CHAPTER ONE

1.0 INTRODUCTION

Nepal is a mountainous Country lying on the southern slopes of the Himalayas between India and China. Its area is about 147,180 square Kilometers. It is about 900 km east to west and 150 to 240 km. north to south. Nepal is bounded on the north by the autonomous region of China i.e. Tibet, on the east by Sikkim and West Bengal of India and on the south and the west by Bihar and Uttar Pradesh of India. Nepal is one of the least developed and a land-locked country.

The country is divided into three distinct regions on the basis of its altitude:

1. Lowland or Terai region (500ft-1000ft)
2. Midland or Mahabharat region (2,000 ft – 10,000 ft)
3. Highland or Himalayan region (10,000 ft – 29,029 ft)

The main portion of the country is occupied by the high mountains and the rolling hills. Eighty three percent of the land of the country is covered by the hills and the high mountains. Seventeen percent of the land is almost flat i.e. Terai. The Terai forms the northern part of the Indo-Gangetic basin and is fertile with alluvial soil. Terai, Nepal's grainary, produces about 60% of total grain output and is rich in forest and agricultural resources. Thus, of the three regions, Terai is the most potential area for agriculture production and most suited for fish culture.

The northern part of the Terai is a little more elevated and the rugged area called Bhabhar is ideal for growth of forests. Churia hills in the north rise suddenly from gentle slopes and are intersected by gorges and streams. The Mahabharat Range lies between Churia hills near Terai and the low areas of the midland rising up to 3,500 m. altitude. It is covered with thick forests. The midland consists of valleys between snow-clad Himalayas and the south side of the Mahabharat range. Its average altitude is about 2000m. The climate here is temperate and comfortable. About 52 percent of the total population of the country lives in this zone. The northern part of the country is highland and most of the snow-covered peaks lie in this zone. Land above 4500m.

is covered with snow. This area comprises about 20 percent of the total area of the country.

1.1 Fresh Water Resource of Nepal

Nepal is rich in fresh water resources comprising varieties of hydrosphere. There are many beautiful rivers, lakes, ponds and brooks in Nepal since it is situated on the laps of snow capped mountains of the Himalayan region. These rivers, lakes and streams originate from the melting of ice/glaciers of Himalayas and the monsoon rainfall. Glaciers are important in the study of the river systems as they supply the snow water to the main rivers. The snowmelt starts in March and continues up to August. Snow fed rivers is perennial carrying significant flows in dry season.

Table 1. Water resources and Estimated Water Surface Area

Types of water resources	Estimated Area (ha)	Percentage (%)	Potential Area (Ha)
Natural Water	401,500.0	48.8	
Rivers	395,000.0	48.0	
Lakes	5,000.0	0.6	
Reservoirs	1,500.0	0.2	92,400
Village ponds	6,500.0	0.8	14,000
Marginal Swamps	12,500.0	1.4	
Irrigated rice field	398,000.0	49.0	
Total	818,500.0	100.0	

Estimated water surface Area in Nepal (FDD, 1996)

Water is an important physical resource and plays important role in different characteristic features of this country. Water has a nature and property to maintain annual water balance of surroundings. The inflow in water balance comprises precipitation in the form of rain and snow from atmosphere and surface flows from northern reaches of basins. The outflows consist of the most visible river discharge amounting to about 160 billion cubic meters, evapo-transpiration into the atmosphere, human consumption use and seepage into deep ground water.

1.1.1 River Systems of Nepal

In Nepal, total area covered by running water is 395000 hectare which is 9.31 percent of the total area (Table 1). There are more than 6000 existing rivers exceeding 25000 km in total

length. Surface water is estimated to occupy 2.7 percent of the country area of which 97 percent occupied by large rivers. Rivers in Nepal can be classified into three categories. The first group of rivers has sources of water in the dry season from the melting of snow and glaciers. The Mahakali, Karnali, Gandaki and Saptakoshi are the four rivers belonging to first category. The second group of rivers is originated in the middle mountains which are mostly rain fed and have low dry season flow. The Bagmati, West Rapti, Mechi, Karnali, Kankai, Kamala and Babai are the rivers in the second category. Third category of river is originated in the Churia. These rivers have small catchment areas and discharge of these rivers become nominal or several rivers dry up in dry season. Tilawe, Sirsia, Manusmars, Sunsari, Banganga are some up the rivers of this group.

1.1.2 Saptkoshi system

The Saptkoshi River is the biggest river of the Nepal and said to be next to indo-Brahamaputra of Indian subcontinent. It drains large area between Langtang and Kanchanjunga Himalayas. The total length of the river is 72.0 km. The seven torrential rivers of the Saptkoshi are Sunkoshi, Indrawati, Tamakoshi, Likhu, Dudhakoshi, Arun, and Tamur. These rivers are originated from the Himalayas and Tibet which flow more or less from north to south through Nepal. The total drainage area of the Koshi River is 60,400 km^2, out of which 28,140 km^2 lies in Nepal. It has estimated annual run off about 1566 m^3/s.

The Sunkoshi River is one of the most important tributaries of Saptkoshi. Sunkoshi River may be the oldest river present before the origin of Himalayas (Ganser, 1964). At the upper reaches of Sunkoshi River lies Bhotekoshi which was originated during early Cretaceous to Pleistocene period. Bhotekoshi River enters into Nepal at Kodari from where it flows to the south -west and conjugates with the Sunkoshi at Sunkoshi Bazaar. The Sunkoshi River meets the Balephi Khola at Balephe Dobhan and meets the Indrawati River at Dolalghat.

1.1.2.1 Sunkoshi

The Sunkoshi River has snow covered area of 605 km^2. The snowy area helps it in water balance along with ground water during dry period of summer. Sunkoshi River covers around 50 km up to Dolalghat. The river is perennial with the annual sedimentation rate of about 54.2 x 10^6m. Hydrological cycle of this river is maintained by heavy rain monsoon precipitation, melting of snow/ice cover and discharging aquifers. The main catchment area of the Sunkoshi River remains under perpetual snow and ice. The catchment area of Sunkoshi river is 42900 km^2 and discharge is 34000m^3/s (Shrestha, 1990).

1.1.2.2 Indrawati

Indrawati is another tributary of Sapta Koshi and joins Sunkoshi at Dolalghat. It also flows north-west in the upper part and near Sipaghat the channel becomes wide and river makes easterly bend. It has Melamchi Khola, Jhyarani Khola and Chalk Khola as main tributaries.

1.2 Fish Resources of Nepal

Aquatic ecosystem of Nepal have also have supported and sustained unique aquatic biodiversity by providing critical habitat for various aquatic flora and fauna and 186 fresh water fish species of different ecology (Shrestha, 2001). They are distributed from a range of a few hundred meters from sea level in Terai to about 4000 meters in the mountains. Among them, 59 species are identified as cold water species (Shrestha, 1994). These fishes showed diverse biological and structural adaptation characteristics of different topographies and climates. They also showed a spectacular behavior of migration for food and breeding in response to changes in water quality and volume.

