khola at Riri Bazaar. Further, it joins the Trishuli Ganga at Deughat henceforth known as Narayani. Further south the Narayani meet the Rapti at Golaghat. The total drainage area of the Kaligandaki is 6,630 km² at Seti Beni, and the drainage area of Narayani at Narayanghat is 31,100 km². The total snow covered area of Kaligandaki watershed is about 21,000 km². The total length of Kaligandaki River in Nepal territory is about 300km (Shrestha, 1990). The headwaters of Kaligandaki River flow approximately 60km southward before collecting the Chalunga River to become a

fourth-order stream in the North of the Great Himalaya Range. Kaligandaki then transverses mountain ranges at a Riverbed elevation of about 2500m near Kalapani and flows 80 km before joining the Myagdi at Beni to become a fifth-order stream. Near Ridi bazaar, at Badighat, the Kaligandaki meets the Badigad River and is a sixth-order stream that flows nearly 200 km. to the East before joining the Trishuli. At the confluence with the Trishuli, the river becomes a seventh-order stream and is known as the Sapta-Gandaki or Narayani River (Edds, 1989).

1.4.1. Physiography of Kaligandaki:

The total area of the catchment basin of Kaligandaki is approximately 13,000 km^2. The river system of Kaligandaki composed of numerous tributary streams. The five longest tributaries are Barigad (79 km), Myagdi Khola (68 km), Aandhikhola (65 km), Riri Khola (63 km) and Modi Khola (49 km). The Gandaki River forms the deepest valley as it flows between 8000 m mountains on its way from headwaters on the Tibetan Plateau at more than 4000 m altitude to lowland, subtropical confluence with the Ganges at less than 50 m altitude.

Superimposed on the physiographic feature of the drainage are the dramatic changes associated with the seasonal monsoon. Much of the Gandaki basin south of the Himalayan Mountain receives more than 250 cm of rain during the June-September rainy season which results greatly increases the river discharge and turbidity (Sharma, 1977). Mean monthly discharge, for the Gandaki River at Seti Beni in 1976 ranged from $45m^3$/second in March to $90445m^3$/second in August (Anonymous, 1984). Two other distinct seasons typically occur in dry season from February to May (Edds, 1993).

1.5 Fish Diversity of Nepal:

The published literature on fish and fisheries of Nepal reveals a total of 184 (Shrestha, 2000) indigenous fish species belonging to 92 genera, 31 families and 11 orders which are distributed in different rivers and other water bodies of Nepal (Shrestha, 1981, 1992, 1994, 1995; Terashima, 1984; Subba and Ghosh, 1996). A total of 232 species of fish have been found from Nepal (Shrestha, T. K. 2008). Fishes of Nepal have wide distribution according to the climatic conditions and altitudinal variations. On the basis of published literature, out of 184 species, 127 species are reported from Koshi, 157 species from Gandaki, 119 from Karnali and 71 species from Mahakali River (Shrestha, 1992).

The fishes of Nepal are distributed from few meters in Terai to 3323 meters in Langtang Khola located in Langtang National Park (Shrestha, 1995). *Bagarius*

yarelli (Gounch) is the largest fish found in Nepal where as *Brachydanio rerio* (Zebra) is the smallest fish (Shrestha, 2001; Shrestha and Chaudhary, 2003).

1.5.1. Protected Status:

None of the fish species found in Nepal belongs to the categories of IUCN and CITES lists of endangered fish species. Shrestha (1995) has enumerated a list of indigenous fish species from Nepal. Biodiversity Profile Project studied all scattered accounts of fish species recorded from Nepal including their conservation and distribution status and prepared a status account of fish species of Nepal. The report indicates that out of 184 listed species 57 are common, 63 insufficiently known, 23 rare and 32 species are categorized as threatened species. 8 species are categorized in vulnerable category where as one species is given protected status (Shrestha, 1995).

Neolissocheilus hexagonolepis, Anguilla bengalensis, Tor putitora, Schizothoraichthys progastus, Schizothorax richardsonii, Chagunis chagunio and *Psilorhynchoides pseudecheinus are* few species listed in vulnerable category. Tor tor is the only endangered species found in Nepal. *Amblyceps mangois* and *Euchiloglarius hodgartitora* are categorized as rare.

1.5.2. Endemic Species:

Six species found in Nepal are given endemic status. *Schizothoraichthys nipalensis*, *Schizothoraichthys macroptalmus*, *Schizothoraichthys raraensis* and *Psilorhynchoides pseudecheneis* are the endemic species of Nepal. The other species categorized under endemic category are *Myersglanis blythi* and *Pseudeutropis murius batarensis* (Shrestha, 2001, Shrestha and Chaudhary, 2003).

1.5.3. Migratory Behavior:

Fishes of Nepal are divided into three major groups such as long distance migrant, mid range migrant and resident species on the basis of migratory behavior. The fish species categorized in each group are:

Table 2: Migratory fishes

Long Distant migrant	**Midrange migrant**	**Resident Species**
Tor tor	*Neolissocheilus hexagonolepis*	*Channa orientalis*
Tor putitora	*Labeo angra*	*Garra gotyla*
Anguilla bengalensis	*Labeo dero*	*Puntius sophore*
Clupisoma garua	*Labeo pangusia*	*Noemacheilus rupicola*
Bagarius yarrellii	*Schizothorax richardsoni*	*Botia almorhae*
	Schizothoraichthys progastus	*Barilius barila*
		Macrognathus pancalus
		Macrognathus aral

(Source: Shrestha, 2001, Shrestha and Chaudhary, 2003).

1.6.1. Fish diversity of Kaligandaki River:

Out of 157 fish species reported from the Gandaki River Syatem, 57 species were collected from Kaligandaki River during different levels of study conducted by the Kaligandaki "A" Hydroelectric Project. According to the Kaligandaki Fish Hatchery, Beltari, Syangja, the collected species are altogether 32 species.

The principal groups of fish found in Kaligandaki River are:

- Carps: Snow trout, Long nose trout, Sucker head and River Carps.
- Mahaseers: Copper mahaseer and Mahaseer
- Murrels: Bhoti and Hile.
- Live fish: Singhi
- Loaches: Stone loach
- Torrent Minnows: Faketa
- Catfishes: Torrent catfish and River catfish
- Barbs: Sidra and Pothi

1.6.2. Fish species recorded from Kaligandaki River:

Altogether 57 species of fishes were recorded in Kaligandaki River during different level of studies conducted by the Kaligandaki "A" Hydroelectric Project.

Economically Important Species:

Tor tor, Tor putitora, Clupisoma garua and *Neolissocheilus hexagonolepis* are the economically important fishes found in the Kaligandaki River. The other important fishes found in the Kaligandaki River are *Labeo angra, Labeo dero, Schizothorax* sp. and *Schizothoraichthys* sp. (Shrestha and Chaudhary, 2003).

1.7 Hydropower Development in Nepal:

Although Nepal is a small land locked country it is proud being a second richest country in water resources in the world. The southern faced slopes with rapid flow of water have high capacity to generate tremendous amount of electricity. For the development of nation, reliable and adequate supply of electricity is necessary. The Hydro power development in Nepal started from the establishment of first 500 KW Pharping Hydro Power Plant (HPP) in 1968 B.S. The available Hydro power potential, which is about 83,000 MW, is the preferred means of generating electricity in the context of Nepal. Despite this tremendous potential, present installed capacity of hydropower is very small, which isjust about 269 MW. This indicates that Nepal has to do a lot regarding HPP development (Bhandari, 1999). In the fiscal year 2000/01, the total available energy was 1868.42 GWh; the peak load recorded was 391.9 MW on January 18, 2001 (NEA, 2001).

1.8. Kaligandaki 'A' Hydroelectric Project:

The Kaligandaki 'A' Hydroelectric Project (KGA-HEP) is located in the Gandaki Zone of the Western Development Region of Nepal. The main component of the project is located at Syangja District in Gandaki Zone and partially encompasses other districts such as Gulmi, Palpa and Parbat. The Project site is approximately 180 km west from Kathmandu. The diversion dam is about 500 meters downstream from the confluence of Kaligandaki River and Aandhai Khola and in between the Harmichaur and Mirmee village of Gulmi and Syangja districts respectively.

The site was identified as most attractive among 37 potential sites for power production on the basis of Master Plan study of the Gandaki Basin carried out by

Snowy Mountains Engineering Corporation, Australia in 1979. The feasibility study of this Project was also completed in 1979. The study was funded by UNDP, NORPOWER Consultant carried out the detailed feasibility study and bridging site investigation in 1993 with the financial assistance from UNPD.

The power generated from the plant has been connected to the national grid through 132 kV single circuit transmission line to Lekhnath Sub-stations in Pokhara and double circuit transmission lines to Butwal Sub-stations. The Project work puts into commercial operation to integrated Nepal Power System on August 16, 2002. This Hydroelectric Project was constructed under the joint investment of government of Nepal and Nepal Electricity Authority on the loan assistance of donor agencies: Asian Development Bank and Japan Bank for International Co-operation. Morrison Knudsen International, USA, carried out the design and construction supervision of the Project (Anonymous, 2004).

Kaligandaki 'A' Hydrelectric Project is a daily poundage type scheme located on the Kaligandaki River with an installed capacity of 144 MW. The Project generates about 842 GWh of electric energy annually by utilizing a net head of 115 m. The main component of the Project comprises of; a concrete gravity diversion dam of about 100 meter in length and 43 meters of height, open surface desander, tunnel of about 6 km in length and 7.4 meter diameter and a surface power house. The surface area of the reservoir is 65 ha and 5.3 km long back water level. The project includes a 28.5 km of main access road running from the Siddharatha highway to the dam and power plant. The catchment area at the dam site is at 7618 km^2. The project diverted 141m^3/s water from Kaligandaki River for power generation. Due to diversion of river water flow is reduced in 50 km section of Kaligandaki from dam to powerhouse. The flow is subsequently reduced in 13 km stretch in dry period since there is no major tributary between dam to Badigad Khola. The project construction was started in 1997 and completed in April 2002.

The Environmental Impact Assessment (EIA) study was conducted in 1996 according to National EIA Guidelines (1993) and Asian Development Bank Guidelines (1990). Nepal Electricity Authority, Environmental and Social Studies Department (ESSD) have prepared the Post-Construction Environment Audit report of Kaligandaki "A" Hydroelectric project in 2003.

1.8.1. Diversion Dam:

The diversion dam is located at the border of Syangja and Gulmi districts on the Kaligandaki River. It is designed as a concrete gravity structure with gates with

overflow spillway. The spillway consists of three bays, each controlled by a 15 m wide by 19 m high radial gates. The left bay gate is provided with a 7 m wide and a 7.5 m high basculated gate can pass about 20 m^3/s. On the right side a non-over flow gravity section of 20 m in length connect to the rock abutment. The dam is about 110 m in length. Two bridge decks, over the spillway section, one upstream and one downstream, are provided for handling for stop logs by individual gantry cranes.

The hydraulic design capacity of the spillway is 6400m^3/s, which is the 1000 year flood at the dam site. The spillway energy dissipater profile is shaped as a sub-merged roller bucket. The weir crest is at El.505.00, which are about 5 m about the pre-project riverbed. The heavy riprap stone placed immediately downstream of the bucket protects the rock bed against scour (Mahmood and Shrestha, 2001).

During and after the construction and operation period of 7 years, the regular systematic impact study has not been conducted. Monitoring study as recommended in EIA and in plan is also not conducted in a regular basis. Therefore, the core aim of the present investigation is to determine the degree of impact on fishery resources of the dewatered zones of Kaligandaki River between Mirmee to Beltari along with the effect on native people.

Damming and channelization on river obstruct the fish species in many ways such as: low flow of water or absent of water flow destruct the environment, loss of spawning ground, effect on fish migration of migratory species, chemical pollution, passing to high flow channel and turbine etc. which directly hamper fish population with seriously affecting the native fishing people Bote and Majhi.

1.9. Justification of study:

For the nation development, electricity is necessary but damming on river for power generation has caused different long and short term effects losing biodiversity. The establishment of aid operation of Kaligandaki "A" Hydroelectric Project increases the importance of the river to study the present impact situation. Blocking the water below dam area is at present a serious problem which causes loss of habitat, spawning ground for fishes. Altogether 57 fish species of fish have been reported from Kaligandaki River during different level of studies carried out by Kaligandaki "A" Hydroelectric Project. Among them, Asala, Katle, Budhuna, Sahar, Gardi,Fageta, Khurpe and Tilkabhre were dominant. The long distant migratory fish species were Sahar (*Tor putitora*), Jalkapoor (*Clupisoma garua*), fresh water shark (*Bagarius bagarius*) and King fish (*Semiplotus semiplotus*) (EIA, 1995). Such hydraulic structure will have direct and indirect impact on the environment and

aquatic biodiversity. Some environmental impacts due to the establishment of Kaligandaki "A" Hydroelectric Project in Kaligandaki River include the reduction in water flow below the dam, blockage of fish migration due to dam, increased erosion and landslides, loss of forestry resources, change in water quality and biodiversity (Norpower, 1992).

From the loss of fish diversity, mainly the local Majhi and Bote people are badly affected. So present study is an attempt to study the impact of dam on fish fauna and local community of the dewatered zone. Attempts have also been made to study the water quality in this zone and impat of dam on culture and socio-economy of Botesthe fishing populations of the region. The study will help the planners in improving or correcting any ongoing mitigation measures, which are not up to the standard for the better management of the whole Kaligandaki ecosystem. The study will throw light on the current economic situation of the fishing community.

1.10. Limitations of the Study:

The present study is mainly concerned with the impact of dam on fish diversity and native fisher communities of the dewatered zones. Due to the absence of well equipped biological and chemical laboratory in project site, some of the biological and chemical parameters could not studied. It was difficult specially in the rainy season to continue study because of higher turbidity of the river water.

CHAPTER TWO

LITERATURE REVIEW

Nepal is a landlocked country and rich in fresh water fish fauna. There are four major river systems viz. The Sapta Koshi, The Sapta Gandaki, The Sapta Karnali and The Mahakali River system providing a suitable habitat for diversity of fishes and other aquatic animals.

2.1 Fish Diversity:

Fishes were familiar to man since very ancient time but their study began only in the 18^{th} century focuissing only ontheir taxonomy and morphology. But later with the development of new scientific techniques and equipments, works on other areas of fish were also possible.

The oldest documented report on fish from Nepal dates back to 1793 A.D. by colonel Kirkpatrik. In his book on Nepal, he reported fishes like Sahar (*Tor* spp.) from Rapti River, Eel (*Amphipnious* spp.), Asala (*Schizothoraichthys* sps.) and Fageta (*Barilius* sps.) from Tadikhola. However, the credit of first scientific report on the fish fauna of Nepal goes to Francis Buchanon (Later Hamilton). He gave valuable authentic information on the fishes of Nepal in his book entitled "An account of the fishes found in the River Gangas and its tributaries" in 1822. He reported 24 species from the Koshi River and 2 fish species from Rapti River of Nepal. Rasbanshi (2005) published a paper from RONAST where he reported 187 fish species under 10 orders, 30 families and 94 genera.