Table 2. Migratory and resident

Migratory Fishes

Fish Species	**Migratory Patterns** Downstream Upstream	**Spawning Time**
Tor putitora (Golden mahaseer)	J F M A M J J A S A N D	Sept- Oct
Tor tor (Deep bodied sahar)	J F M A M J J A S A N D	Sept- Oct
Bagarius bagarius (Freshwater Shark)	J F M A M J J A S A N D	June –July
Clupisoma garua (Jalkapoor)	J F M A M J J A S A N D	June –July
Anguila bengalensis (Fresh water eel)	J F M A M J J A S A N D	June –July
Schizothorax plagiostomus (Pointed nose snow trout-Asala)	J F M A M J J A S A N D	Sept-Oct
Schizothorax richardsoni (Blunt nose-Asala)	J F M A M *J J A S A N D*	Sept-Oct
Acrossocheilus hexagonolepis (Katle)	J F M A M J J A S A N D	Sept- Oct

Resident Fishes

Barbus chillinoids (Karange)	Habitat prefers ,rock gravel bed pool	Sept- Oct
Psilorhynchus pseudoecheinus (Tite)	Slow run rapid	June –July
Pseudoecheinus sulcatus (Kabre - torrent catfish)	Head water stream	May–June
Glyptothorax cavia (Capree)	Head water	May- June
Glyptothorax blythi (Tilkabre)	Rocky boarder stream	June
Garra gotyla (Buduna, rock carp)	Backwater pool, rock crevices, algal bed	May- June
Garra annandalei (Buduna - stone roller)	Shelter rocks boulder back, water crevices of stone	Sept-Oct.

Culturally, fish is considered to be an auspicious item by the Nepalese people, and displayed as a "sagun" during many religious and social functions, apart from releasing them in religious ponds. Fish as a food is commonly acceptable to all non vegetarians in Nepal. This nature's gift is not only region's biodiversity and valuable genetic resource but also protein supplementing and income generating livelihood opportunity for the of fisher communities. Aquaculture and fisheries plays very important role in Nepal not only in sustainable food supply but also in securing a healthy national economic growth by supporting aquatic product exporting industry. Nepal being a land-locked country, the production of fish is entirely dependent on proper utilization of its various types of inland water resources. Significantly increase in the amount of fish produced can be achieved through the development and management of culture and capture fisheries. Aquaculture and fisheries have always been one of the national development priorities.

Currently, studies are focused in coldwater fishes such as Asala (S*chizothorax spp*), Katle (*Neolossochilus hexagonolepis*) and Mahaseer (*Tor spps*) as these indigenous fish species are famous for delicacy, and sport fishing. The warm water sport fishes are *Wallago* (Buhari), *Clupisoma (*Jalkapur), *Eutropichthys, bagarius bagarius* (Gonch) etc. They are also important game fish and start upstream migration in early May and reaches the head water of rivers and streams upto 1424 m in June. These days, 13 exotic fish species including crustacean (fresh water prawn) were introduced by the public and private sector in the country (Pantha, 1994). Out of these S*almo gairdneri* and O*nchorhynclus rhodurus* do not exist any more. Some of remaining is used for fish culture while other are kept for research purpose. Common carp (C*yprnus carpio),* Grass carp (*Ctenopharyngodon idell),* silver carp (*Hypopthalmichthys molitrix)* and big head carp (*Aristichthys nobili*s) are being cultured with three indigenous species (rohu- *labeo rohita,* bhakura-*catla catla* and naini- *Cirrhina mrigal*) in different aquaculture production system.

Table 3: Exotic species (culture in Nepal)

S.N	Name of fish	Imported in year	Source
1	Common carp (*cyprinus carpio)*	1956, 1960	India and Israel
2	Grasscarp (*Ctenopharyngodon idella*)	1967	India
3	Silver carp (*Hypophthamichthys molitrix*)	1968	Japan
4	Bighead carp (*Aristichthys nobilis*)	1971 and 1972	Hungary

Exotic coldwater fish like Rainbow trout (*Onchorhynchus mykiss)* is being studied for commercial production in cold water raceway ponds at government research stations and private fish farms. Seeing the great prospect of rainbow trout, government and FNCCI in collaboration have launched the program of spreading the rainbow trout culture in Trisuli, Nuwakot under OVOP program (one village one product). In addition to them, exotic fish species tilapia (O*reochromois niloticus*), silver barb (*Puntius gonionotus*) and crustaceans such as giant fresh water prawn (*machrobrachium rosenbergii*) have been introduced from neighboring countries with the purpose to study the feasibility of their commercial production in Nepal.

Cold water fishes are abundant in Sunkoshi in Sindhupalchok providing protein rich tasty food and means of livelihood to about more than 100 households of fisher communities. They used different traditional gears like long line loops, rod and line, cast net and scoop lift net in fishing. Cold water fish of Nepal are facing problems due to an increasing number of hydropower projects. Once abundant indigenous fish stocks have been declining due to overfishing, harmful fishing practices (electro fishing, dynamiting and use of chemicals), pollution and developmental works. Developmental works such as river damming have a major impact on river ecology, aquatic flora and fauna, including fish. Water resources development programs have overlooked so far aquatic biodiversity conservation/ management and related socioeconomic aspects. Only recently, after the promulgation of Nepal Biodiversity Strategy, 2002, biodiversity conservation and management received due attention In view of this, His Majesty's Government (HMG) of Nepal has made Environment Impact Assessment (EIA) compulsory under the EIA National Guidelines (HMG 1993) for all the hydroelectric projects above 5 MW. In the eyes of HMG of Nepal, the conservation status of the fish species seems yet not to be alarming in Nepal. Similarly, the leaflet “endangered and threatened wildlife animals of Nepal" published by IUCN in Red List (1994) as well as “Nepal’ s flora and fauna in the current CITIES list reported" did not include any fish for conservation.

But there is an urgent need of fish conservation realized already by conservation workers. Old exploitation model of development is shifted to awareness, sustainable use of natural resources in the interests of long term food security and conservation of gene

pool/environment. This transitional change involves a rethinking of strong central planning in favor of transferring ownership and responsibility to the local government and people at grass root level like fisher communities to develop more sustainable utilization of natural resources like fish and fishery.

1.3 Study Area

Sunkoshi and Indrawati Rivers lying at Dolalghat Kavrepalanchowk district were selected as the study area which is located at about 57 km from the Katmandu. This area was named after famous temple known as Dulaleshwaor Mahadev present at the bank of the Sunkoshi and Indrawati River. Dolalghat is located at an altitude of 710 m above the sea-level and lies in the foot hills of Chautara, the head office of Sindhu Palchowk district. Soil is red and sandy and the climate found is sub-tropical type with the range of temperature varying from 27-35^{0}C during summer and 13.0-20^0 C in winter. The average rainfall is 135 mm. There are about 150 houses and shops near the Indrawati Bridge, which is supposed to be the main market of this village. This village is located at northern east side of Deurali and Phalante village. On the northern side lies Chautara and Palanchowke Bhagwati lies on southern west side of this village.

This VDC is resided by about 4000-5000 people with about 60-70 majhi households at the other bank of Sunkoshi. Local people of this area include Tamang, Newar, Chhetri, Brahmin and Majhi. Vegetation includes sal, sallo, laligurans, utis, chilaune and katus. Wild life of the area includes few kaliz, dhukur, junjal fowl, lampuchhare, Deer etc. Livestock found of this area included cow, buffalo, goat, pig, bangur, poultry and duck. Dolalghat consists of one Dulaleshwor secondary vidyalaya, and one primary school. Agriculture is the main profession of this area; however, tamang and newar run business. Agriculture production includes maize, millet, wheat, but no paddy. Vegetable grown in this area are tomato, cauliflower, bean, green vegetable etc. And fruits include papaya, orange, pear and banana.

1.4 Objective of the study

There are a lot of marine fishes distributed in seas and oceans in the world and these marine fishes are cultured for fish farming. Due to land locked country, Nepal has not any marine fishery resources. But Nepal is endowed with vast fresh water resources and different rivers emerging from the Himalayas are the main ground for large number of coldwater fishes distributed throughout the year. These fishes have a great prospect of fisheries in Nepal. General survey, collections and identification of fishes present in the rivers are very important to maintain baseline information. Due to the variation in climatical factor, the decrease in the population and loss of fish species may occur, so it is necessary to carry out the survey of fishes from time to time to revise and verify the old information. The main object of this work is to emphasize the importance fish resources, fishing techniques and marketing to assess the trend of fish production.

The main objectives of present study are as follows:

1. To analyze general water quality parameters as database for the conservation and management of commercially important food fishes.
2. To identify undesirable factors affecting fish growth, survival and manage them for the conservation of fishery resources of Dolalghat area.
3. To recommend the need of reservoir fishery/ ranching to propagate indigenous fishes by culture on a large scale to maintain continued supply of fish available.
4. To investigate the marketing potential around locality of Sunkoshi & Indrawati rivers.

1.5 Scope and Limitation

The field study was totally based on secondary data obtained from Department of Measurement and unit (Nepal Government), Department of Hydrology and Meteorology, local people and a variety books, research papers, bulletins etc. Information was also gathered by field trip in study area (Balefi, Sukute, Chehare and Dolalghat), the interpretation was done by self observation and information gathered from interviews with different class groups like fishermen, local people and local businessmen.

CHAPTER TWO

2.0 LITERATURE REVIEW

According to literature, the first fish farming was done in China. Phanlie (475 B.C.), had written a book about the fish farming. Later on many people of different countries followed him and the people kept interest to study about the fish and fisheries to gain more knowledge about it. Hamilton (1822 A.D.) had collected some fishes from Nepal and deposited them in British museum, London.

Beaven (1877) had mentioned some of the fishes of Nepal. Day (1878) had mentioned few fishes from Nepal in his classical book. Regan (1907) had reported some fishes collected from Nepal. Hora (1920-52) described several fishes of Nepal and obtained specimen collection through Colonel Bailey in 1935 from Nepal. His collection included 22 fish species. Hora (1937) compared the fishes of Northern and Southern faces of the great Himalayan range. Menon (1949) reported few fishes from Koshi and Himalayas. Menon and Dutta (1961) head reported and described a Cyprinid fish *Psilorynchus, pseudoecheneis* collected from Dudhkoshi River.

Taft (1955) during surveying the fishes of Nepal, collected 94 species from Kathmandu, Pokhara, Trisuli, Simra etc. Dibbs in 1965 had studied various aspect of development of fisheries in Nepal. Thapa and Rajbansi (1968) presented a paper on few hill stream fishes with reference to Nepal and dealt with 28 species.

According to Dewitt (1961), the total number fish species reported from Nepal amounted to be 102. Shrestha (1977) reported a total number of fresh water fishes as 107 species in Nepal. Bhatta and Shrestha (1979) gave information about 57 species of fishes in his book “The Natural History and Economic Botany of Nepal “.Jha (1983) studied on the fishery resource of the Karnali River. He had described the distribution, economic importance and taxonomy of 51 fish species. Jha and Shrestha (1986) had given a report on fish fauna of Karnali River. They had described the occurrence and distribution of the fishes in the various sections of the Karnali River. Edd (1986) had studied the fishes of the Kali Gandaki River, one of the principal drainage of the Gandaki River System.

Joshi (1988) studied fishery resources of Sunkoshi River and collected 28 species of fishes. He had described habit and habitat, economic importance, taxonomy etc, of each fish species. Shrestha (1995) in his book "Fish Catching in Nepal" had reported 200 species of fishes.

Fisheries Development Directorate had carried out extensive studies on limnological/biological aspects of Sunkoshi River and Trisuli River (Yearly Progress Report, FDD, Balaju, 1998/99). A numbers of workers like Shrestha (1991) and Shah et. al. (1992) had explored the lower stretch of Arun River Koshi at Saptari District. Subha (1995) had reported a new record of hill stream fish Olyra longicaudata Mc Clelleland from tributary of river Trijuga, a tributary of River Koshi at Saptari District.Subha and Ghos (1996) had reported a new record of the pygmy barb, P*untius phutunio* (Ham) from Koshi Tappu wild life Reserve's low land catchments area. Shrestha (1998) had recorded 40 different species of fishes from Dudh Koshi, Shrestha and Swar (1998) reported 19 fish species from Tamur in EIA studies. Yadav (2001) had reported 93 species of fishes in plains of Koshi River.

Similarly, an extensive study on distribution of micro-flora and fauna was done by Ranjit (2002) in mountain River of Nepal for the conservation of aquatic diversity. Ranjit (2002) had described *Schizothorax* as very common and dominant fish species from Tatopani to Dolalghat.A total of 81 cold water species was listed with updated nomenclature and systematic position (Shrestha 2002). The prospect of ranching Mahaseer (*Tor* spp) was reported by Shrestha (2002) in the running waters of Nepal.

There is a couple of EIA report on Bheri- Babai (1999), Budhi Ganga (1998), Dudh Koshi (1998), Ilam (1994), Kali Gandaki A (19960, Kulekhani (1997), Likhu (1998), Melamchi (1999), Tamur (1998), West Seti (2000), Upper Karnali (1997) containing biodiversity studies with possible impact of damming for hydropower developments and mitigation measures. Upadhyaya and Shrestha (2002) had described the impact of Kali Gandaki 'A' Hydropower and also discussed about different mitigation measures. Similarly, an extensive study on distribution of macro-flora and fauna was done Ranjit (2002) in Mountain River of Nepal for the conservation of aquatic diversity.

Shrestha (2002) had described problems and mitigation measures of cold water fisheries development in Nepal. Swar had highlighted economic and sport fishery prospectus of cold water fishes along with self employment and income generating opportunities to poor fish farmers. He had reported 31 species of fishes from Koshi System. Dhital and Jha (2002) had reported about 69 species of fish belonging to 9 orders and 19 families from Narayani River system. Rai et. Al. (2002) had described the status of snow trout (*Schizothorax* and *Schizothoracthhyes*) in Nepal. Rajbanshi (2002) had reviewed the status, taxonomy and distribution of 76 indigenous cold water fishes of Nepal.

Gaurav Integrated Development Association (2004) had done an extensive study about the fish biodiversity and management in Sunkoshi River (Phase I. A total of 15 species of fishes were caught in cast net in Phase I at different stations of Sunkoshi. While a total of 22 fish species were recorded from Indrawati and Dollaghat in an extensive study about the fish biodiversity and management in Sunkoshi River (Phase II) done by AEFIM Consult Pvt. Ltd. AEFIM had also carried and extensive study of whole Koshi System from Chataraghat to Dollaghat and recommended to involve fisher communities in conservation management for sustainable utilization of fishery resources in Koshi System for this purpose, this consultancy firm had established four different 'Fish Conservation Groups' in Chataraghat, barahachhetra, Tribeni and Dolalghat.

Despite of a large contributions cited above, much remains to be done on the aspects of biodiversity and fishery management of Sunkoshi River. The present study, therefore, is carried out to contribute further knowledge about ecology and biodiversity of fishes of Sunkoshi River. It is hoped that this comprehensive ecological study will help in planning and programming for cold water fish culture in it.