Gunther (1861) reported some cold-blooded vertebrates including fishes collected by Hodgson in Nepal. 35 fish species were included in the checklist prepared by him. After them, Mc Clelland (1839), Beavan (1877), Day (1878-1881), Boulenger (1907) and Regan (1907) also reported different fish fauna of Nepal. Regan (1907) reported five species from Nepal. Hora (1920-1952) studied the Himalayan fishes with particular stress on paleogeographical distribution. He obtained a collection of fishes from Nepal through Bailey including 158 specimens comprising 22 different genera. He also included a full description of *Glyptosternum* collected from Pharping.

Menon (1949) collected 11 families of fishes comprising 26 genera and 52 species from Koshi River and also prepared a checklist of fishes of Koshi River. Taft (1955) submitted a report on his survey "Fishes of Nepal" and described 94 species of fishes from Kathmandu and adjoining areas.

Thapa and Rajbanshi (1968) studied the ecology of hill stream fishes of Nepal.

Majupuria and Shrestha (1968) published a paper on fresh water fishes of Nepal. Shrestha (1970) worked on the taxonomy of fishes of Nepal. She started the survey work in the year 1970 and attempted to survey most of the major rivers of Nepal and collected fishes including hill stream fishes from different zones throughout the country. Bhatt and Shrestha (1973) have studied the fish fauna of Suklaphanta and listed out 27 species.

Shrestha (1979) studied the resource biology and aquatic ecology of freshwater in Kathmandu valley with particular reference to fish population, marketing management and conservation. Again, in 1979, Shrestha and Pradhan studied the aquatic ecology and fishing potential of Bagmati River.

Shrestha (1981) publishes a book entitled 'Fishes of Nepal' covering the description of scientific data of 120 species.

Tarashima (1984) reported three endemic species of genus *Schizothorax macrophthalmus, S. nipalensis and S. rarensis*. Edds (1985) added a list of eight new records of fish previously not recorded from Nepal. Jha and Shrestha (1986) highlighted the prospects of fishery resources of Karnali River and recorded 51 species of fishes. Joshi (1988) studied the fishery resources of Sunkoshi River with particular references to dam and its impact on fishery. Shrestha (1991) reported 59 species from the natural water bodies of mountains and Himalayan region of Nepal in 'Cold water fish and fisheries of Nepal'. Shrestha (1994) described 66 genera and 129 species of fish in her book entitled 'Fishes, fishing implements and methods of Nepal'. Shrestha (1995) made an enumeration of 185 indigenous fish species but again in 2001, she revised her work with total of 182 species belonging to 93 genera, 131 families and 11 orders. Smith et al. (1996) reported 121 and 135 fish species in the Karnali and Narayani River.

Shrestha (1997) in his book, 'The Mahaseer, in the rivers of Nepal disrupted by dams and ranching strategies' identified some environmental impacts of hydropower developments on fish species. According to him, convention of free flowing rivers and hill streams to impounded waters with concomitant causes the loss of fisheries, physical habitat alteration of tail waters including changes in water temperature, channel morphology or stream substrates impact on indigenous fishes causing the reduction of recruitment of local species due to loss of spawning and rearing habitat. The stress and direct loss of fisheries due to Project operation causes standing nitrogen saturation and reduced oxygen

level, which culminates into loss of stream productivity and replacement of native species.

Malla (2004) studied on diversity, distributional patterns and frequency occurrence of fish and invertebrate species in Daram Khola, Baglung, Nepal. A total of 21 fish species elonging to 16 genera, 8 families and 4 orders were represented.

Shrestha (2008) reported a total of 232 fish species in Nepal in his book 'Ichthyology of Nepal'.

2.2 Limnological Study in Nepal:

As far as the limnological studies are concerned, Brehm (1953) was the first limnologist who studied some aquatic fauna along with the limnological studies from Kalipokhari, Eastern Nepal. Ferrow (1978) studied the limnology of the Lakes in Pokhara valley and its implication for the fishery and fish culture. Limnology of Bagmati and Trishuli Rivers have been studied to some extent by Shrestha et al. (1979). Swar (1980) has described the status of limnological studies and research in Nepal.

The physico-chemical parameters of Tadi River in relation to fish production and management were studied by Mahaseth (1988). Talling and Lamoalla (1998) reported some information about some tropical and temperate lakes of Nepal. Rai (2000) carried detailed study on limnological characteristics and seasonal abundance of Zooplanktons and Phytoplanktons from Phewa, Begnas and Rupa lakes in Pokhara valley, and reported 26 species of phytoplanktons and 18 species of zooplanktons.

Apart from these, various limnological works have been performed as parts of M.Sc. dissertation works and submitted to the Central Department of Zoology, Tribhuvan University, Kirtipur, Kathmandu by Sharma (1990), Upadhaya (1991), Kushwaha (1991), Chhetri (1992), Mandal (1992), Mahato (1994), Shrestha (1994), Shah (1994), Dangol (1994), Kushwaha (1996), Shrestha (1997), Shah (1998), Shah (1999), Kunwar (2002), Gautam (2003), Shrestha (2004) and Sharma (2004) worked on limnology of various water bodies of Nepal.

Pandey (2004) studied the fish and fisheries resources of Kaligandaki River with particular references to impact of dam on the River and reported 14 species of fish species from the Kaligandaki River.

The different studies carried out for EIA (1995, 1996) reported a total of 57 fish species present in Kaligandaki River.

2.3 Literatures on Socio-Economic Condition of the Fishermen of Nepal:

The team organized by Ministry of Labor and Social Welfare, HMG/N (1982) reported some socio-economic information about the least developed communities' people such as Satar, Dhimal, Darai, Kumal, Magar and Bote of various districts such as Jhapa, Morang, Sunsari, Chitwan, Nawalparasi and Palpa. The aim of study was to observe the employment improvement for the least developed country.

Gubhaju et al. (2002) have highlighted the contribution of cold-water fishes in livelihood of mountain people of Nepal. They have reported that indigenous cold-water fishes have significant contribution as nutritional protein supplement and as a means of income source for the livelihood of local fisher communities.

Pandey (2004) studied the socio-economic condition of local fisher community of Kaligandaki River in respect to the effect of Kaligandaki High Dam and found the economic condition to be poor. Literatures of Kaligandaki "A" Hydroelectric Project

There were different works carried by different workers in different time period on fish diversity, water quality parameters and socio-economic conditions of fishermen at different places at Kaligandaki River.

Edds (1989) made a multivariate analysis of fish assemblage, composition and environmental correlates in a Himalayan river- Nepal's Kaligandaki/ Narayani. He reported 111 and 107 species from Kaligandaki and Narayani respectively.

Shrestha (1990) carried out a research on fishery resources of Kaligandaki River and its water quality. Altogether, 69 species of fishes were reported from Kaligandaki River.

2.4 Literatures of Kaligandaki-A Hydroelectric Project:

Norpower conducted the feasibility EIA in the Kaligandaki Hydroelectric Project in 1992. This study concluded that the KGA Project would be one of the potential hydropower Projects from environmental point of view provided some mitigation measures were carried out effectively.

The main report includes the data on Project area, hydrology, geology and geo-technical water supply sector, Project layout and engineering EIA, institutional and legal arrangements, financial, evaluation, implementation and references drawing. No

significant adverse environmental impacts of the Project were visualized in this study. However, the EIA team recommended that certain measures should be taken to mitigate the general impacts of the Project (Pandey, 2001).

EIA (1996) reported " The Fisher's community of Kaligandaki River around the region of dam'' will be severely affected by the Kaligandaki "A" Hydroelectric Project. Biological study of the major River systems of the Nepal was carried out by NARC (1996-97). A survey was made in Karnali and Kaligandali River to study the basic water quality parameters, fish species and socio-economic status of fishermen. In this study, Karnali River showed the higher fish diversity than Kaligandaki River. The study also enlisted the economically important fish species of the study area.

NARC (1997-98) studied the basic water quality parameters, zooplanktons, fish species and socio-economic status of fishermen at three stations of Kaligandaki River.

Upadhyaya and Shrestha (2000) carried out fish trapping and hauling test program in Kaligandaki River. They also recorded the water quality parameters of the Kaligandaki River.

Wagle et al. (2000) surveyed the fish species and environmental variables in Kaligandaki River near dam area. A total of twenty-four species under seven families were collected from Kaligandaki and Aandhi-Khola. It was reported that Cyprinids, *Barilius bendelisis* and *Barilius vagra* were most common fish species in pools and runs of these areas occurring in every season. The loach species *Nemacheilus beavani, Nemacheilus rupicola* were also the most common fish species. Pandey (2001) studied the environmental impacts of Kaligandaki 'A' Hydroelectric Project (KG'A'HEP) on vegetation resources in the dam and reservoir area during the period of its development (1996-2001). He reported that the vegetation clearance and mass movement of soils at the dam and reservoir area have resulted greater impact on ground vegetation and the vegetation of dam and reservoir area of KG'A'HEP was affected by project implementation. Pandey et al. (2002) studied on environmental impacts of hydropower development on vegetation and wildlife resources of Kaligandaki 'A' Hydroelectric Project.

Shrestha and Chaudhary (2003) studied the fish diversity in the Kaligandaki River before and after the Project construction. The study mainly revealed the consequences for the depletion of fish population in Kaligandaki River after the construction of dam. They documented 14 species of fishes in the post construction study in six different sites.

Further the Kaligandaki Fish Hatchery has been taking the water quality parameters regularly in the dam and power house area in a monthly basis, since its establishment.

CHAPTER THREE

OBJECTIVES

General objective of the present study was to study the impact of dam of Kaligandaki River on the fish and fish diversity and local fisher community of Kaligandaki River. The study was carried in the dewatered zone of the river fromMirmee to Beltari.

The specific objectives of present study are:

- To study the impact of dam and mitigation measures.
- To study the fish diversity.
- To analyse the water quality.
- To study the impact of dam on the culture and socio-economy of the fishermen of the study area.

CHAPTER FOUR

MATERIALS AND METHODS

The field study was conducted for 12 months (one year) from September 2009 to August 2010. T he field work was performed once in every four month but the Bote villages were visited every month of the year. To analyze the impact of dam on fish diversity and local people mostly fishermen (Botes), the present study was particularly confined to the range of dewatered zone between Mirmee, Aandhimuhan (Dam area, Syangja District) to Beltari (powerhouse area, Syangja District) with different stations between them like Cherlung (Palpa District), Dailatung Phant (Palpa District) and Darpuk (Palpa District).

4.1 Physical materials:-

A. Glass wares

1. Conical Flasks 2. Burettes 3. Glass Jar 4. Beakers 5. Pipettes

6. BOD Bottles 7. Droppers 8. Glass Rod 9. Measuring Cylinders and

10. Standard Mercury Thermometer

B. Laboratory Instruments:-

1. pH meter 2. Weighing Balance

C. Other Requirements:-

1. Burette Stand 2. Plastic Bucket 3. Measuring Tape 4. Small Plastic Bottles

Chemicals:-

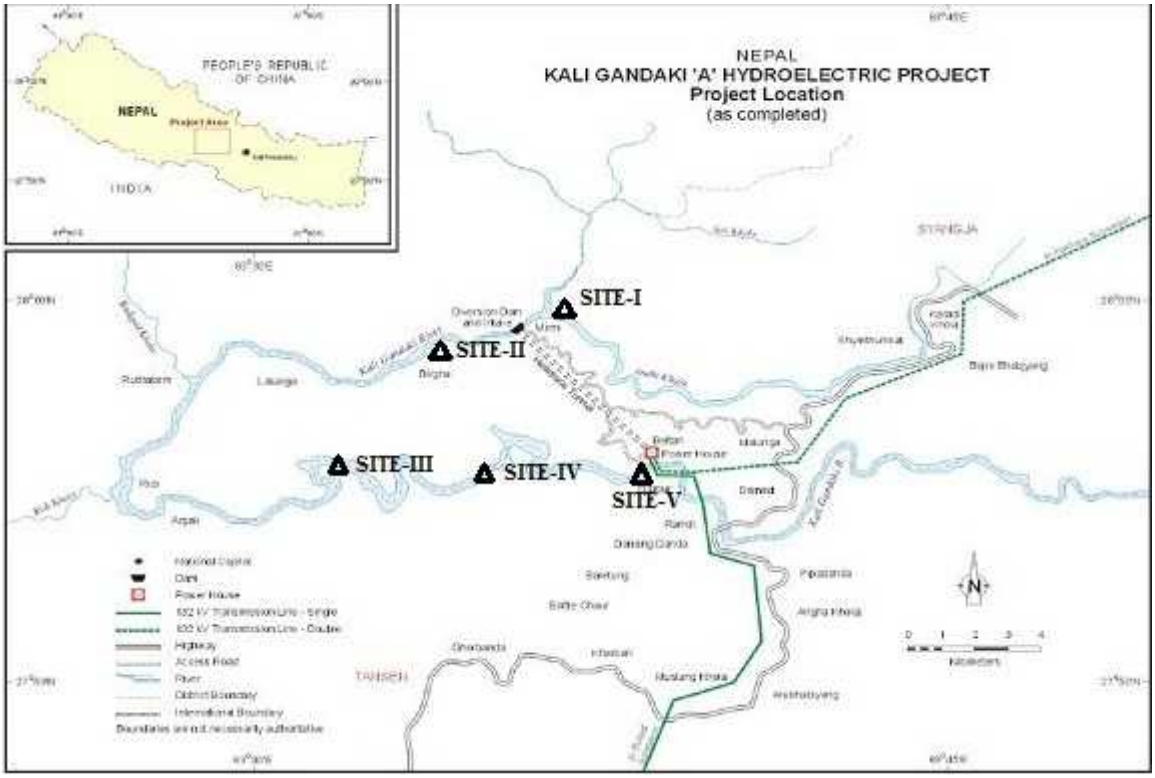
a. Winkler's A solutions or MnSO4 solution
b. Winkler's B solutions or Alkaline Iodide solution
c. Magnecium Sulphate
d. Potassium Iodide
e. Sodium Thiosulphate
f. Conc. H2SO4
g. Starch
h. Sodium Hydroxide
i. Phenolpthalin
j. Methyl Orange

k. HCl Acid
l. Eriochrome Black-T
m. Buffer Solution
n. EDTA Solution

4.2 Study Area:

The present study was carried out in the Kaligandaki River. The Kaligandaki River is one of the tributaries of the Gandaki River System and an important river of Himalayan region. Kaligandaki "A" Hydroelectric Project is located at Syangja District in Gandaki Zone and partially encompasses other districts such as Gulmi, Palpa and Parbat. The dam and reservoir area of this project covers the part of Syangja, Gulmi and Parbat Districts. The dam has been built on the Kaligandaki River (about 500m below from the confluence of Kaligandaki and Aandhi Khola). The length of reservoir is approximately 5.3 km and estimated covered area is 65ha (MKI, 1995).

The main study area of present work was the dewatered zone, 50 Km distance between Mirmee (Dam area) to Beltari (power house area). The water flow greatly reduced in 23 Km between dam to Badigad Khola due to diversion of water.