CHAPTER THREE

3.0 METHODOLOGY

The basic source of primary data and information is based on self observation and local interviews while secondary data on hydrology, meteorology and topography needed for the study work was provided from meteorological Department and Department of Measurement and other data were obtained from articles, research papers, technical papers etc which are considered as tertiary source.

3.1 General survey of work

General survey was done on following different places:

a) **Balefi:** It is 72 km away from Kathmandu, here the Bhotekoshi River, the upper reaches of Sunkoshi river system connects with Sunkoshi River at Sunkoshi Bazaar and proceeds downwards. The bottom of river consisted boulders of all sizes and sand etc. The speed of water was 0.71 to 1.3 m/sec and temperature 18^0C to 21^0 C. The primary bio-productivity of Bhotekoshi was low noticeable due to transparent crystal clear water lacking plankton's population.

b) **Sukute:** It is about 67 km east of Kathmandu. The speed of water current here ranged from 0.6 to 1.1 m/sec and temperature from 19^0 C to 22^0 C. Primary production attained reasonable compared to Balefi.

c) **Chehare:** The water current showed the speed of 0.5 to 1.0 m/sec and temperature around 18^0 C to 22^0 C. The primary production reached higher than in Sukute.

d) **Dolalghat:** Dolalghat lies at 57 kms east of Kathmandu. The feeding river (Indrawati river) mix with Sunkoshi River flowing from Chehare. Water current speed was 0.4 to 0.6 m/sec with temperature between 18^0 C to 25^0 C. The primary production was higher. The river bottom consisted coarse sand, gravels and silts and exhibited an excellent fishing channel or delta created by bifurcation/trifurcation of the main river.

3.1 Fish collection and identification

The fish collected were from local markets, fishermen employed for it and collected fishes carefully preserved in 5 to 8 % of formaldehyde. Small specimens were kept directly in 5 % formation while the medium and larger fishes were fixed by injecting 5 to 8 % formaldehyde in the muscle and abdomen. Fixed specimens were tagged with important data including locality, name of collector and date of collection. Then the specimens were kept with head downwards and caudal fin upwards in the container. The group of fishermen of each locality from A to D was regarded as first four samplings. Likewise, the local businessmen in relation to fish business regarded as 5^{th} sampling and the local people as 6^{th} sampling. Then, a set of questionnaires with particular reference to the conservation of fishes and food value of fishes were forwarded to the six different samplings in the same manner and the answers received from six samplings were studied comparatively to draw the conclusion.

The following morphological parameters of fish were measured for taxonomic study.

Total Length: It was measured from the tip of the snout to the base of the caudal fin.

Length of Head: It was measured from the tip of the snout to the posterior-most bony extremity of the opercula.

Heigh/Depth of Body: It was measured along the vertical line at its deepest part.

Length of Caudal Peduncle: It was measured from the posterior base of anal fin to the base of caudal fin.

Height of Caudal Peduncle: It was measured along the vertical line at its narrowest point.

Length of Head excluding the Snout: It was measured from the anterior margin of the orbit to the posterior-most bony extremity of the opercle.

Width of Head: It was measured along the broadest part of the head.

Inter-orbital Width: It was measured along the dorsal surface between the eyes.

Diameter of Eye: It was measured from margin to margin of the bony orbit.

Snout: It was measured from the tip of the snout to the anterior margin of the orbit.

Pre-dorsal Length: It was measured from the top of the snout to the origin of the dorsal fin.

Height of fin: The height of dorsal and anal fin was measured along wits base i.e. distance between the insertion of the first spine or ray to the insertion of the last ray. In case of pectoral, ventral and caudal, the length was measured along its longest way.

Lateral Line Scale (Lr.): The number of perforated scales between the angle of gill opening up to caudal base was considered the lateral line scale. If the lateral line was absent, the scales are counted along the row where lateral line would have normally been and was abbreviated as Lr. Transverse row of scales were counted from the anterior base of dorsal to ventral line and their number was written as L. Tr. If the lateral line was present, the scales above and below lateral line were separated by an oblique stroke.

Fin Counts: The following abbreviation were used for various fins:

D: Dorsal fin P: Pectoral fin V: Ventral or Pelvic fin

C: Caudal fin A: Anal fin A: Adipose

The measurement were done with the fish lying on its right side, snout to the left, on a measuring board consisting wooden base or metal base carrying a central scale and having a head piece. Every attempt had been taken to measure the whole fish in fresh and weight condition. Hill stream cat fished and other dorso-ventrally flattened fishes were measured while lying straight on their ventral surfaces.

CHAPTER FOUR

4.0 Results and discussion

4.1 Physical features of Sunkoshi River

River Sunkoshi had maximum depth of 7.0m. The upper reaches of Sunkoshi river (Bhotekoshi) had high water velocity with ability to remove all particles less than 5mm size leaving behind clear stony bottom. The extensive stands of algae were grown over rocks and stones on the stream bed forming slippery bottom and often dangerous to fishermen and local villagers.

The upper reaches of Bhotekoshi were least productive due to high current of water and low temperature which offered poor substratum/habitat for the growth of fresh water organism.

The river Sunkoshi had brook, ground water and spring fed. Many good sized pools were encountered in Bhotekoshi below Tatopani up to the confluence of Indrawati and Sunkohsi River near Dolalghat. The pools of deeper water had reduced water velocity, silt and loose materials settled down at the bottom. Such habitat provided soft bottom unfavorable for benthos (insect larvae) but favorable for borrowing forms.

4.2 Water Chemistry

Water of Sunkoshi River was found neutral with high dissolved oxygen. Sodium potassium and carbonate level could not be detected but hardness, bicarbonate and sulphate level were 32 mg/l, 38 mg/l and 18 mg/l respectively. Chloride and calcium level were 9 mg/l and 11 mg/l while magnesium was 1 mg/l only (Table 2). Both Bhotekoshi and Sunkoshi river fed by ground wate, feeder spring received a great amount of bicarbonate in solution. Neutral pH reflects rich in carbonate, bicarbonate and associated salts. Such condition is found admirably suitable to support larger snow trout as compared to the stream with acid water, where have generally low nutrients.

Table 4. Data of water quality parameters.

Parameters	Data
Hardness (mg/l)	32.0
pH	7.0
Dissolved oxygen	8.9 mg/l
Carbonate (mg/l)	Nil
Bicarbonate (mg/l)	38.0
Sulphate (mg/l)	18.0
Chloride (mg/l)	9.0
Calcium (mg/l)	11.0
Magnesium(mg/l)	1.0
Sodium (mg/l)	Nil
Potassium (mg/l)	Nil

4.3 Aquatic plants - phytoplankton and macrophytes

Many aquatic macrophyte plants such as *Equistitum, Chara, Potamogeton, Hydrodictin* and phytoplankton like *Oedogonium, Chlorella* etc were present in lower reaches of river close to Dolalghat which provided both food and shelter for fishes and aquatic insects, but the upper reaches of Sunkoshi was poor in rooted macrophutic plants due to high water current. From production point of view, water of Sunkoshi River was good in lower reaches than upper reaches of Sunkoshi with abundant aquatic insects and fishes population and density.

4.4 Aquatic insects

The upper reaches of Bhotekoshi were least productive due to high current of water and low temperature offering poor substratum for freshwater organism. The gravel bottomed Sunkoshi River provided shelter and protected places for insect larvae. Mayfly nymphs were most abundant on rubble substratum of the river while dipterans larvae on bed rock and gravel. Most animals in riffles (fast streams broken into pools) were carried by water current to pools. The majority of insect larvae and rock fishes inhabited in riffles on the underside of rubble and gravel. Where they got refuse for shelter away the current of water. Mayfly, dragon flies, damsel flies nymphs and water skaters were characteristic inhabitants of riffles. Insect larvae were unique with streamlined body with an ability to dart among stones in swift water. It moved from stone to stone with great rapidity. Some aquatic insects like black fly

larva (*Simulium*) found attached in the lower side of stones. The larvae of some caddis fly (*Rhynocophila*) were found in cases of sand or small pebbles and some were also seen roaming over stones. Tadpoles and variety of mollusks of genus *Cardium* and *Limnea* were also seen drifting along the current of fast streams. The drifting animals were indicator for high production from stream habitat.

4.5 Fishes

In overall, fishing starts just before and after rainy season i.e. from February to June and from August to October. Fishing is not done during flood as most of the fishermen were found engaged in agriculture and fishing practice was comparatively difficult during high water.

The fishery resources of Sunkoshi River System was represented by 38 different species of different families; out of which *Schizothroax richardsonii*, *Garra annandalei*, *Noemacheilus rupicola* and *Barilius barna* were most common. Similarly, *Garra gotyla, Acrossocheilus hexagonolepis*, *Crossocheilus latius, Schizothoraicthys progastus, Noemacheilus beaveni, Noemacheilus corica, Puntius sarana, Puntius ticto, Puntius sophore, Tor putitora Schizothorax plagiostomus, Psilorhynchus pseudecheneis, Glyptothorax sps, Labeo angra, Amphipnous cuchia* were also common. While *Garra mullya, Diptychys maculates, Lepidocephalithyes guntea, Botia lohachata, Anguilla bengalensis* etc. were uncommon fishes found here .

Table 5. Fishes of Sunkoshi and Indrawati River.

No.	Name of the species	Local Name	Locality
1.	*Acrossocheilus hexagonolepis*	Catle	Sunkoshi & Dolalghat
2.	*Anguilla bengalensis*	Raja bam	Dolalghat
3.	*Amblyceps mangois*		Dolalghat
4.	*Amphipnous cuchia*	Bam machha	Dolalghat
5.	*Botia almorhae*		Dumja
6.	*Botia lohachata*		Sunkoshi, Chehare
7.	*Barilius barna*	Faketa	Sunkoshi, Dolalghat
8.	*Barilius bola*	Bola	Sunkoshi, Dolalghat
9.	*Barilius bendelensis*	Faketa	Dolalghat

10.	*Barilius barila*	Chahale	Sunkoshi
11.	*Barilius jalkapoorei*	Jalkapoor	Dolalghat
12.	*Bagarius bagarius*	Gounch	Dolalghat
13.	*Crossocheilus latius*	Buduna	confluence of Sunkoshi Indrawati
14.	*Danio aquipinnatus*	Bhitte	Dolalghat & Sunkoshi
15.	*Diptychus maculates*		Sunkoshi, Balephi Khola
16.	*Garra gotyla*	Buduna	Bhotekoshi
17.	*Garra mullya*		confluence of Balephi - Sunkoshi
18.	*Garra annandeli*	Lohari or Buduna	Lower reaches of Sunkoshi
19.	*Glyptothorax telchitta*	Kotel	Sunkoshi & Dolalghat
20.	*Glyptothorax annandeli*		Sunkoshi
21.	*Labeo angara*	Gurdi.	High water phase of river
22.	*Labeo dero*	Gurdi	Sunkoshi
23.	*Lepidocephalichthys* guntea	Lata	Flooded fiver
24.	*Noemacheilus beavani*	Gadela	Dolalghat
25.	*Noemacheilus corica*	Gadela	Dolalghat
26.	*Noemacheilus rupicola*	Gadela	Bhotekoshi
27.	Oreoglanis macropterum	Tel chopre	Upper reaches of Sunkoshi
28.	*Psilorhynchus pseudecheinus*	Tite Machha	Bhotekoshi & Sunkoshi
29.	*Puntius sarana*	Kande	Sunkoshi & Dolalghat
30.	*Puntius sophora*	Poti machha	Sunkoshi & Dolalghat
31.	*Puntius ticto*	Darahi or Poti	Fedder stream
32.	*Pseudechenais sulcatus*	Kapre or Kabre	Dolalghat
33.	*Pseudeutropius muriusbatar ensis*	Jalkapor	Dolalghat
34.	*Schizothorax plagiostomus*	Buchhe asla	Bhotekoshi, Sunkoshi
35.	*Schizothorax richardsonii*	Buchhe Asla	Bhotekoshi, Sunkoshi
36.	*Schizothoraicthys annandalei*	Thunde	Bhotekoshi, Sunkoshi
37.	*Schizothoraicthys progastus*	Chuche Asla	Sunkoshi & Dolalghat
38.	*Tor putitora*	Sahar	Sunkoshi & Dolalghat

4.6 Diagnosis, natural habit and habitat, feeding habit, fishing season, fishing implement and food value of some important fishes:

Genus – *Schizothorax* Heckel

Local name: Locally, *Schizothorax* sps are called "Asla Machha" which is commonly known as cold carp fishes. *Schizothorax* and *Schizothoraichthys* were most dominant fish species found in Sunkoshi. Generally, four different species of them reported from Sunkoshi.

Locality: This fish was found widely distributed from the upper reach Bhotekoshi to lower reach Dolalghat of the Sunkoshi River.

Table 4. Asla Machha of Sunkoshi and Indrawati River.

No.	Name of the Species	Local Name	Locality	Diagnostic Characters
1.	*Schizothorax plagiostomus*	Bucche Asla	Bhotekoshi Sunkoshi & Dolalghat	Body elongated with distinct tubercles in male, four arr asp and colour uniform silvery or with black spots depending upon the habitat.
2.	Schizothorax richerdsonii	Buchhe asla	do	Body elongated and slender in having a short head with blunt snout and lower jaws with a suctorial disc.
3.	Schizothoraichthys progastus	Chuche Asla	Sunkoshi & Dolalghat	Having pointed head with tubercles on snout. Dorsal profile slightly convex. Barbels four.
4.	S. annandalei	Thunde	do	Body elongated and streamlined with uniform color.

Habit and Habitat: *Schizothorax sps* were also common is a cold water fish of Sunkoshi area. It is resident and comes down to main cradle of Sunkoshi during winter when water volume recedes in feeder stream. These fishes are common in all ice cold feeder streams as they prefer to live in clear water where temperature ranges from 8 to 22^0 C and pH ranges from 5 to 8 throughout the year. Highly oxygenated water with dissolved oxygen 5 to 7 ppm and a bloom of green algae are favorable for their survival. It is a delicate fish and it cannot tolerate high intensity of sound/noise.

Economic Value: As compared to other types of the fishes, the *Schizothorax* sps as a whole can be counted as the tasty and delicious fishes which have a great demand in fish market. In terms of condition of preservation, these fishes are smoked or sun dried. Most of the large fishes are smoked and the small sized or their fingerlings are sun dried. Preserved fishes are widely used in various ways as pickle, fried dish etc.

Fishing season: Being widely distributed in the river, the fishing season is round the year. Although, the best season for fishes can be regarded as from the month of February to June.