Map 2: Study Area

4.2.1 Physical Environment:

i. Climate and Meterology:

The climate of this area is typical South Asian summer monsoon type with a hot and wet summer and a cool and comparatively dry winter. As it is a typical watershed in Nepal, the Kaligandaki basin covers a wide range of climates and climatic differences. The climate is strongly affected by altitude and as a consequence substantial differences occur over very short distances. Maximum temperature is about 36⌈C in early summer while minimum temperature is about 10⌈C (MKI, 1996).

ii. Topography and Geology:

The Project is situated in the midland of lower Himalayas between latitudes 27⌈ 60 to 28⌈ 50 N and longitudes 83⌈ 33Ú to 83⌈ 38Ú E (MKI, 1996). The study region of the Kaligandaki basin is mountainous or hilly and deeply incised. Elevation ranges from 480m to 1600m in the study area. The average precipitation in the area is 1500-2000 mm per annum. The watershed contains different natural zones with different landforms, vegetation and socio-economy. Landslides are common in the region,

particularly during the monsoon. The project area is composed of dolomites and phyllitic state of greenish gray to brownish gray color. The dam and diversion tunnel site are located in a wide belt of dolomite limestone rocks which are very hard and often form inaccessible rock faces. The river bed is covered by a low-level alluvium consisting of boulder, gravel, sand and silt (MKI, 1996).

4.2.2 Streams and Drainages:

The main streams in the study area are Seti Khola, Aandhi Khola, Thulo Khola, Jaimare Khola. Other streams of Kaligandaki River below dam are Badigad Khola, Ridi Khola, Barangdi Khola and Ramdi Khola. Because of the Aandhi Khola Hydroelectric Project, located 5 Km upstream from the dam of Kaligandaki Hydroelectric Project, the water flow in the Kaligandaki River is slightly decreased.

4.2.3 Biological Environment:

The EIA confermed that the distribution of wildlife in the project area is not uniform and depends upon habitat type, topographic features and human influences. At least 146 species of birds, a number of mammals and reptiles were observed.

Like many rivers of the Himalayas, the Kaligandaki hosts a wide range of fish species, adapted to the river's distinct ecological conditions that include dramatic changes in river flow and turbidity.

4.3 Ecological Zonation of the Kaligandaki River:

On the basis of distribution of indicator fish species, the Kaligandaki River is divisible into three distinct zones viz. the Snow Trout Zone (1800 to 3000m), the Mahaseer Zone (1200 to 1800m) and the River Carp Zone (80 to 300m). These three Zones overlap each other and thus bring mixing effects of fish species and community (Shrestha, 1990).

4.4 Selection and Description of Sampling Sites:

To study the impact of dam on fish and fish depended fishermen in dewatered zone below dam in Kaligandaki River, a preliminary survey of study area was performed in July 2009. For the present study five sampling sites were selected. Out of them, only one was located near the upstream of diversion dam which is the dam area at Aandhimuhan and is the habitat of Bote community. The other three sites were below dam. They were Aruwa Ghat near Gahalam Ghat (Birgha), Chherlung and Dailatung Ghat. The last site was below dam which is Beltari near the Darpuk village, a Bote area. These sites were selected to represent the overall study area which covers about all dewatered zone (50km distance) of Kaligandaki River and desinated as the 1^{st}, 2^{nd}, 3^{rd}, 4^{th} and 5^{th} sampling sites respectively.

4.5 Criteria for Selection:

Kaligandaki "A" Hydroelectric Project is the largest project among the existing projects of Nepal. The impoundments in rivers are known to impact adversely on fish biodiversity and fisher community. For the study of impact of dam on fish and fisher community in dewatered zone below dam area, the study must be located near the dam so that both upstream and downstream could be studied at a time. The other reasons for the selection of those sites were because all the Bote villages were found between Dam and the Power house. Description of Sampling Sites:

4.5.1 Site- I: Aandhimuhan (Dam Area):

The first sampling site i.e. Kaligandaki at Aandhimuhan (Dam area) is the junction of Kaligandaki and Aandahikhola. The feeder stream Aandhikhola joins with Kaligandaki. It has high flow at rainy season but low flow at summer. Aandhikhola electric power house is also constructed in the Aandhikhola at Galyang, Syangja. This site is the main reservoir site of Kaligandaki HEP-A. Aandhimuhan which is the main area of Botes is the trade centre between Syangja, Parbat and Gulmi and lies about 2km away from the dam site. The present study is confined to this site for study of the cage culture, diversity of fish and cultural and economic status of fishermen. The fishermen are poor at that site but only a few are engaged in project work. There is only one primary school for Bote child.

4.5.2 Site-II: Aruwa Ghat (Gahalam Ghat):

This site is second and located at 3km downstream of the Kaligandaki River, below the dam known as Aruwa Ghat near Gahalam Ghat. In dry season, the normal flow of water in this site reduces little bit because of the diversion but in summer season, the flow reduces extremely. So this site is dry in summer.

4.5.3 Site-III: Chherlung Ghat:

This site Chherlung ghat is selected as third site. This is nearly 32km below dam and the downstream flow is reduced but the waters from Badigad and Ridi Khola flows from this site. So water flow is as high as site II. Chherlung is a village of Palpa district located in Baughagumba VDC ward no. 1. It is also a fishermen village along with other people, Brahaman, Magar, Kshetri etc. There are altogether 48 houses of fishermen (Bote). A primary and a secondary school are there.

4.5.4 Site-IV: Dailatung Ghat:

Dailatung ghat is selected as site fourth and located 40km below from dam. It is in Khanigaun VDC ward no. 6, Palpa. Thevillage has Botes along with other casts such as Magar, Brahman, Newar etc.. Water flow is reduced. The main occupation of fishermen is fishing and navigation. Altogether, 14 houses of Botes are there. A lower secondary school is there. This site is selected for the study of economic and cultural status of fishermen.

4.5.5 Site-V: Beltari (Darpuk):

This site is the fifth site and located near powerhouse area (Beltari) and a village of Bote communities Yamgha, Palpa. The water flow is low above power house but it is high below the power house. There are altogether 21 houses of fishermen. The main occupation of fishermen is fishing and some are diverted to farm and trade also. Most of young men have gone to foreign countries and large cities for employment.

4.6 Sources and Tools of Data Collection:

Primary data were collected from direct observation, semi structured interviewand questionnaire survey. Questionnaires were prepared to collect the information regarding the fish diversity around the study area and impact of dam on the socio-economic condition of the fishermen. The other sources of data collection were reports, papers etc. from the hydroelectric project and the Kaligandaki Fish Hatchery of Beltari, Syangja.

4.7 Fish collection:

Fishes were collected from September 2009 to August 2010 from each sampling site. Local fishermen were hired for the collection of fishes. Cast net, gil net, ghorlang, hook and line, mosquito net and other local available devices such as Bhaddu (rice pot) with thin cloth were used for collection of fish sample. The "*Duwalo thunne*" at rainy season in small streams of Kaligandaki was also done with the help of local fishermen. The length and weight of fishes were recorded for each individual to the

nearest centimeter and gram respectively. Number of total fish species collected from each sampling site was also recorded. Then these collected samples of fish species were preserved in 4-8% formaldehyde solution.

The preserved fish species were brought to the laboratory of Central Department of Zoology, Tribhuvan University, Kirtipur for identification and further investigation. These collected fishes were identified after Shrestha (1981, 1994, 2001), Shrestha, T.K.(2008) and Jayaram (1981, 1999).

4.8 Data collection on Socio-economic Condition of Fishermen:

Structured questionnaires were prepared and administered to the local fishermen to understand their current social and economic status and also to know the impact of dam on their economy and livelihood. General information on fish market and fish yield was also collected.

4.9 Impact Analysis of Dam on Fishery Resources:

The impact of dam on fish diversity was analyzed on a comparison basis. Data from the present work were compared with those form the previous literatures. The comparison of fish species present before and after the construction of dam was done during this study.

4.9.1Water Quality Analysis:

Different limnological parameters such as temperature, pH, free carbon dioxide, dissolved oxygen, total alkalinity and total hardness were tested after APHA (1998), Adoni (1885) and Trivedy & Goel (1986). These tests were performed in the morning hour between 9-10 am.

The main physico-chemical parameters that were studied are as given below:

4.9.1.1 Temperature:

Temperature of the surface water of the study area was recorded with the help of standard mercury thermometer graduated up to 50 ⌈C with a precision of ±0.1 ⌈C.

The recording was simply done by dipping directly the thermometer bulb into the water for two minutes at each station.

4.9.1.2 Hydrogen-Ion Concentration (pH):

The Hydrogen ion concentration is one of the most important environmental factors that affects the composition and distribution of all aquatic community. A portable pH meter was used to measure the pH value of the water. The pH of water at different sampling stations was taken and mean value was noted.

4.9.1.3 Dissolved Oxygen (DO):

Dissolved Oxygen of the study site was determined by using Winkler's methods. Winkler first developed this method in 1888. The principle of this method is as follows-

$MnSO_4 + 2KOH \rightarrow Mn(OH)_2 + K_2SO_4$

$Mn(OH)_2 + 2H_2SO4 + 2KI \rightarrow MnO(OH)2$

$MnO(OH)_2 + 2H_2SO_4 + 2KI \rightarrow MnSO_4 + 3H_2O + I_2$

Water samples were collected from the surface water in BOD bottle having 250 ml capacity. One ml of each $MnSO_4$ and Potassium Iodide were added into the BOD bottle and the bottle was made airtight and shaked well. Then, brown precipitation obtained in the BOD bottle was allowed to stand for half an hour. After that, two drops of conc. H2SO4 was added in it and shaked well. Fifty ml of the sample was taken in the conical flask and two drops of starch as indicator was added. Then this sample was titrated against the Sodium Thiosulphate (Na2S2O3) taken in the burette till the color of the sample solution disappears. Similarly, 3 burette reading were taken and their mean was the dissolved oxygen of the sample. The dissolved oxygen was analyzed by using the following formula.

$$\text{Dissolved Oxygen (mg/l)} = \frac{(\text{Volume} \times \text{Normality}) \text{ of } Na_2S_2O_3 \times 8 \times 1000}{\frac{V_2 (V_1 - V)}{V_1}}$$

Where, V = Volume of MnSO4 and KI added

V_1= Volume of the sample bottle

V_2=Volume of the contents titrated

4.9.1.4. Free Carbon Dioxide:

Free Carbon dioxide was determined by taking water sample in a conical flask. Then this sample was titrated against 0.05 N of NaOH.

Calculation was made by using the following equations:

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

4.9.1.5 Total Alkalinity:

In total alkalinity, water sample (50ml) was taken in a conical flask. Then, 2-3 drops of phenolphthalein and methyl orange were added to the sample. It was titrated with 0.1 N of HCl. Total alkalinity is often expressed as mg/l, which was calculated by using the following formula.

$$\text{Total alkalinity as mg/l} = \frac{\text{(ml normality) of HCl} \times 1000 \times 50}{\text{ml of sample taken}}$$

4.9.1.6 Total Hardness:

Fifty ml of water sample was taken in a conical flask and one ml of the buffer solution was added into it. About 100-200 mg of Erichrome Black T (as indicator) was added, and then the solution turned to wine red in color. Then this, content was titrated against EDTA solution. At the end point, the color was changed from wine red to blue. Similarly, three burette readings were taken. Total hardness was estimated as follows-

$$\text{Total Hardness mg/l} = \frac{\text{ml of EDTA used} \times 1000}{\text{ml of sample taken}}$$

CHAPTER FIVE

OBSERVATIONS AND RESULT

The present study was conducted from September 2009to August 2010 in five sampling site in Kaligandaki River (Aandhimuhan, Aruwa ghat, Chherlung, Dailatung and Beltari). The following results were obtained from the study:

5.1.1. Temperature:

Air temperature of five Smpling sites remained more or less similar for a month. The lowest air temperature was observed on January 2010 (15.8⌈C) at site II while the highest air temperature was recorded on July 2010 (28.1⌈C) at site II.

The range of water temperature was 23.5⌈C- 13.2⌈C from October 2009 to July 2010. The highest peak of water temperature (23.5⌈C) was recorded in July 2010 at site I then it goes gradually decrease to its lowest temperature (13.2⌈C) in January 2010 at site III as shown in table 3.

5.1.2. pH:

The pH remained almost alkaline through out the whole study period which ranges from 9.7 to 8.3 with in slight fluactuation in different sites. The highest pH (9.7) in April 2010 in site I and lowest was 8.3 in site V in October 2009.

5.1.3. Dissolved Oxygen:

The range of DO concentration of the study area was 6.5 to 9.6mg/l. The highest DO (9.6 mg/l) was mwasured from site II in January 2010 and lowest (6.5mg/l) was found from site III in July 2010.

5.1.4. Cabondioxide:

The range of CO2 of the study area was 8.3mg/l to 14.2mg/l. The highest range was found from site I in January 2010 and lowest from site III and IV in April 2010.

5.1.5. Alkalinity:

The alkalinity of water ranges from 115-192mg/l. The highest range was found from site I in April 2010 and lowest was found from site I in July 2010.

5.1.6. Hardness:

The hardness i.e. 160mg/l of water was found to be highest on October 2009 from site I and site V and lowest 135mg/l was found I site V I April 2010.

Table 3: Physico-chemical Parameters of the study area with different months:

Site	Site-I dam area (upstream)				Site-II, Aruwa Ghat				Site-III Chherlung				Site-IV Dailatung Ghat				Site-V Beltari			
Month	Oct 09	Jan 10	Apr 10	Jul 10	Oct 09	Jan 10	Apr 10	Jul 10	Oct 09	Jan 10	Apr 10	Jul 10	Oct 09	Jan 10	Apr 10	Jul 10	Oct 09	Jan 10	Apr 10	Jul 10
Air Tempr (⌈C)	21	16	27	27	24.5	15.8	26.5	28.1	24.5	17	26.9	27.5	25.1	17.5	27	26.9	24.2	17.2	27.2	27.1
Water Tempr. (⌈C)	19.8	13.8	18.1	23.5	17.3	13.5	19.1	23	17.8	13.2	18.9	22.5	18	14.1	19.5	21.9	19	14.5	20.5	22.1
pH	8.9	8.5	9.7	9.2	9.5	8.5	9.2	9.5	9.4	8.9	9.5	9.2	8.9	8.7	9.2	8.8	8.3	8.3	9.5	8.9
DO (mg/l)	7.2	8.6	7.2	6.8	8.6	9.6	7.8	6.5	8.5	9.1	7.9	6.8	8.5	8.8	8.1	6.9	7.8	8.9	6.8	7.1
CO_2 (mg/l)	14	14.2	8.5	9.3	12.5	8.9	8.1	9.1	10.7	9.3	8.3	9.0	10.9	9.8	8.3	9.2	12	9.2	6.9	9.1
Alkalinity (mg/l)	190	123	192	115	135	132	185	125	140	135	160	132	160	138	168	136	187	140	190	142
Hardness (mg/l)	160	146	145	149	145	141	143	151	150	144	140	151	155	149	138	148	160	148	135	151

5.2 Migratory fishes:

The collected fishes can be categorized into the following groups on the basis of range of migration:

Fish groups:

Migratory Species:

- *Clupisoma garua*
- *Tor putitora*
- *Macrognathus aral*

Mid –Range migrant

- *Labeo dero*
- *Labeo boga*

Resident Species:

- *Garra gotyla*
- *Barilius vagra*
- *Barilius barila*

Economically Important species:

- *Clupisoma garua*
- *Labeo dero*
- *Tor putitora*

5.3 Fish Distribution:

The following table shows the distribution pattern and abundance of fish species in the study area. Among them the most common fish species recorded from the study area was *Barilius vagra.* Apart from this, *Barilius barila* and *Schistura savona* were quite common fish species. The highest frequency occurrence of 29.10% was for *Barilius vagra* and lowest frequency occurrence of 0.77% was for *Macrognathus aral* which is shown in table: 4.