Fishing method and implements: Mostly these fishes are caught with hook and line with unbaited nylon loop which is a device to capture live fishes. It is generally made up of nylon fibre which is tied in fishing line with a stone sink overhanging at the upper edge. Loop and its hanging stone act as lure and a shimming Asla enter inside the loop and get tied up. During the fishing, surkee gantho i.e. automatic knot in loop is quite helpful. Mostly in loop, the cut pieces of pumpkin, wild yam (tarul) etc. are used as bait.

A local Khungo, made up of twigs and fibers of timber plants, is widely used in autumn. It is set in the area with steep gradient and high current velocity, fishes trapped in Khungo cannot escape out due to high current gradients.

Asla fishing is also done with the aid of light as Petromax at night. It helps to locate the sole of Asla in the stream. The light lures the swimming fishes in promise of bait and fishes pass nearby. At the same time fishermen chop the head of the fishes and are collected by scoop net or gill net which is widely used at the time of heavy fishing.

The illegal fishing practice is also applied in Sunkoshi area by striking rock in the river. Hill people knew that the Asla cannot tolerate high intensity of sound or noise. At the time of striking, Asla looses balance due to damage of their internal ear. A huge mass of injured fish float are scooped easily.

Acrossocheilus hexagonolepis (McClell) 1839

Local Name: Catle or Copper Mahaseer.

Locality : Sunkoshi, Dolalghat.

Diagnostic Characters: The fish looks like Mahaseer and can be distinguished from it in head length and the presence of a lateral golden band in the living condition. Dorsal spine is strong.

Habit and habitat: It needs cool and flowing streams with moderate summer and winter temperature, viz neither very cold nor excessively warm. It thrives well in hills streams when water temperature attains 15^0C to 24^0C and pH 5 to 9 with maximum oxygen requirement of 4 ppm. It shows high population when stream will have an abundant supply of fish fry especially of *Barilius* and *arr asps*. It spawns on clean gravel or rubble bottom once in a year and has got a long spawning period lasting for a month. Female as a rule is larger than male. Eggs are left to cling to rock particles and algal blooms.

Feeding habit: It is voracious feeder and feeds on gastropods shells, vegetable debris, planktonic algae, filamentous algae and bottom organisms like aquatic beetles and flies.

Economic Value: It is very good for table eating. It has great aquaculture value. In case of preservation, it is dried or smoked depending on sizes.

Fishing Season: The best fishing season is reported from April to October.

Fishing methods and implements: Fishing is really a thrilling sport. Large sized fishes weighing 2 to 5 kg. are caught with baited hooks with pounded wheat flour. Fishing rods with nylon loop are widely used in clear fresh water.

arr as (Ham) 1822

Local Name: Sahar.

Localtiy : Sunkoshi, Dolalghat

Diagnostic Characters: Body elongated, moderately compressed. Mouth inferior with thick lips, lower lip is produced into folds.

Natural habit and habitat: As a migratory and game fish, it lives in a beautiful environment exhibiting clear and cold water in a variety of quite pools and turbulent rapids. It requires 5 to 7 ppm oxygen concentration, 6 to 8 pH range and 18^0C water temperature. Maximum height is reported as 5 feets weighing 120 lbs.

arr as (also called Mahaseer) migrates upstream during monsoon and downstream when monsoon is over especially for feeding and breeding. Its breeding season has a long duration from August to December. It spawns several times during breeding season and generally, spawning takes place at the interval of 2 to 3 weeks.

Feeding habit: it feeds on variety of filamentous algae, insects etc. and particularly feed on caddis fly larvae, may fly larvae, beetles larvae and small mollusks.

They are mainly piscivorous and depend upon many fries and adult hill stream fishes. As per information, the juvenile Mahseer is insectivorous and adult is herbivorous and the presence of protractible suctorial mouth in Mahseer is suggestive of bottom feeding habit.

Economic Value: It is very good for eating. It is dried or smoked at the time of preservation.

Fishing Season: September to March is the best fishing season.

Fishing Methods and Implements: It is captured in both baited and unbaited hooks. During monsoon, a large unbaited hook and local seine net are used while in peak fishing season, it is baited with small fish or fish fry, especially Asla may be used as suitable bait. Pounded wheat floor may also be used. The fish moving down streams after the monsoon is generally trapped by orienting different fishing gears towards the flow of current by fishermen.

The fish in Sunkoshi River is depleting day by day due to destructive fishing practices such a blasting, rock striking and poisoning.

Genus – *Labeo* Cuvier 1817

Local Name : Locally called Gurdi.

Locality : Reported from he high water phase of the Indrawati river and river Balephi near Sunkoshi confluence.

Two different species of the genus were recorded so far.

Labeo angra (Rohu) –Diagnostic Characters – Body elongated, dorsal profile slightly convex snout studded with pores and with lateral lobes having deep notch on either side. It consists of one pair of arr as, stout body and rounded abdomen.

Labeo dero (Rohu) – Diagnostic Characters – A more slender fish characterized with deep groove across snout and covered with pores without any lateral lobe and with a short maxillary barbell.

Natural habit and habitant: They are uncommon and migrant found in especially May and June. They are also regarded as prized game fishes and famous among the anglers in the hill streams. They thrive well in stream that show temperature around 35^0 C (mid-summer) but generally they live in river where temperature does not exceed beyond 30^0C. They do grow well in snow fed gravel bottomed river which are covered with abundant growth of algal slime. Being migratory fish, they come to head waters during monsoon and they go down to large streams of Terai when monsoon is over.

Feeding habit: They are bottom feeder and feed on bottom organism. Such as fish larvae, may fly larvae filamentous algae etc.

Economic value: The flesh is tasty and delicious. It is food for eating and excellent for table. For the purpose of preservation, it is done by smoking.

Fishing season: April to July is the best season for fishing in river.

Fishing method and implement: One of the most common methods is to sit with line and hook baited with a live fish. The hungry rohu is trapped into hook when it comes to eat the bait. Once it is trapped it makes struggle to escape exhibiting a nice game. For heavy fishing, fishermen use different types of nets with a variety of baits to scoop in a large amount.

Danio aquipinnatus (Day) 1878

Local Name : Bhitte Machha.

Locality : Dolalghat, Sunkoshi

Diagnostic characters: Body is deep and compressed laterally. Abdomen is rounded. Maxillary arr as is minute and rostral one long. Lateral line is complete and concave.

Natural habit and habitant: They need high water phase as they grow well in gravel bottomed river with the presence aquatic insects. They display beautiful color pattern. The breeding season extends up to six months.

Feeding habit: They are insectivorous and feed on water insects such as may fly.

Economic value: It is good for eating and excellent for table purpose. In terms of preservation it is sun dried or smoked or sun dried

Fishing season: The best season for fishing is from April to July.

Fishing method and implement: Similar to *Labeo* sps, baited hooks and line is used. But, to collect a large number of fishes, gill net, cast net etc. are used by fishermen.

Anguilla bengalensis (Gray and Hardw) 1833-34

Local Name : Raja Bam

Locality : Dolalghat

Diagnostic Characters: It is a migratory fish with elongated body. Scales are cycloid type embedded in the skin and can be easily distinguished from other eels in the presence of two gill slits, continuous dorsal, anal and caudal fin and a well developed pectoral fin.

Natural habit and habitat: Its distribution is uncertain as it needs suitable water supply, moderate water surface temperature as 25^0 C, sufficient oxygen usually more than 5 ppm and abundance supply of food organisms and sheltering cover as shade around the pools, deep holes and rock shelter. It is a restless fish and is seen moving slowly to and fro in a manner of a typical snake and is irritable with disturbance causes by human interference. It produces slight swelling head when it is angered. Eels live in group.

Feeding habit: It feeds upon a large variety of foods such as phytoplankton like filament of *Oedogonium, Chlorella* etc and zoo-plankton like rotifers, diatoms and some aquatic insects

such as larvae of may fly, damsel fly and fresh water shrimps. The stronger and hunger eel snatches and tears the food grasped by other fishes.

Economic Value: Fairly good eating and during preservation, it is smoked.

Fishing Season: Occasional.

Fishing method and Implement: An expert eel hunter can recognize the trail of the eel along the way. As the hunter finds eel beneath the shade, there it is beaten with sticks and killed. Snake trap or trapped net is also used.

Genus-Glyptothorax Blyth

Local Name: Locally called kotel machha.

Locality: Dolalghat, Sunkoshi

Glyptothorax telclitta (Kotel Machha) – The colour pattern and genera appearance similar to that of *Pseudecheneis sulcatus* but differs in the structure of adhesive disc and presence of minute tubercles throughout body.

Glyptothorax annandeli – Body elongated, head depressed, presence of adhesive disc.

Natural habit and habitat: They prefer rocky or gravel bottomed river and stream which should be snow fed or spring fed with oxygen concentration 4 to 7 ppm.

Feeding habit: They feed on bottom aquatic insects.

Economic Value: It is good for eating. It is smoked during preservation.

Fishing season: June – July is regarded as good fishing season.

Fishing method and Implement: The most common method for fishing is done by baited or unbaited hook and line. A shoal of the fish are scooped by scoop net.

Genus-*Noemacheilus* Van Hasset 1823

Local Name: Locally called Gadela.

Locality: Bhotekoshi, Dolalghat

Noemacheilus beavani (Gadela) – Typical hill stream fish with tapering body and 9 to 10 vertical bands.

N. corica – Small fish with 13 to 14 broad and slightly curved vertical bands on the middle of the body.

N. rupicola (Gadela) – Easily distinguished owing to black vertical stripes at yellow bed, slender body and broad snout.

Natural habit and habitat: They are resident fishes. *N. beavani* reaches maximum during May and June. While, *N. rupicola* increases with monsoon. It needs cool water temperature in comparison to *N. beavani* and *N. corica*. As a whole, they prefer torrential streams and brooks.

Economic Importance: Though they have also food value but they are mainly used as bait to catch the larger fishes in the river. They are also eaten by arr as.

Fishing Season: It can be started from April up to July.

Fishing method and Implement: The common method is applied by using earthworm as bait in hook. They are also fished by creating a diverting channel in the river.

4.7 Importance of food value of fishes of Dolalghat:

The Sunkoshi watershed is very rich in fish fauna. Fish is an excellent source of protein. It is also rich in mineral and vitamins. 15 to 20 % of the total body weight of the fishes is occupied by proteins. The five different essential amino acids are present in fishes which vary from species to species. Besides protein, fish contains potassium, calcium and phosphorous which constitute 1 to 2 % of the edible parts of the fish. Similarly, the fish liver is a well known source of vitamin A, D, B, (thiamin) and B_{12} (Riboflavin) which occur in the same degree as present in meat, fat is invariably present in all fishes which varies in different parts of fish. According to expert, more fat is present in the head part than in the tail part. Over all, it is proved fish is c superior to cereals.

We know that the Nepalese diet is largely starchy due to using rice, wheat, millets and cereals as main food. As a result, the average Nepalese diet is deficient and poor for sustaining stamina and health. Health of citizen is a question of paramount importance because the manpower is the valuable asset of the nation. Fish in diet can supplement nutrient deficiency and improve sustaining stamina and health of Nepalese people throughout the country. Therefore, fishes like *Tor putitora, Pseudecheneis sulcatus, Garra* sp, *Danio acquipinatus, Labeo* sp, *Amphipnous cuchi, Puntius* sp, *Bagarius bagarius* etc from Sunkoshi river system can taken to capital market and international market. Moreover, these fishes needed to be propagated and cultured on a large scale in Sunkoshi river system so as to make continued supply of them in market at reasonable price.

The pristine waterways of Sunkoshi River should be improved based on the conservation of present fishes as well as the possible development of fish resources. Development works like damming of river for hydropower generation, diverting channel for irrigation and illegal fishing methods like poisoning, blasting, electro-fishing and use of small mesh sized fishing nets have altered the environment of river system and its physicochemical and biological parameters gradually in Sunkoshi System. During field survey, a reasonable amount of fish collection could not achieve due to a trend of fish decline in study area. Almost all fishermen are badly suffered from illegal fishing practices and impact of developmental works. Most of the fishes recorded are going to be affected by altered physical and biological factors of the river created by anthropogenic activities. The main emphasis must be laid in the conservation

of fishes and the sustainable utilization of them as food sources based upon the principle of eco-development.

Sunkoshi River with feeder streams and pools was inhabited by admirable account of fresh water hill stream fishes and other aquatic life. Besides, Sunkoshi and Indrawati River provide beautiful sceneries and verdant sunny beaches to attract tourist both local and international for sport fishery. Sport fishery also has a great prospect Sunkoshi corridor with the development of dry port in Tatopani area, Khasa business center and Banji Jumping center at Bhotekoshi. Boating and rafting also have great prospect in Sunkoshi in Balphi Dovan, Dumja, Dolalghat and Koshi system as a whole up to Chatara with 72.0 km water system.

4.8 Fishing method and gears used

Fishing practices in Sunkoshi river system is one of the most striking aspects that depend upon the fishing season and fishing implements/gears. The most common fishing implements in Sunkoshi river from upper reaches of Bhotekoshi to lower reaches at Dolalghat include hook, jal (cast net), ghorlung (scooping net), tiyari (small gill net also called small seine net), phunga (Basket case) etc. Besides these, gundi and duwali are also used for fishing. Fishing is mostly done at night as compared to day time by applying various fishing methods with different fishing gears on the basis of the nature of riverine fishes and the level of water in the river.

The fishing in Sunkoshi river may be classified as follows:

1. Without gear

Collection by hand: This is one of the most primitive methods of fishing which is practiced almost during day time in dried areas after having been flooded and also in feeder stream. It depends upon the skill and swiftness of the fishermen who feels the fishes hiding under the stones or in mud and catch them. It is mostly practiced in Dolalghat.

2. Wounding gear

Khukuri Fishing : It is widely used in fishing hill stream fishes in shallow water river generally 4 to 6 persons are engaged during fishing at night. For this method of fishing, fishermen use a source of light intensity such as lantern or petromax in the river. As a result, fishes start gazing towards the light and at the same time fishers chop the fish head with the Khukuri. A new method called optomotor reaction for fishing Asla also have been introduced in Sunkoshi and Dolalghat.

3. Manual method

a. Use of rock stone: In Dolalghat fishermen kill fishes with a little effort by producing sound by striking stones on stone against the fish sheltering rock and as a result, the ear of fish gets damaged and looses their balance and become almost paralyzed. They are then caught. It is harmful fishing practice. It should be checked, because fries of Sahar, Asla etc. are badly affected by this method of fishing.

b. Poisoning: A broad spectrum of fish poisons are used for paralyzing and blinding fishes by throwing leaves some certain plants like leaves of pirija (*Polygonium*), underground wild ginger (Zingibar) etc. after crushing. These irritate the fishes and come to surface for air then they are collected by scoop net. Fishes of all kinds are killed by this method.