Table 4: Sampling Stations of Kaligandaki River

S. N.	Scientific Name	Local Name	Sampling Stations					Total No. Fish	Frequency (%)
			I	II	III	IV	V		
1.	*Barilius barila*	Faketa	+	+	+	+	+	88	23.28
2.	*Barilius vagra*	Faketa	+	+	+	+	+	110	29.10
3.	*Botia almorhae*	Baghi	-	-	+	+	-	24	6.35
4.	*Botia geto*	Loach	-	-	+	+	+	9	2.38
5.	*Botia lohachata*	Baghi	-	-	+	+	+	13	3.44
6.	*Clupisoma garua*	Jalkapoor	-	-	+	+	+	10	2.65
7.	*Garra gotyla*	Buduna	+	-	-	+	-	10	2.65
8.	*Glyptothorax pectinopterus*	Capre	-	+	+	+	+	16	4.23
9.	*Glyptothorax telchitta*	Telcapre	-	-	-	+	+	6	1.59
10.	*Labeo bata*	Bata Labeo	+	+	+	+	+	21	5.56
11.	*Labeo boga*	Rohu	+	-	-	-	-	10	2.65
12.	*Macrognathus aral*	Bam	-	-	-	+	-	3	0.77
13.	*Pseudoechenesis sulcatus*	Kabre	-	-	-	+	+	6	1.59
14.	*Schistura savona*	Gadela	+	-	+	+	-	52	13.76

+ = Present and - = Absent

5.3.1 Fish Diversity in Site-I:

The fishes collected from the site-I are listed with their average weight, length and frequency of occurrence in the following table: 5.

Table 5: List of Fish species Collected in Site-I

S.N.	Fish Species	Oct 2009	Jan 2010	Apr 2010	July 2010	Total	Average length (cm)	Average wt (gm)	Frequency (%)
1.	*Schistura savona*	5	-	2	7	14	7.5	13	16.47
2.	*Garra gotyla*	2	-	1	2	5	10	27.5	5.88
3.	*Barilius barila*	17	1	3	12	33	93	13.2	38.83
4.	*Barilius vagra*	11	3	2	1	17	10.1	19	20
5.	*Labeo bata*	1	-	-	5	6	15	120	7.06
6.	*Labeo boga*	3	5	2	-	10	10	80.4	11.76
	Total	39	9	10	27	85			100.00

A total of 6 species of fishes under 2 families and 4 genera coming under 1 orders i.e. Cypriniformes were collected from the study site-I. This site is located at the reservoir area near Aandhimuhan village. This site showed the third highest fish diversity among five sampling sites. *Labeo bata* (Bata Labeo/Rohu) was the largest fish species with an average body length 15 cm and its average body weight was 120 gm. The *Barilius barila* was the most frequent fish species found in site-I with maximum frequency 38.83%.

5.3.2 Fish Diversity in Site-II:

The fishes collected from the site-II are listed with their average weight, length and frequency of occurrence in the following table: 6.

Table 6: List of Fish species Collected in Site-II

S.N.	Fish Species	Oct 2009	Jan 2010	Apr 2010	July 2010	Total	Average length (cm)	Average wt (gm)	Frequency (%)
1.	*Barilius barila*	4	3	-	2	9	7.2	14	22.50
2.	*Barilius vagra*	13	2	5	6	26	8.5	12.5	65.0
3.	*Labeo bata*	-	1	-	1	2	12.5	75.2	5.0
4.	*Glyptothorax pectinopterus*	2	-	-	1	3	12	38	7.5
	Total	19	6	5	10	40			100.00

Altogether 4 species of fishes under 2 families and 3 genera belonging to 2 orders i.e. Cypriniformes and Siluriformes were found among 40 collected specimens from the study site-II. This site is located slightly below the dam area and the most dewatered zone. This site showed the least fish diversity among five sampling sites. *Labeo bata* (Bata Labeo/Rohu) was the largest fish species with an average body length 12.5cm and its average body weight was 75.2 gm. The *Barilius vagra* was the most frequent fish species found in site-II with maximum frequency 65%.

5.3.3 Fish Diversity in Site-III:

The fishes collected from the site-III are listed with their average weight, length and frequency of occurrence in the following table: 7.

Table 7: List of Fish species Collected in Site-III

S.N.	Fish Species	Oct 2009	Jan 2010	Apr 2010	July 2010	Total	Average length (cm)	Average wt (gm)	Frequency (%)
1.	*Botia geto*	-	-	3	1	4	12	40.2	5.98
2.	*Botia almorhae*	-	-	9	5	14	8	32.5	20.89
3.	*Glyptothorax pectinopterus*	1	1	-	3	5	12.5	27	7.46
4.	*Botia lohachata*	-	-	2	1	3	8.2	32.5	4.48
5.	*Barilius vagra*	5	-	2	6	13	8.5	21	19.40
6.	*Barilius barila*	7	1	-	3	11	7.4	24	16.42
7.	*Labeo bata*	2	-	1	-	3	16	118	4.48
8.	*Clupisoma garua*	-	3	1	-	4	14.2	63.4	5.97
9.	*Schistura savona*	3	-	-	7	10	8.6	18.5	14.92
	Total	18	5	18	26	67			100.00

Altogether 9 species of fishes under 4 families and 6 genera belonging to 2 orders i.e. Cypriniformes and Siluriformes were found among 67 collected specimens from the study site-III. This site is located below the two main tributaries of Kaligandaki River, the Badigad Khola and the Riri Khola and is the reduced flow area near Chherlung village .This site showed the second highest fish diversity among five sampling sites. *Labeo bata* (Bata Labeo/Rohu) was the largest fish species with an average body length 16cm and its average body weight was 118 gm. The most frequent fish species found in site-III was the *Botia almorhae* (Baghi) with the maximum frequency 20.89%.

5.3.4 Fish Diversity in Site-IV:

The fishes collected from the site-IV are listed with their average weight, length and frequency of occurrence in the following table: 8.

Table 8: List of Fish species Collected in Site-IV

SN.	Fish Species	Oct 2009	Jan 2010	Apr 2010	July 2010	Total	Average length (cm)	Average wt (gm)	Frequency (%)
1.	*Botia geto*	-	-	2	-	2	13.2	25	1.71
2.	*Botia lohachata*	-	-	7	1	8	9.1	27.5	6.84
3.	*Botia almorhae*	-	-	10	-	10	8	30	8.55
4.	*Labeo bata*	2	1	10	14	27	8.5	20.5	23.08
5.	*Barilius vagra*	1	1	12	3	17	7.2	18.4	14.53
6.	*Barilius barila*	2	-	2	-	4	15	135	3.42
7.	*Glyptothorax telchitta*	1	2	-	1	4	10	75.3	3.42
8.	*Glyptothorax pectinopterus*	2	1	-	-	3	9.8	81.5	2.56
9.	*Garra gotyla*	4	-	-	1	5	10.2	47.2	4.28
10	*Clupisoma garua*	1	1	1	-	3	15.3	125.5	2.56
11.	*Macrognathus aral*	1	-	-	2	3	20.5	215	2.56
12.	*Pseudoechenesis sulcatus*	3	-	-	-	3	13	35.8	2.56
13.	*Schistura savona*	9	2	1	16	28	4.2	15	23.93
	Total	26	8	45	38	117			100.00

Altogether 13 species of fishes under 6 families and 9 genera belonging to 3 orders i.e. Cypriniformes, Siluriformes and Synbranchiformes were found among 117 collected specimens from the study site-IV. This site is located near the Dailatung ghat slightly below the Barangdi Khola and is the reduced flow area. This site showed the highest fish diversity among five sampling sites. *Macrognathus aral* (Bam) was the largest fish species with an average body length 20.5cm and its average body weight was 215 gm. The *Schistura savona* was the most frequent fish species found in site-IV with maximum frequency 23.93%.

5.3.5 Fish Diversity in Site-V:

The fishes collected from the site-V are listed with their average weight, length and frequency of occurrence in the following table: 9.

Table 9: List of Fish species Collected in Site-V

S.N	Fish Species	Oct 2009	Jan 2010	Apr 2010	July 2010	Total	Average length (cm)	Average wt (gm)	Frequency (%)
1.	*Glyptothorax pectinopterus*	1	-	-	3	4	16.2	60.1	5.79
2.	*Glyptothorax telchitta*	-	-	2	1	3	14.6	42.3	4.35
3.	*Clupisoma garua*	-	-	3	-	3	16.5	115	4.35
4.	*Barilius vagra*	3	12	10	2	27	6.2	13	39.14
5.	*Barilius barila*	2	10	3	3	18	7.5	10.2	26.09
6.	*Botia geto*	-	-	3	-	3	12.5	30	4.35
7.	*Botia lohachata*	-	-	2	-	2	11	17.5	2.89
8.	*Pseudoechenesis sulcatus*	2	-	-	1	3	18.2	30.2	4.35
9.	*Labeo bata*	1	2	-	3	6	25	102	8.69
	Total	9	24	23	13	69			100.00

A total of 69 fish specimens were collected from the site-V. Among them, 9 fish species under 4 families and 6 genera belonging to 2 orders i.e. Cypriniformes and Siluriformes. This site is located near the powerhouse area, Beltari. This site showed the second highest fish diversity among five sampling sites. *Labeo bata* (Bata Labeo/Rohu) was the largest fish species with an average body length 25 cm and its average body weight was 102 gm. The *Barilius vagra* was the most frequent fish species found in site-V with maximum frequency 39.14%.

5.4 Breeding seasons:

The information about the breeding season of some common fishes was obtained through the structured questionnaire and field visit in the Kaligandaki Fish Hatchery, Beltari. According to the obtained results, most of fishes become active for reproduction, when the temperature of water starts to increase. *Garra gotyla* and *Bagarius yarellii* complete their egg laying activity till May-June. However, *Neolossocheilus hexagonolepis* and *Tor putitora* lay their eggs up to month of September-October. *Schizothorax richardsoni* lays its eggs on November-December and February-March.

Table10: Breeding Season of some Common fishes:

Name of the Fishes	Period of Reproductin
Gardi (*Labeo dero*)	February-March
Katle (*Neolissocheilus hexagonolepis*)	August-October
Sahar (*Tor putitora*)	June- September
Bam (*Mastacembalus armatus*)	April-May
Asla (*Schozothorax richardsoni*)	September-October, March-May
Buduna (*Garra gotyla*)	May-June
Gounch (*Bagarius yarellii)*	May-June

5.5 Conservation Status of Collected Fishes:

Among the collected fish species in different sampling sites during the field visit could be categorized under the 5 common species (C), 5 Uncommon or Lower Risk Least Concern species (UN), 2 Data Deficient Pristine Rare Ornamental (PRO) and 2 Conservation Dependent and Rare (CDR).

Table 11: Conservation Status of Collected Fishes:

S. N.	Scientific Name	Local Name	Conservation status
1.	*Barilius barila*	Faketa	C
2.	*Barilius vagra*	Faketa	UN
3.	*Botia almorhae*	Baghi	PRO
4.	*Botia geto*	Loach	PRO
5.	*Botia lohachata*	Baghi/ Tiger loach	UN
6.	*Clupisoma garua*	Jalkapoor/ Baikha	UN
7.	*Garra gotyla*	Buduna	C
8.	*Glyptothorax pectinopterus*	Khasre	UN
9.	*Glyptothorax telchitta*	Khasre	CDR
10.	*Labeo bata*	Rohu	C
11.	*Labeo boga*	Rohu	C
12.	*Macrognathus aral*	Bami/ Bam	C
13.	*Pseudoechenesis sulcatus*	Kabre	CDR
14.	*Schistura savona*	Gadela	UN

5.6 Impact of Dam on Fish Resources of Kaligandaki River:

The Kaligandaki –A Hydroelectric Project has both positive and negative impacts.

5.6.1 Positive Impacts:

Establishing the cross dam on Kaligandaki River to store water for the power generation is probably the most popular water control method. It has the additional advantage that water can be used for generation of power as well as for irrigation. Kaligandaki-A Hydroelectric Project is the largest Hydroelectri Project among existing projects of Nepal having the capacity of 144MW.

The generated power is used in the electrification of nation in different parts of Nepal. The rural electrification programme was implemented at the project area. More than 3,000 households in 11 VDCs have access to electricity. The other positive aspect of the project is the construction of 28.5 Km of main access road running from Siddhartha Highway to the dam and power plant site. A health facility in Project Health centre for local people was also good effect through project implementation. There was a maximum utilization of local communities (Constructional provision of priority of hiring for affected families including local residents). Local employment ratio was 50% during the project construction phase. Besides, local communities also got some benefits from the project establishment. There has been increment in literacy rate after the project was launched. After the establishment of Kaligandaki-A Hydroelectric project, it has been possible to open a a primary school in Aandhimuhan, Botegaun. A great contribution hase been made by the project by opening Kaligandaki Public School in Mirmee. Another school atat Beltari and Jaipate has now been upgraded to a campus..

The reservoir at Aandhimuhan, collects a lot of water all the time except rainy season. So the steamer facility at that place is becoming popular for the transport and recreation in reservoir. It takes three hours to reach Seti Beni (A religious place) on foot but Steamer takes only half an hour. So it also provides the employment to the local people. The Aandhimuhan at Mirmee Bazaar have become a trade centre for the Parbat, Gulmi and Syangja after construction of Kaligandaki-A Hydroelectric Project. A research center and hatchery (Kaligandaki fish Hatchery) was established at Kaligandaki-A power plant site and fish distribution centre (Chisopani Matsya palan Kendra) at Mirmee to distribute fries and fingerlings to the local people.

5.6.2 Negative Impacts:

Hydropower generation enhances the development of nation, but the river ecosystems are adversely affected especially affecting fish species. The Kaligandaki River system has been dammed for hydroelectric power generation of 144 MW capacity with a proposed reservoir. The Snow trout or Asala (*Schizothorax richardsonii)* and *Schizothoraichthys progastus)* are the dominant fish species in Kaligandaki River, and the migratory Mahaseer or Sahar (*Tor* spp.) are also common in that area. As these fishes need running water with high oxygen content. Damming the reservoir has changed the water quality where these species can not survive. Mahaseer and Eels are long range migratory fishes that can not move up and down the closure of dam. It is noteworthy that sahar spawn during rainy season of monsoon (September to Ocrober), they migrate upstream but the dams blocks their migratory routs. The ecosystem of many dammed river in Nepal was changed in past and both feeding grounds and breeding grounds were destroyed, leading to fish species loss. The recommended fish trucking and transport device are considered as substitute of fish ladder but did not work properly rather affected indirectly many migratory species as Mahaseer and catfishes. Many households living around the reservoir are thus affected. Therefore, to minimize negative impacts and to address or readdress any adverse impacts to the people and the ecosystem, holistic planning and management of dam construction should be adopted.

From the economic and developmental point of view, project construction and running is most beneficial but from the biological and ecological point of view, it has more negative impacts to the ecosystem. A large area of land was occupied by the construction of dam and reservoir. Approximately 97.1 ha land was occupied by the project during construction period. Large area of cultivated land was used to make the construction of main road (28.5 km), location of construction camp (3.8 ha) and NEA Permanent Village (3.5ha). These impacts have changed the land use patterns and land values of adjoining areas.

The existing topography and land use pattern have been changed permanently by the excavation works related to the desender slope, intake and desender basin, batching plants, disposal area, access road, laydown area and construction camps etc. Construction activities affected ground vegetation, trees and natural sceneries.

Reduction in livestock due to the reduction of public grazing areas, vegetation clearance, unmanaged soil disposal, change in physical and biological environment, threat to wildlife and fishes, social and cultural impacts, loss of habitat and biodiversity were the negative impacts of the project.

The other negative impacts of the Project associated with the construction of dam and reservoir area were habitat degradation due to unusual erosion, displacement of river boulders, no regular downstream releases, blockage of upstream migration of fishes, changes in habitat condition in upstream area. Morpho-ecological changes in both above and below the dam, changes in water temperature of the reservoir, inundation of spawning grounds, fluctuation of water levels, turbidity and silting patterns etc.

Population pressure during the construction period resulted in the increased harvesting of many species of fishes, plants and wildlife. Construction activities, human encroachment, illegal harvesting of fishes during construction, unmanaged soil disposal below the dam were some of the causative agents for the decrease in the population of fishes.

The most important factor for the loss in the fish diversity was because of the use of steamer boat which ran with diesel thus polluting water of the reservoir. Sound produced by the boat affected the fish badly and its random movement destroyed the fish habitat and spawning area. The leakage of diesel in the reservoir also caused pollution and affected the fish growth. Many of the fish species diedin the polluted water causing permanent elimination of fish species. As such the temperature of the the lentic water body in the reservoir becomes more that that in the lotic water body the steamer was more responsible for the rise of temperature there.

All the new changes that were introduced because of construction of the dam also affected the traditional ways of life of the native fishermen. These now began to adapt differently from their ancestors in the new situation. . Consequently there was erosion of the ancient culture and introduction of new imported culture. Like the Bote culture “The Aargha” is going to be extinct. (which is the post mortal culture and took 13 days to complete. That culture took 13 days in other places) but in Aandhimuhan area, they complete in only 11 days. The young populations of the village left their traditional occupation of fishing on the river and got attracted to the new jobs..

Thus the project the affected both the components-ecosystems and the traditional fishermen of the area. Project Activity and Impact Prediction:

Components of environment are affected by Project implementation at different degrees of intensity and level. The effect can be analyzed in terms of magnitude-referring to the severity, spatial-referring to the areas of coverage, reversibility (if the pre-developed situation can be recreated) and time scale.

Therefore, the impacts may be of high or low magnitude, reversible or irreversible, from a spatial point of view, local, regional or international and in the temporal aspect long-term, short term and medium term, depending upon the intensity of the impacts.

The magnitude of an impact is considered high if a major adverse impact is not mitigated. In prediction of impact, the magnitude is often expressed as high (H), medium (M) and low (L).

The spatial (Place at which real impact occurs- local, National and International) extent or the zone of the influence of the impact should always be determined. An impact can be site specific or limited to the project area (sp), a locally occurring impact within the watershed of the proposed project (L), a regional impact that may extend beyond the watershed (R) and a national impact affecting resources on a national scale (N).

Environmental impacts have a temporal (long term, medium term, short term) dimensions that needs to be considered. An impact that generally lasts for only 3-9 years after project initiation may be classified short (S) impact. An impact which continues for 20 years, may be defined as medium-term (M), and impacts that continues beyond 20 years are considered long-term (L).

The negative impacts of the project and their prediction are given in the following table no: 12.

Table 12: Negative impacts of the project and their prediction.

Resource/Project activity	Impact	Impact Prediction		
		Magnitude	Extent	Duration
Construction (infrastructure development)	Change in land use pattern	Major	Site specific	Long term
Land occupied by project	Reduction in cattle grazing area	Minor	Site specific	Short term
Construction of Dam and Reservoir	Treating of wildlife, loss of habitat and biodiversity	Major	Site specific	Long term
Clearance of ground vegetation	Erosion	Major	Site specific	Short term
Construction	Displacement of river boulders	Minor	Site specific	Short term

Table 12: Negative impacts of the project and their prediction. (contd..)

Reservoir construction	No regular downstream release	Major	Local	Long term
Dam construction	Blockage of upstream migration of fishes	Major	Site specific	Long term
Reservoir construction	Changes in habitat condition in upstream area	Major	Site specific	Long term
Impoundment	Change in water temperature	Minor	Site specific	Long term
Construction of impoundment	Inundation of spawning ground	Moderate	Site specific	Long term
Reservoir construction	Fluctuation of water levels	Minor	Site specific	Long term
Dam construction	Turbidity and silting pattern	Moderate	Site specific	Long term

In the present study it was found that the construction, operation and the maintenance of the Project have given negative impact to several fish species. The fish species having the migratory habitat cannot move upstream and the downstream due to the damming.

5.7 Comparison of Fish Diversity before and after construction of Dam:

EIA (1996) reported that the fish diversity was low in upstream, high in middle stretch (Dam and reservoir area) and slightly reduced in downstream part of the Kaligandaki River. In the present study it is found that the fish diversity was high in downstream in

site-IV, slightly reduced in middle stretch (site-III) and low in upstream reservoir (site-I) and lowest in site-II, just below Dam.

1. Upstream of Aandhikhola, reservoir area:
   EIA (1995) reported thirty-five fish species from proposed dam site, upstream of Aandhikhola and proposed reservoir section during the survey period (June-December 1993 and January 1994) whereas only 6 species were found during the present study period (October 2009- July 2010) but Pandey (2004) reported 8 species from this site. Twenty eight species were reported on November 1993 before the construction of dam according to the EIA survey 1995 whereas 6 species were collected during November 2002 by Pandey. Seven species were collected in EIA survey in the month of the September-October 1993 whereas 6 species were found in the present study (October 2009) and Pandey also reported 6 species during September-October 1994. Five species were recorded in EIA survey in January 1994 whereas only two species were found by Pandey(2003) and three species were found in the present study in January 2010.

2. Kaligandaki (Harmichour, Gulmi), Ding Khola ,Gahalamghat and Aruwa Ghat:
   During EIA survey (1995), highest fish diversity was obtained in December-January 1994 (i.e. 8 species) whereas in the present study, highest fish diversity was recorded on July 2010 (i.e. 4 species) but Pandey reported 5 species in June-July 2002. Before construction of dam the lowest record on fish diversity (i.e. 3 species) was obtained on September-October 1993 as documented by EIA 1995 and the present study also revealed the lowest diversity in the month of April 2010. Pandey(2004) found lowest record in September-October month.

3. Kaligandaki at (Chherlung) Ghat:
   The highest fish diversity was found in the month of the July 2010 i.e. 7 species and lowest record was 3 species in the month of the January 2010.

4. Kaligandaki at (Dailatung) Ghat:

   The highest fish diversity was found in the month of the October 2009 i.e. 10 species and lowest record was 6 species in the month of the January 2010.

5. Kaligandaki at (Darpuk, Beltari) Ghat:

   The highest fish diversity was found in the month of the July and April 2010 i.e.6 species and lowest record was 3 species in the month of the January 2010.

Table 13: Comparative Assessment Of Fish Diversity before and after construction of The Kaligandaki Project In Site-I

		Before (EIA, 1995)					After Pandey 2004					Present (Study)			
S.N	Scientific Name	June/ July 93	Sept/ Oct 93	Nov' 93	Dec 93	Jan' 94	June/ July'02	Sep/ Oct'02	Nov' 02	Dec '02	Jan' 03	Oct' 09	Jan' 10	Apr' 10	July' 10
1	*Neocheilus hexagonolepis*	4	0	20	-	15	4	4	7	-	4	-	-	-	-
2	*Burbus chilinodes*	-	-	9	-	-	-	-	-	-	-	-	-	-	-
	Barilius barna	-	-	10	-	-	-	-	-	-	-	-	-	-	-
4	*Barilius bendelisis*	8	-	10	-	-	5	-	4	-	-	-	-	-	-
5	*Barilius barila*	-	2	-	-	-	10	2	2	3	-	17	1	3	12
6	*Bariliua vagra*	4	-	-	5	-	-	-	-	-	-	11	3	2	1
7	*Labeo dero*	7	5	-	-		4	5	-	-	-	-	-	-	-
8	*Labeo bata*	-	-	-	-	-	-	-	-	-	-	1	-	-	5
9	*Pseudotropius garua*	4	-	-	-	-	-	-	-	-	-	-	-	-	-
10	*Chagunius chagunio*	-	-	9	-	-	-	-	-	-	-	-	-	-	-
11	*Cyprinon semiplotum*	11	10	43	2	-	-	1	4	1	-	-	-	-	-

12	*Danio aequipinnatus*	-	-	10	-	-	-	-	-	-	-	-	-	-	-
13	*Garra annandalei*	-	-	4	-	-	-	-	-	-	-	-	-	-	-
14	*Garra gotyla*	5	-	6	10	-	-	2	2	3	-	2	-	-	2
15	*Labeo angra*	4	-	17	-	5	-	-	-	-	-	-	-	-	-
16	*Labeo pangusia*	-	-	8	-	-	-	-	-	-	-	-	-	-	-
17	*Puntius ticto*	-	-	15	5	-	-	-	-	-	-	-	-	-	-
18	*Schizothorax plagiostomus*	7	-	29	-	-	-	-	-	-	-	-	-	-	-
19	*Schizothorax richardsoni*	-	-	26	-	5	-	-	-	-	-	-	-	-	-
20	*Schizothorax progastus*	10	2	7	-	3	-	-	-	-	-	-	-	-	-
21	*Tor putitora*	6	3	17	23	-	2	3	4	5	-	-	-	-	-
22	*Tor tor*	2	5	8	1	-	-	-	-	-	-	-	-	-	-
23	*Balitora brucei*	-	-	6	-	-	-	-	-	-	-	-	-	-	-
24	*Psilorhynchus pseudoechinus*	-	-	12	-	-	-	-	-	-	-	-	-	-	-

25	*Glyptothorax cavia*	-	-	9	-	-	-	-	-	-	-	-	-	-	-
26	*Glyptothorax telchitta*	8	-	-	-	-	-	-	-	-	-	-	-	-	-
27	*Glyptothorax pectinopterus*	2	-	-	-	-	4	-	-	1	-	-	-	-	-
28	*Pseudoechinus sulcatus*	7	-	10	-	-	-	-	-	-	-	-	-	-	-
29	*Bagarius bagirius*	-	-	5	10	-	-	-	-	-	-	-	-	-	-
30	*Clupisoma garua*	-	-	18	-	5	-	-	-	-	-	-	-	-	-
31	*Channa gachua*	-	-	6	-	-	-	-	-	-	-	-	-	-	-
32	*Channa punctatus*	-	-	8	-	-	-	-	-	-	-	-	-	-	-
33	*Amphipnous cuchia*	-	-	3	-	-	-	-	-	-	-	-	-	-	-
34	*Mastacembalus armatus*	-	-	1	-	-	-	-	-	-	-	-	-	-	-
35	*Macrognathus aculeatus*	-	-	5	-	-	-	-	-	-	-	-	-	-	-
36	*Schistura savona*	-	-	-	-	-	-	-	-	-	-	5	-	2	7
37	*Labeo sp*	-	-	-	-	-	-	-	-	-	-	3	5	2	-

Table 14: Comparative Assessment Of Fish Diversity before and after the construction of the Kaligandaki Project In Site-II.

		Before (EIA, 1995)			After Pandey 2004			Present (Study)			
SN	Scientific Name	June/ July 93	Sept/ Oct 93	Dec/ Jan'93	Jun/Jul ' 02	Sept/Oc t'03	Dec/Jan ' 04	Oct' 09	Jan' 10	Apr' 10	July' 10
1	*Barilius bendelisis*	-	-	-	-	-	-	-	-	-	-
2	*Barilius vagra*	3	-	3	3	-	-	13	2	5	6
3	*Neolissocheilus hexagonolepis*	3	12	-	6	9	-	-	-	-	-
4	*Tor putitora*	3	-	2	-	-	-	-	-	-	-
5	*Labeo pangusia*	1	-	-	-	-	-	-	-	-	-
6	*Labeo angra*	2	-	-	-	-	-	-	-	-	-
7	*Pseudoechinus sulcatus*	2	-	2	-	-	-	-	-	-	-
8	*Schozothorax plagiostomus*	3	-	-	4	1	5	-	-	-	-
9	*Cyprinon semiplotun*	-	14	-	-	-	-	-	-	-	-
10	*Labeo dero*	-	2	-	3	-	1	-	-	-	-
11	*Schizothorax annandalei*	-	-	1	-	-	-	-	-	-	-
12	*Glyptothorax telchitta*	-	-	3	2	-	3	-	-	-	-

13	*Glyptothorax trilineatus*	-	-	1	-	-	-	-	-	-	-
14	*Garra gotyla*	-	-	3	-	-	-	-	-	-	-
15	*Glyptothorax pectinopterus*	-	-	-	-	-	-	2	-	-	1
16	*Barilius barila*	-	-	-	-	-	-	4	3	-	2
17	*Labeo bata*	-	-	-	-	-	-	-	1	-	1

Table 15: Fish Diversity in Site-III

S.N.	Fish Species	Oct 2009	Jan 2010	Apr 2010	July 2010
1.	*Botia geto*	-	-	3	1
2.	*Botia almorhae*	-	-	9	5
3.	*Glyptothorax pectinopterus*	1	1	-	3
4.	*Botia lohachata*	-	-	2	1
5.	*Barilius vagra*	5	-	2	6
6.	*Barilius barila*	7	1	-	3
7.	*Labeo bata*	2	-	1	-
8.	*Clupisoma garua*	-	3	1	-
9.	*Schistura savona*	3	-	-	7

Table 16: Fish Diversity in Site-IV

S.N.	Fish Species	Oct 2009	Jan 2010	Apr 2010	July 2010
1.	*Botia geto*	-	-	2	-
2.	*Botia lohachata*	-	-	7	1
3.	*Botia almorhae*	-	-	10	-
4.	*Labeo bata*	2	1	10	14
5.	*Barilius vagra*	1	1	12	3
6.	*Barilius barila*	2	-	2	-
7.	*Glyptothorax telchitta*	1	2	-	1
8.	*Glyptothorax pectinopterus*	2	1	-	-
9.	*Garra gotyla*	4	-	-	1
10	*Clupisoma garua*	1	1	1	-

11.	*Macrognathus aral*	1	-	-	2
12.	*Pseudoechenesis sulcatus*	3	-	-	-
13.	*Schistura savona*	9	2	1	16

Table 17: Fish Diversity in Site-V

S.N.	Fish Species	Oct 2009	Jan 2010	Apr 2010	July 2010
1.	*Glyptothorax pectinopterus*	1	-	-	3
2.	*Glyptothorax telchitta*	-	-	2	1
3.	*Clupisoma garua*	-	-	3	-
4.	*Barilius vagra*	3	12	10	2
5.	*Barilius barila*	2	10	3	3
6.	*Botia geto*	-	-	3	-
7.	*Botia lohachata*	-	-	2	-
8.	*Pseudoechenesis sulcatus*	2	-	-	1
9.	*Labeo bata*	1	2	-	3

5.8 Socio-economic Status of Fishermen:

A preliminary survey was carried out to study about the socio-economic condition of the fishermen. Out of 60 households from five sampling sites i.e. Aandhi Muhan, Aruwa Ghat (Gahalamghat), Chherlung, Dailatung Ghat and Darpuk near Beltari to the bank of Kaligandaki River, 40 households were selected randomlyfor the household level survey.

Table 18: Fishermen Involvement in Fishing Activity:

Fishing Activity	Full Time	Part Time	Occasional	Total
No. of Households	20	12	8	40
Percentage	50%	30%	20%	100%

Among the sampled households, 50% households were found to depend fully in fishing while 30% households were engaged in part time fishing and 20% households were involved in fishing as an occasional fishermen. Fishermen those devoting 125-250 days per year in fishing are categorized as full time, those devoting 50-60 days in a year are categorized as part time and those devoting 20-25 days in fishing are categorized as occasional fishermen.

Table 19: Annual Fish Capture, Consumption and Sell:

Type of fishermen	Average fish capture Kg/year	Average fish consumption Kg/year	Consumption %	Average fish selling Kg/year	Fish selling %
Full time fishermen	115	18	15.65	97	84.35
Part time fishermen	88	25	28.41	63	71.59
Occasional fishermen	12	10	83.33	2	16.67

Active fishermen of the study area were found to capture 100-130 Kg of fishes annually. The fishermen that engaged partly in fishing activities captured 75-100 Kg/year and the occasional fishermen captured less than 20 Kg annually.

The average percentage consumption of captured fishes of full time, part time and occasional fishermen was found to be 15.65%, 28.41% and 83.33% respectively, whereas the average percentage selling fish was found to be 84.35%, 71.59% and 16.67% respectively.

Table 20: Population Distribution of Sampled Households:

Age group (yrs.)	Male	Percentage	Female	Percentage	Total	%
0-9	10	12.19	11	14.67	21	13.38
10-19	18	21.95	17	22.67	35	22.29
20-29	25	30.49	27	36.00	52	33.13
30-39	15	18.29	12	16.00	27	17.19
40-49	7	8.54	4	5.33	11	7.01
50-59	5	6.09	3	4.00	8	5.09
60 above	2	2045	1	1.33	3	1.91
Total	82	100	75	100	157	100

The total population of the Bote people of the sampled households was 157. Among them, 82 (i.e. 52.23%) were males and 75 (i.e. 47.77%) were females. Their average family size was found to be 5.2. Mostly males were found to be actively involved in fishing while females were involved in household chores.It was also noticed that the females lacked the specific skill that was needed for fishing in the fast flowing river. Male population belonging to 20-29 year age group was found to be the highest ie 30.49% followed by 10-19 year age groups (21.95%) and that of 60 or above age group was least i.e. 2.45%. The population of the males belonging to 30-40 and 10-19 year age group was found to be the most active fishermen. The population of females belonging to 20-29 year age group constituted higher percentage and that of 60 or above year age group the lowest.

In total the population of age group of belonging 20-29 years was higher and the population of age group belonging 60 above was least.

Table 21: Educational Status of Fishermen:

	Male				Female			
Age Group	Illiterate	%	Literate	%	Illiterate	%	Literate	%
Below 9	8	14.29	2	7.69	7	13.46	4	17.39
10-19	11	19.64	7	26.93	10	19.23	7	30.44
20-29	15	26.78	10	38.46	18	34.62	9	39.13
30-39	10	17.86	5	19.23	9	17.31	3	13.04
40-49	5	8.93	2	7.69	4	7.69	-	-
50-59	5	8.93	-	-	3	5.77	-	-
Above 60	2	3.57	-	-	1	1.92	-	-
Total	56	100.00	26	100.00	52	100.00	23	100.00

The literacy rate of the group was found to be 31.21%. Literacy rate in males was found higher that that in females.

The price rate of some important fish species was also studied around the study area. *Mastacembalus*, *Anguilla* (Bam) and *Tor* sp. (Sahar) were found to carry the highest market price while Goanch *(Bagarius bagarius)* had the lowest price. The price of other fishes like Asala *(Schizothorax richardisoni)*, Katle *(Neolissocheilus hexagonolepis)*, Gardi *(Labeo dero)* and Buduna (*Garra gotyla)* fluctuated at different times. All the capture fishes were sold in the nearby market area and villages like Aandhi Muhan, Mirmee, Beltari, Birgha, Khanigaun, Tansen, Darpuk etc.

Table 22: Price Rate of Different Fishes at Study Area:

Types of Fishes	Price/Kg				
	Aandhi Muhan	Aruwaghat (Gahalam Ghat)	Chhrelung	Dailatung Ghat	Darpuk (Beltari)
Asala *(Schizothorax richardisoni)*	250	250	235	225	220
Gardi *(Labeo dero)*	250	250	235	225	220
Bam *(Mastacembalus, Anguilla)*	315	300	300	300	300
Sahar *(Tor sp)*	260	260	240	250	250
Khosre (*Glyptothorax pectinopterus)*	230	230	215	215	220
Katle *(Neolissocheilus hexagonolepis)*	215	215	220	210	200
Goanch *(Bagarius bagarius)*	200	190	175	175	190
Buduna (*Garra gotyla)*	200	200	190	190	200

5.9 Mitigation Measures:

Kaligandaki –A Hydroelectric Project, having the capacity of 144MW electricity, has been built by impounding the Kaliagandaki River at Mirmi, Syangja district, which provides basic needs to increase the GNP of the country. However, impoundmentin rivers is known to impact adversely on fish biodiversity and fisher communities, who depend on fishing for their livelihood.

The project has undertaken different mitigation measures suggested in different levels of studies to minimize the adverse impacts due to construction of various components of the project. EIA 1995 gave instruction to build a fish hatchery, fish trapping and passage facilities and riparian releases. Some of the mitigation measures of Kaligandaki-A Hydroelectric Project were:

a) Fish Hatchery:

Kaligandaki-A Hydroelectric Project has built a fish hatchery near the Project site. The main objectives of the fish hatchery were to mitigate the damming effect of Kaligandaki-A Hydroelectric Project in Kaligandaki River by producing l economically important indigenous riverine fish species and restocking in the up and downstream of the reservoir, and creating employment opportunities for the fisher community. Fish restocking programmes however have faced a set of basic issues such as technical, biological, social and economic. . Introduction of fish species (stocking programme) in natural water body system was possible only after the development of appropriate institutional arrangements to manage both the stocking programme and natural water bodies. The maximization of sustainable social benefits is one of the principal objectives of fish stocking program in Kaligandaki Hydroelectric Project Site. Besides this, Kaligandaki-A fish hatchery could provide opportunity to conduct the research work. The hatchery is successful to breed different local fishes like Sahar, Gardi, Asala etc.

The hatchery had collected the most native fishes of Kaligandaki River to supply the information and further research work. The collected fish species is given in the table: 21.

Table 23: Fish species preserved in Kali Gandaki Fish Hatchery

S.N.	Scientific Name	Local Name
1.	*Nemacheilus rupicola*	Pate gadela
2.	*Glyptothorax pectinopterus*	Capre
3.	*Schizothorax spp.*	Asala
4.	*Pseudoechinus sulcatus*	Kabre
5.	*Puntius chilinoids*	Karange
6.	*Neolissocheilus hexagonolepis*	Copper Mahaseer
7.	*Glyptothorax cavia*	Bhedra
8.	*Barilius bendelisis*	Phaketa
9.	*Labeo dero*	Gardi

Table 23: Fish species preserved in Kali Gandaki Fish Hatchery (contd..)

10.	*Cyprinon semiplotus*	Khurpe/ Kingfish
11.	*Barilius barila*	Tilwa/faketa
12.	*Botia lohachata*	Baghi
13.	*Labeo pangusia*	Hade
14.	*Garra gotyla*	Budhuna
15.	*Garra annandalei*	Lahare
16.	*Heteropneustes fossilis*	Singhi
17.	*Barilius shacra*	Faketa
18.	*Barilius vagra*	Laus faketa
19.	*Puntius ticto*	Sidhre/pothi
20.	*Pseudotropius murius*	Jalkapoor/ Nemna
21.	*Schizothoraichthys annandalei*	Chuche Asala
22.	*Acrossocheilus hexagonolepis*	Chocolate mahaseer
23.	*Glyptothorax telchitta*	Khosre
24.	*Tor putitora*	Sahar/ golden mahaseer
25.	*Glyptothorax horai*	Kapre
26.	*Glyptosternum cavia*	Vedra/bhedra
27.	*Anguilla bengalensis*	Eel/Rajbam
28.	*Macrognathus aculeatus*	Stone eel/ chuche bam
29.		Jhinge machha
30.		Sun macho

The fish hatchery has not been able to meet the desired production goal due to the lack of skilled human resources, brood fish management for mass seed production and delay in open water stocking. The hatchery aimed to produce 2 million fingerlings but only 100,600 were released on Nov. 2003. (NARC, 2003).

Hatchery has been collecting economically important wild species of fishes possibly bigger ones for brood stock. More than 400 brood fish of different species have been collected from Kali Gandaki River and maintained in the hatchery. *Bagaarius yarrelli* locally called Gonch is the biggest fish weighing over 100kg was reported from Kali Gandaki River. Jalkapoor (*Pseudotropius murius*) and Gonch (*Bagaarius yarrelli*) are carnivorous. Attempts have been made for mass seed production of economically important indigenous species such as Asala, Sahar, Katle and Gardi. Broods of Sahar, *Tor putitora (*Golden Sahar) and *T. tor* (Copper Sahar) are being reared here. Gardi *(Labeo dero*), one of the dominating native fish species of Kali Gandaki River has been reared in captivity for the first time in 2003 at this hatchery. *Labeo pangusia*, a member of genus *Labeo* locally called 'Hade' responded to stripping and nearly 25,000 fries were produced in 2005. The total fingerling production in the Kaligandaki Fish Hatchery was 13, 00, 000 in the year 2009-2010 during my field visit which is shown in the table no. 24.

Table 24: Stocking of fish in different ponds:

Pond No.	Hatchling nursery	Date	Fish species
B-5	3,50,000	2067/3/13	Hade
B-6	80,000	2067/3/13	Hade
R-7	80,000	2067/3/14	Gardi
B-2	2,00,000	2067/3/17	Hade
R-8	1,00,000	2067/3/17	Hade
R-11	50,000	2067/3/21	Gardi
N-1	1,60,000	2067/3/24	Hade
N-3	1,80,000	2067/3/30	Hade
N-13	1,00,000	2067/4/3	Gardi
Total	13,00,000		

Source: Kali Gandaki Fish Hatchery (2010)

b) Fish Trapping and Hauling:

The introduction of trapping and hauling approach is relatively new in Nepal. It had been proposed to reduce impacts on up and downstream migration of fish species and overall fisheries resources of the Kaligandaki River around the project area. The program aimed to capture and transport fish species upstream over the dam, and to test the relative efficiency of different types and applications of fish traps including hook net, cast net, fyke net, bamboo weir, fish wheel trap and other locally available fish traps. The programe was initiated through civil contractor Impregilo SPA hiring 8 Botes fishermen from Andhimuhan Bote Villlage. The program was launched from 5th April 2000 by using one fyke net, two hoop nets, cast nets and bamboo trap. Unfortunately, one fyke net and two hoop net were swept away on 8th June 2000 due to heavy rain and flood in Kaligandaki River. After that, the programme was continued by using cast net, dip net, ghorlang etc. But the fabricated fish wheel trap could not be deployed due to the lack of anchoring facility and high water current. For the test of the relative efficiency of different nets and applications of the fish traps, most of the caught fishes were recorded before releasing them back into the river. Some were kept in gravel bar water storage pond of crusher plant for the future brood fish and hauling purposes.

Fish tagging is also done to determine movement, distribution and time associated with migratory behavior of mid and long range migratory fishes captured through the fish trap. A total 33 fishes were tagged and released in the downstream of Kaligandaki River.

The trapping and hauling program was implemented only during the test phase but was not implemented during the operational phase. These programmes should be carried out to gather information on fish species availability, migration and breeding behavior but it could not run in its full scale and there was no significant progress with regard to fish trapping and hauling test program, due to the lack of equipments, materials, experienced human resources, insufficement information and lack of full time vehicle (Upadhyaya and Shrestha, 2000).

c) Cage Fish Culture:

Cage Fish Culture had been carried out by Chisopani Matsya Bikas Kendra, Mirmee with the participation of fisher communities for an alternative source of income to uplift livelihood of those fisher communities affected after damming of the Kaligandaki River. Twelve floating cages of 25mm mesh size of 32 m^3 were landed at Aandhimuhan. Silver carp, Big head carp and rainbow trout were stocked separately in randomized triplicate cages. In other three cages, silver carp and big head carp were mixed in 1:1 ratio. Growth of silver and big head carp was based on natural food production and rainbow trout was provided with pellet feed. The experiment was carried for about 90 days from March to June

2003. the results of cage culture demonstrated that the growth of silver carp and big head carp in both mono and mixed cultures were rather slow due to poor abundance of plankton level. No relation could be established between density of fish stocked in mono and mixed culture on the body weight of silver and big head carp. Rainbow trout also could not grow well. However it was evident that comparatively better growth of trout could be attributed to continuous nutritious feed supplied to them (NARC, 2003).

d) Kaligandaki Environment Monitoring Unit (KGEMU):

This unit was established in 1997. It has been established to oversee and implement environmental and social mitigation and monitoring measures in order to minimize adverse impacts from Kaligandaki-A Hydroelectric Projec's construction and operation. This unit focuses on additional resources on poverty alleviation and local infrastructure improvement (Pandey, 2001).

e) Riparian Release (Downstream Release):

The KGA Project has diverted stream flows from the Kaligandaki River, partially dewatering the 50-km reach between the dam site and Power plant site. As part of the project's proposed mitigation, a $4m^3/s$ riparian release or minimum flow has been proposed to maintain aquatic habitat for fish and wildlife within the 50-km reach. In addition to the minimum flow of $4m^3/s$ there would be an additional $2m^3/s$ flow provided for a total of $6m^3/s$ during auspicious religious days.

Reduced flow within the diverted 50-km reach would principally affect aquatic biological resources and dependent wildlife. However, tributaries those join within this 50-km reach are diverted for domestic water supply or irrigation.

Upstream 13-km Reach:

The upstream 13-km reach extends from the dam site to the confluence of the Badigad River, covering about 26 percent of the dewatered 50-km reach.

Downstream 37-km Reach:

The downstream 37 km reach extends from the Badigad River to the power house, covering about 74 percent of the dewatered 50-km reach.Potentially significant adverse impacts to aquatic habitat, fish and wildlife resulting from implementing the $4m^3/s$ minimum flow release would be restricted to the dry season within the 13-km reach between the dam site and confluence of the Badigad Khola.

The primary season for the assuming that potentially significant adverse impact could occur within the upstream 13-km reach during the dry season (November to late May-early June) is the diversion would reduce flows to 5-10% of natural mean monthly flow. This effect would be most evident in the riffle habitat. Substantially reduced velocities in riffle habitat could adversely affect fish and other aquatic organisms and lower flow rate increased susceptibility to predation.

There would obviously be a significant loss in the amount of aquatic habitat during the dry season within the upstream 13-km reach under the $4m^3/s$ minimum flow alternative (EIA, 1995).

There was a provision of downstream release of $4m^3/s$ water during dry season and additional $2m^3/s$ release during festivals. But the compensatory flow was not released in dry period and sometimes river stretch was completely f dry due to diversion of water.

Other Mitigating Measures:

- There is the provision of siren warning system but it is not sufficient to cover the long distance from the project area.
- To generate employment and opportunities, the implementation of rehabilitation programme and micro credit revolving fund program had been launched.
- Rural electrification program was implemented for more than 3,000 households in 11 VDCs near the project area. About two thousand four hundred and ninety-seven households of various VDCs of Syangja, Gulmi, Parbat and Palpa districts are directly benefited by the rural electrification program of Kalihgandaki-A Hydroelectric Project. Moreover, 13000 households of Shree Krishnagandaki VDC, 58 of Jagatradevi, 198 of Birgha Archale, 197 of Nibuwakharka and 108 of Pidikhola VDC have benefited according to the project record section but this program is also continued for several VDCs of other districts.
- According to the provision of resettlement of affected Bote families to new houses with legal ownership, resettlement and rehabilitation program was launched. Altogether, 18 Bote households in Aandhimuhan were affected by road and dam construction. Eight of these households have been shifted to a new location from the roadside. However, there was lack of proper compensation of those with undocumented land rights particularly members of the Bote caste. But there was not proper supply of daily need materials and other facilities.
    - There is provision of fish bypass system at the dam and adequate compensation and provision of rehabilitation grants for Project affected families.
    - Fish collector channel was constructed but it is not in operation.

The mitigation measures recommended by EIA and their present condition can be summarized in the following table:

Table 25: Status of Mitigation Measures Recommended by EIA

S.N.	Mitigating measures recommended by EIA 1995	Mitigating Measures performed	Remarks
1.	Suggested sites for the spoil disposal a) Flat areas adjacent to Mirmi b) Canyons on the Aandhi Khola and South bank of Kaligandaki c) River Berm (Preferred Alternative)	The preferred alternative (River Berm) was used for the spoil disposal during the construction.	-
2.	Establishment of Kaligandaki Environmental Management and Monitoring Unit	Kaligandaki Environmental Management and Monitoring Unit was established and it worked until the construction period. This unit performed revegetation, bioengineering works, fuel wood conservation and also supported to the micro nurseries for the community plantation throughout the construction period.	-
3.	Fish Hatchery	Fish hatchery was constructed and operated. One-year (August 2002-July 2003 at the beginning and extended 4 months upto November 2003) program had launched on contract basis by NARC to operate the hatchery for producing fingerlings of of indigenous riverine fish species available in Kaligandaki River.	Open water stocking was delayed and fish hatchery was unable to produce the desired production goal. Only 100,600 fingerlings were released on November 2003. Hatchery was designed for 2 million fingerlings production in capacity.

Table 25: Status of Mitigation Measures Recommended by EIA (contd..)

4.	Fish trapping and hauling	Fish trapping and hauling programme was implemented during the test phase only (from 5th April 2000 to December 2000) by KGEMU.	Fish traping and hauling programme was not implemented during the operational phase.
5.	Peparian release (a 4m³/s minimum flow during dry season and additional 2m³/s during festivals.	There is the provision of riparian release.	Riparian release was not released regularly in dry season and sometimes river stretch was completely dry due to diversion of water.
6.	-	Cage fish culture technology was implemented at Aandhi Muhan for an experimental basis from March to June 2003 by NARC.	Growth of silver and Bighead carp in both mono and mixed culture was rather slow. Rainbow trout was cultured by supplying pellet feed could not grow well.
7.	-	Provision of siren warning system.	This system was not sufficient to cover the long distance from the project area.
8.	-	Rural electrification program at the Project area.	According to available information, about 2497 households in various VDCs of Syangja, Gulmi, Parbat and Palpa districts are directly benefited by the rural electrification programme of Kaligandaki-A Hydroelectric Project.

DISCUSSION

In the present study, fishes were captured by using gill net, cast net, hook and line, ghorlang and other available devices. Other devices generally used in fishing by Botes are hand capturing, hitting the captured fish on the stone with force and the mosquito net. Some fishes come in the evening and morning time to the bank of river and fishermen pick them up by capturing from the base of the stone or hitting the stone with force. Altogether, 14 species of fishes under 6 families and 9 genera belonging to order Cypriniformes, Siluriformes and Symbranchiformes were captured from the sampling sites of Kaligandaki River (Aandhi Muhan to Beltari) dewatered and reduced flow area. From the sampling site Aandhi Muhan i.e. reservoir area, six species of fishes were collected whereas only four from Aruwa Ghat, Gahalam Ghat. Nine species from Chherlung, thirteen species from the Dailatung Ghat and nine species from the Beltari. In a similar way of study, conducted in August 2003 by Shrestha and Chaudhary, five species from Seti Beni and Seti Khola site, two species from Kaligandaki at dam area and two species from Kaligandaki at Paundi area were collected. The difference is due to the duration of the study period. Pandey (2004) found six species from Seti Khola and Seti Beni, eight from Aandhimuhan and five from Gahalamghat. Present study shows that there is reduction in number of fish species in comparison to the earlier study. Shrestha (1990) reported 69 species of fishes from the Kaligandaki River. EIA (1995) reported 44 species of fishes from Seti Beni and Seti Khola. The study was carried from June 1991 to March 1994. No new record of fish has been found in the present study. Lesser number of fish species has been reported from the present study as against 35 fish species reported by EIA(1995). This difference in number of fish species could be due to the difference in study period as well as due to the dam impact. The EIA study duration was very long as compared to the present study and it was carried out before the construction, operation and maintenance of the dam. Capture fishery in the project area became vulnerable, associated with the decreasing population of many native fish species after the damming of Kaligandaki River. So it can be concluded that the construction of dam adversely affected the diversity of fish species around the study area. Construction of dam not only affected the migration of fishes but also the physico-chemical parameters of the water which in turn may have resulted in creating adverse environment for fish species. This unsuitable environment must have overall negative impact in their normal growth, reproduction, food availability etc. In the same report of EIA, 39 fish species were recorded from proposed dam site, upstream of Aandhi Khola and proposed reservoir section. The study was carried from June 1991 to March 1994. Only seven species in the present study were found to be common with EIA report, however 32 species could not be captured. Fishing in the reservoir is very difficult after the construction of dam. So the present study mostly confined to the upstream area of Aandahi Khola. The study area below the dam is mostly confined tothe bank region and settlements of Botes. Various factors such as the duration of study period, impact of dam and small range of sampling site, must have been

responsible for this type of finding where fewer number of species have been reported as against more fish species reporting of EIA (1995). Only four species from Aruwaghat (Gahalamghat) were reported in the present study but nine from Chherlung, thirteen from Dailatung Ghat and nine from Beltari. This type of differences in finding must have been because of mixing of other tributaries of Kaligandaki River like Badigad and Ridi Khola in the latter parts.. Before the construction of dam, EIA (1995) recorded 21 fish species from Kaligandaki (Harmichaur, Paundi, Gulmi etc.) Ding Khola, Badihari Khola. Pandey (2004) reported five species below dam at Gahalam Ghat. The fish species below the diversion dam are affected by low quality of water, irregular flow, reduced space and reduced food producing zone along with the blockage of migration route. The sedimentation load occurring due to the activities of the project works have been creating a serious problem in the spawning of fishes around this site lying just below the dam. NARC (1998-99) did a survey of fish species and environmental variables in Kaligandaki River near the diversion dam. It was reported that 24 species under 7 families were collected from Kaligandaki and Aandhi Khola near Kaligandaki Hydroelectricity dam, 23 species of 7 families from Kaligandaki and 17 species of 3 families from Aandhi Khola. Fishermen reported nine species as commonly occurring species and 11 species were fairly common while 2 species were reported as uncommon. NARC (1997) reported that the fish population inhabiting near the dam site at Mirmi would likely be affected due to dam barrier especially the migratory fish, the tor spp. (Sahar) and *Anguilla bengalensis* (Rajbam). *Anguilla bengalensis* (Rajbam) is catadromous in behavior and migrates from the fresh water to the ocean for spawning and back to fresh water for growth. *Schizothorax* spp. (Asala) also moves upstream, as it needs more oxygenated running water and cannot tolerate the environment of stagnant water.

Physico-chemical parameters of water were also found to be influenced by the construction of dam. In the reservoir section, the movement of water is very slow, which directly results in the increase in water temperature and free carbon dioxide whereas it decreases the dissolved oxygen of water. Obviously, these changes in water quality parameters have direct effect on the fish fauna in their normal growth, feeding, reproduction and other activities of life. When the lotic environment is changed into lentic, covering more land, the oxygen content of water generally decreases with the rise in temperature. The pH of lentic water (water of reservoir section) was found to be non-uniform however the result shows decrease or increase of pH according to the decrease and increase of water temperature. According to Welch (1992), the current in lotic environment tends to keep pH uniform over considerable distance. NARC (2003) reported that water temperature ranged from 13⌈C in January to 24⌈C in June/July. The results were more or less similar to the present study, similarly, the pH ranged from 8.4 to 9.7 whereas Pandey reported the pH range between 8.4 to 9.4 and NARC (2003) reported the range of from 7.1 to 9.1. Upadhyaya & Shrestha (2000) obtained the result from the water quality analysis of powerhouse and dam site of Kaligandaki from January 2000 to December 2000. The result revealed that parameters were still suitable for

the growth of fish and aquatic life. One of the important parameters of the water quality, the dissolved oxygen content was in the range of 7.1 to 8.9 mg/l of the powerhouse site and 6.8 to 8.6 mg/l of dam site, which is fairlya better range in relation to fish and other aquatic fauna. The pH of the dam site was slightly alkaline (i.e. 8.5 to 9.7) which is suitable for fish growth but increament in alkalinity as compared to those by Pandey (2004) which was (7.o to 8.4). The atmospheric temperature recorded in the dam site was 16⌈C in January to 27⌈C in April and July and the water temperature was lowest 23.8⌈C in January and highest 23.5⌈C in July but increased water temperature than that reported by Pandey (2004) which was (16.4⌈C- 20⌈C). The river water temperature below 20⌈C is considered suitable for growth of hill stream fishes. The transparency of water at the dam site has been found to be 2.7cm in October and 75cm in July and at powerhouse site, it was found 2 cm in October and highest in 150cm in April. Thus the water transparency of water shows that water becomes most turbid in the month of October-the rainy season.

Shrestha (1990) recorded the pH of Kaligandaki ranging from 7.1 to 8.1 and water temperature at the upper reaches 5-18⌈C, in the middle reaches 15-22⌈C and in the lower reaches, it varied from 25 to 30⌈C. Dissolved oxygen varied from 8.3 to 10 ppm (December to April) and 3 to 6 ppm (July to September). Temperature, pH, DO, CO2, alkalinity and hardness in the downstream of the diversion dam were also measured to generate some ideas about impact of dam on those parameters. Water temperature was found to be lower than that of the reservoir area. Similarly, free CO2 and hardness were also reduced. Slight increment in DO was observed in downstream of the diversion dam. The water environment, when changed from lentic to lotic, showed decreased in water temperature, which directly influenced and resulted in increased DO. The CO2 content of water increased with the decrease of dissolved oxygen content. The steamer at reservoir section for the transport also causes the water pollution by leakaging the diesel used, increasing the water temperature and producing huge sound destroying the fish habitat at the reservoir area. The water of downstream is more suitable for the fish fauna regarding the physico-chemical parameters but the amount of water in its irregular flow have adverse impact on fish fauna. According to available information, compensatory flow was not released in dry period and river stretch was completely dry due to diversion of water. The resultant impact of these factors became responsible for the decrease in fish diversity just below the diversion of dam. Wagle et al. (2000) reported that the water temperature of the Kaligandaki in Project site ranged from 15.5⌈C in winter to 23.1⌈C in summer. Dissolved oxygen ranged from 8.9 – 13.1 mg/l and pH range was found in between 7.4 to 8.1.

Regarding the socio-economic status of fishermen, 52.23% were males and 47.77% were females. Females in the study area were not found to be actively involved in fishing but they took part in fishing at bank side and sometimes were involved in fish processing activities.

Among the sampled households, 50% households were dependent fully in fishing as full time fishermen, whereas 30% were found to be part time and 20% as occasional fishermen.

Gubhaju et. al. (2002) studied the contribution of cold-water fishes in the livelihood of mountain people of Nepal. In the study, it was found that 40% of the fishermen of Melamchi, Tamor, Bheri, Sunkoshi and Trishuli were regular fishermen whereas 60% of them were found to be engaged in fishing as a part time job. Women were not found to be involved in fishing because they remained busy in their household chores. As a result they could not devote time for fishing and thus lacked technical skill required for fishing unlike their male counterparts.

Majority of fishermen inhabiting in the study area was illiterate. Moreover, 31.21% of the sampled population was literate. The literacy rate of females was found to be lesser than that of males. In a similar study conducted for the Environmental Impact Assessment in 1996, it had been documented that only 25.5% of the fishermen inhabiting Andhi Khola Botegaun were literate. At that time, even a primary school had not been established in the area. After the establishment of Kaligandaki-A Hydroelectric Project, it opened a primary school in Aandhi Khola Botegaun, which became responsible for the increment of literacy among the fishermen. NARC (2003) reported that 28.2% of the fishermen the inhabitants of Aandhi Khola Botegaun, were literate. The difference in literacy data obtained by NARC and in the present study is primarily due to difference in the area covered. While the NARC study covered only Aandhi Khola Botegaun, this study also encompassed Chherlung, Aruwaghat (Gahalamghat), Dailatungghat and Darpuk (Beltari). All the sites have the primary school but the literacy rate is low due to the lack of awareness.

The economic condition of fishermen is also very poor. NARC (1996-97) reported that the people involved in fishing belonged to low-income group as they acquired less land. Rice, wheat, maize and mustard were the main agricultural crops and in addition, they raised some domestic animals, which are not enough for their livelihood. At other times, they are engaged in fishing activity. In the sampling sites, boating and fishing were the main job of Botes but now they cannot do those activities because of the construction of bridges in different places. Besides all these, water level of river is also decreasing. So fish diversity has also decreased and fishing for their daily livelihood could not be done. These people thus changed their occupation from boating and fishing to daily wages, agriculture etc.

In the present study, age group of 20-29 year of male fishermen comprised the highest i.e. 30.49% of the male population while the females between 20-29 years occupied the highest rank i.e. 36% of the female population. Among the overall population, 33.13% comprised of the age group between20-29 years. The lowest 2.45% of the male population and 1.33% of the female population fell above 60 year age groups. EIA (1996) reported that 42.45% of the overall population (population of Aandhi Khola, Botegaun) was covered by below 14 years

of age groups. The highest percentage of both male and female population also came under the same category. The people of 60 and above formed 1.91% of the total population.

Active fishermen of the study area captured 100-130kg of fishes, while, the part time and occasional fishermen captured 75-100 kg and below 20 kg per year respectively. Full time fishermen sold fish more than 6 times they consumed while the occasional fishermen consumed more than they sold. The occasional fishermen were generally involved in other activities like navigation, wages and labor, livestock keeping, working in agricultural field etc. They went for fishing especially in occasions of festivals for their own consumption. So they became focused on mainly consumption rather than trade.

The market price of *Tor putitora* (Sahar), *Mastacembalus armatus* (Bam), *Schizothorax richardisoni* (Asala), *Neolissocheilus hexagonolepis* (Katla) and *Labeo dero* (Gardi) ranged from 250-315 Rs/Kg in different markets near the sampling area. The price of *Garra gotyla* (Buduna) and *Glyptothorax pectinopterus* (Khosre) in Aandhi Muhan, Mirmi, Beltari was found to be ranging from 175-230 Rs/Kg. However, the fishermen got higher market price in Aandhi Muhan and Mirmi bazaar than other sampling sites.

Aandhi Muhan, Chherlung, Dailatung and Darpuk are inhabited by debt-ridden Bote (fishermen) families. Houses are one storey, thatch-roofed with mud mortar. Poultry and cattle raising is common. Some areas of the locality were inundated due to construction of dam in Aandhi Muhan.

Fishes were more available during their breeding season (June/July) as they migrate from place to place for spawning. Generally, fishermen capture more fish during March/April. Aandhimuhan, and Mirmee are the markets for the fishermen living around the site-I. Fishermen of site-II used Gahalamghat, Birgha Archale and Mirmee bazaar. Baughagumba, Chherlung, Argali Bazaar and Pugha are the fish market of site-III. Khanigaun, Sikhardanda, Dailatung, Urleni, Tansen, Tanglehawa are the fish market fof site-IV and Ramdi, Beltari, Gunga, Malunga, Darpuk are the fish market for the site-V.

During the EIA survey (1995), 35 fish species were reported in the month of the June/July'93, Sept./Oct'93, Nov'93 and Jan'93 from proposed dam site, upstream of Aandhikhola, and proposed reservoir section. In the present study, only 6 species were collected during the month of Oct'09, Jan'10, Apr'10 and July'10 from site-I. The highest fish diversity was obtained on Nov'93 before the construction of dam according to EIA survey 1995. The lowest fish diversity was obtained in the month of January in both the studies carried out before and after the construction of dam, five species before the construction of dam and only three species after the construction of the dam but Pandey(2004) reported only two species from this site. The main cause for the decrease of fish diversity in the upstream at reservoir area might be because of the conversion of free

flowing water to stagnant water and loss of feeding and breeding ground. The pollution caused by the steamer is the main cause for the loss of fish diversity..

The result of the present study obtained from Gahalamghat area and Aruwa ghat can be compared with the Harmichaur and Ding Khola of the EIA report 1995 because these two areas are located near each other. EIA (1995) recorded 15 fish species during the month of June/July'93, Sept/Oct'93 and Dec/Jan'94 whereas 4 species were collected from this site in the same period. During EIA, highest fish diversity was obtained in Sept/Oct'93. In the present study, the highest fish diversity was obtained in July 2010 and lowest fish diversity was obtained in April 2010. Low quantity of water and its irregular flow might be one of the reasons for low diversity of fishes. The other main cause could possibly be due to the blockage of water due to dam construction which directly affects the long and small range migratory fish species like Sahar (*Tor putitora*), Bam (*Anguilla bengalensis*), Jalkapoor (*Clupisoma garua*), Asala (*Schizothorax* sp.) etc.

The third site had the highest fish diversity in the month of July'10 and lowest in the month of January'10 which shows the slightly high diversity due to the joining of the Badigad Khola below the site-II and Ridi Khola at Ridi Bazaar.

The fourth site had the highest fish diversity in the month of July'10 and lowest in the month of January'10 which shows the highest fish diversity among the sampling sites due to the joining of the Badigad Khola below the site-II and Ridi Khola at Ridi Bazaar.

The fifth site had the second highest fish diversity in the month of April'10 and lowest in the month of October'10 which shows the decrease in fish diversity due to the forced water flow from the powerhouse which directly affect the fish behavior and habitat.

The impact of Kaligandaki-A Hydroelectric Project associated with the construction of dam and reservoir area brought changes in Riverine condition in the upstream area. There was habitat degradation due to unusual erosion, displacement of river boulders, absence of regular downstream release, blockage of upstream migration of fishes, morpho-ecological changes in both above and below the dam, turbidity and silting problem due to construction of road near the river, illegal fishing in dewatered zone like bombing, poisoning, gill net using, using steamer in reservoir etc. Hydropower development almost always converts free flowing rivers and hill streams to man-dominated environments. The existing dams of Nepal are deterrents to fish migration and prevent the fish from reaching its usual breeding, rearing and feeding grounds. Many environmental impacts associated with hydropower development include, conversion of free flowing rivers and hill streams to impoundment, physical habitat alternation, reduction in available space and reduction in food producing zone (Khanna, 1996, Shrestha, 1997). Pandey et al.(2002) studied on the environmental impacts of hydropower development on vegetation and wildlife resources at Kaligandaki-A

Hydreelectric Project area. They noticed some prominent impacts like vegetation clearance, removal of wood and threatening of rare and endangered species. They found that the natural habitat of wildlife was also disturbed in vicinity of Project site. They pointed out that most of the impacts were of temporary nature and expected to be reduced after Project completion. Joshi (1988) studied the impacts of dam in Sunkoshi River. The dam of Sunkoshi had obstructed the seasonal migratory fishes. He also reported that the abundance of *Bagarius bagarius* had decreased enormously due to the construction of dam. He also described that construction of dam had brought great many changes in structure and function of natural water courses as well as in physical, chemical and biological characteristics of the river. Pandey (2004) studied the impact of dam in fish resources of Kaligandaki with particular reference to Kaligandaki-A Hydroelectric Project and found that there was decrease in fish species with slight change in water quality. Mostly river changes in lotic to lentic nature due to dam obstruct the migration route and breeding and feeding ground of fishes in both up and down streams of the river.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions:

Following conclusions were made from the results obtained during the study period.

- Kaligandaki River is rich in fish diversity. Altogether, 14 species of fishes under 6 families and 9 genera of the 3 orders i.e. Cypriniformes, Synbranchiformes and Siluriformes were collected during the study period.
- *Barilius barila, Barilius vagra, Labeo bata, Glyptothorax pectinopterus, Clupisoma garua* are the dominant fish species found in the range of study site i.e. dewatered zone.
- According to the interview with Bote fishermen, *Bagarius bagarius, Tor tor, Anguilla bengalensis, Labeo dero, Labeo pangusia* species are found in Kaligandaki River but not recorded in study period.
- The impoundment due to dam affects the water quality parameters. The temperature and CO_2 content of water is found to be increased while DO content of the water is found to be decreased.
- The pollution around the dam site caused by different factor mainly by Steamer is harmful to aquatic biodiversity and is the main problem for fish conservation.
- Damming in the river affects the fish diversity negatively. The migratory fish species can not move up and down stream on one hand, and on the other hand, the water quality parameters are also changed which showed the adverse effect on fish species. The fish diversity above the dam is decreasing due to the change in water quality and riverine condition and that of downstream is affected due to the low quantity of water and blockage of upstream migration by the dam.
- Reduction in the water flow in the dewatered zone, the religious area Ridi and other funeral culture is also badly affected mostly in dry period.
- Reduction in fish diversity, the native fishermen has changed their occupation to other fields. The development work such as bridge on the river has displaced their navigation work.
- The socio-economic condition of fishermen living around the study area is very poor. Only 31.21% of the fishermen are literate. Among them, 31.71% of males and 30.67% of females are literate. The fishermen are no longer able to meet their livelihood needs solely on the basis of their primary occupation ‘fishing’. Therefore, they now have to depend upon secondary profession like navigation, agriculture and wage labor.

Recommendations:

Project activities and construction of dam are creating adverse impacts on fish diversity which in turn directly affects the socio-economic condition of the fishermen. So, the following recommendations are suggested.

1. Provision of fish ladder across the dam is not possible for such a high dam. So, the establishment of fish hatchery is the only feasible alternative. To run the fish hatchery the direct beneficiary agencies should be made responsible for meeting the necessary financial expenses with a proper coordination.
2. Fish population and species diversity should be monitored every year regularly for a long term and short term and the mitigation measures as recommended by the study, should be implemented.
3. Regular monitoring of fishes on up and down stream of the river which are left by the hatchery.
4. The responsible authorities should bear all the cost of biodiversity conservation and should conduct programmes to uplift the livelihood status of fishermen around the affected area.
5. Fish collector channel present in Kaligandaki 'A' Hydroelectric dam should be operated in consultation and supervision of fisheries biologists and experts.
6. Native fishermen groups should be trained by different training programmes and providing them aquaculture materials and fish seeds.
7. Local community should be forced to fallow the Aquatic Life Conservation Act-2017 BS.
8. The dewatered and reduced flow area should be forced to say as non-poisonous and no bombing area.
9. Riparian release of 4 m^3/s water during dry season and additional 2 m^3/s in the religious days as recommended by EIA, should be strictly fallowed.

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Annex I: Fish Species Recorded From Kaligandaki River:

S.N.	Scientific Name
1.	*Amblyceps mangonis* (Hamilton-Buchanan)

2.	*Anguilla bengalensis*
3.	*Amphipnous cuchia* (Ham.)
4.	*Barilius barila* (Hamilton-Buchanan)
5.	*Barilius bendelises* (Hamilton-Buchanan)
6.	*Barilius barna* (Hamilton-Buchanan)
7.	*Barilius shacra* (Hamilton-Buchanan)
8.	*Barilius vagra* (Hamilton-Buchanan)
9.	*Balitora brucei* Gray
10.	*Burbus chilinoides* (Mc Clelland/ Naziritor chelynoides)
11.	*Bagarius bagirius*
12.	*Botia almorhae* Gray
13.	*Botia lohachata* Chaudhari
14.	*Chagunius chagunio* (Hamilton-Buchanan)
15.	*Channa gachua/ Channa orientalis* Bloch and Schneider
16.	*Channa punctatus* Bloch
17.	*Crossocheilus latius* (Hamilton-Buchanan)
18.	*Clupisoma garua* (Hamilton-Buchanan)
19.	*Danio aequipinnatus* (Mc Clelland)
20.	*Eutropichthys vacha* (Hamilton-Buchanan)
21.	*Echiloglanis hodgartii* (Hora)
22.	*Garra mullya* (Sykes)
23.	*Garra annandalei* (Hora)
24.	*Garra gotyla* (Gray)

25.	*Glyptothorax pectinopterus* (Mc Clelland)
26.	*Glyptothorax telchitta* (Hamilton-Buchanan)
27.	*Glyptothorax trilineatus* Blyth
28.	*Glyptothorax cavia* (Hamilton-Buchanan)
29.	*Glyptosternum pectinopterus* (Mc Clelland)
30.	*Glyptosternum blythii/ Euchiloglaris hodgartitora*
31.	*Heteropneustes fossilis* Bloch
32.	*Labeo angra* (Hamilton-Buchanan)
33.	*Labeo dero* (Hamilton-Buchanan)
34.	*Labeo pangusia* (Hamilton-Buchanan)
35.	*Mastacembalus armatus* (Lacepede)
36.	*Mastacembelus pancalus / Macrognathus pancalus* (Hamilton-Buchanan)
37.	M*acrognathus aculeatus/ M. aral* (Bloch & Schneider)
38.	*Neolissocheilus hexagonolepis* (Mc Clelland)
39.	*Noemacheilus rupicola/ Schistura rupicola* (Mc Clelland)
40.	*Nemacheilus bevani/ Schistura beavani* (Mc Clelland)
41.	*Psilorhynchus pseudeuchoneis/ Psilorhynchoides pseudecheneis* (Menon & Dutta)
42.	*Pseudoecheinus sulcatus* (Mc Clelland)
43.	*Puntius conchonius* (Hamilton-Buchanan)
44.	*Puntius sophere* (Hamilton-Buchanan)
45.	*Puntius ticto* (Hamilton-Buchanan)
46.	*Puntius sarana* (Hamilton-Buchanan)
47.	*Pseudeutropius murius/ P. atherinoides*

48.	*Pseudeutropius garua / Clupisoma garua*
49.	*Pseudeutropiu atherernoides* (Bloch)
50.	*Rita rita* (Hamilton-Buchanan)
51.	*Schizothorax plagiostomus* (Gray)
52.	*Schizothrax richardsoni* (Gray)
53.	*Schizothorax annandalei* (Gray)
54.	*Schizothoraichthys progastus* (Mc Clelland)
55.	*Semiplotus semiplotus* (Mc Clelland)
56.	*Tor putitora* (Hamilton-Buchanan)
57.	*Tot tor* (Hamilton-Buchanan)

PLATE 1

Macrognathus aral

Botia geto

Botia lohachata.

Clupisoma garua.

Pseudoecheneis sulcatus.

Glyptothorax pectinopterus.

Glyptothorax telchitta.

Schistura savona.

PLATE 2

Botia almorahae.

Garra gotyla.

Barilius barila.

Barilius vagra.

Labeo bata.

Labeo boga.

Cast net.

Local fisher man holding Ghorlang.

PLATE 3

Bote gaun, Dailatung.

Bote family.

Local fisher man throwing cast net.

Local fisher men making boat.

Saakhar with trapped fishes.

Researcher observing Saakhar

PLATE 4

Kaligandaki Hydro-power dam (Study area).

Aandhimuhan village (Study area).

Breeding ponds of Kaligandaki hatchery.

Breeding tubs of hatchery.

Researcher visiting Cage Fish Culture.

Researcher taking limnological parameter.

Annex II: Questionnaire for fishermen

1. Name: …… Date…….……..

2. Address:

a) Zone: ……..... b) District: …… c) VDC: ……..

d) Ward no. :…….. e) Location: ……

3. Family information:

a) Family member: …….. b) Male…….. Female……..

c) Head of Family …… d) Caste …….

e) Sex …… f) Age ……

g) Religion…….. h) Occupation……

i) Education: i) Illiterate ii) Literate

4. Fisheries:

a) Is fishing is your main occupation? i) Yes/ No

ii) If yes annual income from fishing…….

iii) Is it covers your family expenditure? i) Yes/ No

iv) If no how do you meet the daily expenses?

By ……..

5) What fish species of fish are available in river?
……

6) Most common Fish……. …….

7) Biggest fish……

8) Fishing season……..

9) Fishing implements used……..

10) What do you do with captured fishes? a) Consume b) Sell C) Both

11) Where do you sell fishes? a) Market b) Village

12) How much fish do you sell per year?
……

13) How much fish do your family consume per year?
……..

14) How do you preserve fish for long time? .....

15) What do you think fish population has increased or decreased? ……..

Reason for that ……

16) Do you get any support from any public and private institutions?

a) Yes b) No

17) If yes, what type of support you got? ……

18) If no, what type of support do you want? .....

Thank You

Name of the interviewer: …….