This is the most destructive fishing practice, as they kill the brood as well as the fry fishes, mostly done in Dolalghat and the fishes like *Schizothrax* sps, *Barilius* sps, *arr asps*, etc are caught.

c. Blasting: This method is very harmful as it destroys eggs, fingerlings, and fries of many sps and causes a serous decline in fish population. It was applied in Dolalghat but at present the method is almost checked.

4. Line

Rod and Line: This is one of the most common method or fishing, which is also called "Balchhi Hanne" in all parts of the Sunkoshi river system. Doing this method, the hook which is referred as Balchi in which different types of baits like millet cereals, insects, annelids, live faketa and small fishes are encapsulated and dips into the river where the fishes attract around the bait and are then caught.

5. Barriers

Diverting river channel: This is one of the oldest methods in Nepal. In low water phase, fisherman divert small side branches of the river from one place to another place or by diverting it from one place to another with a dam or walls of big stones boulders, soils and

leaves of trees and create practically dry fishing channel which are also kept undisturbed for a forth night to scoop fishes. This method is also applied during the flood by diverting channel of streams. This method is called garro-thapne and mostly done in Dolalghat, Balephi other place.

6. Basket Implements:

a. Fishing with bamboo fish trap: Dhameri is one of the highly evolved fish trap used in capturing fishes of moderate size, Dhameri is set in diverting channel or in the pool of river and kept for overnight. Mostly oil cakes or cereal foods are kept inside Dhameri as baits. Huge amount of fish can be trapped overnight.

b. Fishing with basket cage: It is one of the most unique catching methods. The basket cage also called “Phunga” made up of small bamboo sticks of about 1.2m in length and 0.45 m in breadth which is used when current of water is slow. The cage is made in such a way that fishes can enter through holes but can not come out it.

c. Fishing in riffle with twig basket: In riffles, up streaming and down streaming fishes are caught by using spindle shaped basket made up of twigs also called “Khungo Thapne”. Fishes are forced to enter trap and die off soon due to high current gradient.

7. Nets

The nets in Sunkoshi river system are regarded as important fishing implements/gears which are generally prepared by the local fishermen from the fibers extracted from the thistle plant called Allo. This plant is boiled with ashes for a day till the color of the plant turns into white and then it is beaten and dried and finally nets are woven. Now a days, the nylon thread is also used for preparing nets.

In medium water phase of the river from October to December, locally made net called cast net, is used. The use of small seine net also called Tihari or Tiyari is common used in all big rivers.

During low water phase from January to April, a special kind of baited nylon loop is used to trap fishes. A line made of small bamboo shoot is set in mid stream together with sink, a loop and bait. Such a line is called “Paso” fish entering the baited loop is tied up automatically along the pectoral and caudal fin.

1. **Cast net:** It is commonly called “Jaal”. It is a circular net, somewhat bell shaped and weighted with iron balls. The central rope is first tied to the force finger of the left hand. While throwing the net, the fisherman throws it with a jerk into water. It spreads out in the water in a rounded way. After some time with the help of a central rope, the net is dragged and the catch is collected in a basket made up of bamboo called phurlung. By this method fishes like katle, sahar, bhitte, faketa are caught in large number in Dolalghat area.

2. **Big seine net or large gill net:** It is also called “Mahjal” which is most popular method for fishing table fishes.

3. **Scoop net:** It is also called Gholung which is a dip net. It consists of a long wooden handle of about 1.5m in length. The handle is joined to a wooden circular frame made of two pieces. It is 1.5m long while the breadth is 0.9m. It is handled by a single man. It is used mostly in June to August when the current of the water is rapid. This net is used in Dolalghat, Balephi etc.

CHAPTER FIVE

5.0 Conservation

The fish conservation and biological resources management in Dolalghat area is still in its infancy. There is a limited study of the ecology of the fish stock of the area. A long term incentive survey program is needed to judge correctly the states of fish species in fresh cold water of Dolalghat area. Thereafter, the fish conservation in Sunkoshi & Indrawati River will be of the great interest in future.

The following approaches are forwarded towards the protection of rare fish species and the conservation of present fishes of Dolalghat area.

1. **Protection of rare species:** Sunkoshi & Indrawati River need to establish fish reserves in certain sanctions of the streams in order to protect the rare sps such as coldwater carp fishes, loaches, fresh water eel, gonch etc. It is highly desirable to maintain certain flood plain area for normal flooding in future which may help in the survival of fish species which spawns in such habitat. Therefore, the Sunkoshi River should be set aside for the conservation of the natural stocks exploitation.

2. **Regulation of inter-disciplinary management:** In Sunkoshi & Indrawati river system, the protection of river basin and watersheds by their control of run-off and flooding has ever been a challenging task but such control can be brought about by thoughtful inter-disciplinary management. The restriction of destructive fishing practices, such as blasting, poisoning and rock striking affecting the fishes and fingerlings of all kinds, should be legally prohibited throughout the Sunkoshi & Indrawati River. In spite of this, the barriers which completely blocks river channel stopping fish migration should be improved by creating fish ladders and fish lifts in different courses of the river.

3. **Regulation of closed season:** For the protection of rare fish stocks as well as common fish stocks, the prohibited areas or closed seasons are quite common device. The basic of such areas should allow fish freedom to complete spawning cycle and early life cycle without being hindered but the time of spawning of various fishes should be known in order to establish closed season. In this way, the commercial fishing in the river can be regulated.

4. **River improvement:** The prime important essential factor towards conservation of fishes is river improvement which should be maintained in a good hydrobiological condition. The seasonal changes of water level and total discharge should be controlled by check dams, side by side the winter desiccation should be avoided by managing suitable pools. The water pollution affects all kinds of fishes and fresh water organism which may be caused by accumulation of domestic and agricultural wastes. The use of pesticides, herbicides in nearby agricultural land have increased the incidence of pollution.

5. **Control of fishing implement:** In courses of Sunkoshi & Indrawati River, the fry net also called Bhura Jal is used by most of the fishermen which should be controlled, because it is a damaging practice of natural fish stock. It will sweep out easily the teeming abundance of fry which have all potential to grow into adult fishes.

6. **Introduction of hatchery reared fishes (Rehabilitation):** The fishing of game fishes such as asla, katle, sahar etc. are one of ancient form of recreation in Sunkoshi river due to having their excellent behavior of charm and sport properties. As a result of which, the cross section of Sunkoshi river is over fished. The fishing efforts exceed high in comparison to the abundance of fish population. Therefore, to relieve such a fishing pressure, artificial reared fish fries of these species have to be released in the river from time to time.

7. **Cultivation of local food fishes:** The cultivation and management of local food fishes is to be encouraged and should be promoted. Fries or fingerlings of such fishes should be distributed to fishermen. Better foods for such fishes should be provided.

8. **Fishery legislation:** Based on survey of diverse and isolated nature of fishing water, fishing legislation should be enforced. For local fishermen, license should be distributed so as to have a statistical data of total fishermen involved and total fishes caught in that area.

CHAPTER SIX

6.0 Fish Market

Under proper reverine fishery management, fishes can be produced in a large amount so as to fulfill the needs of people. For this case, fish market should be expended systematically. Dolalghat area has a tremendous potentiality on fish resources. There is a vast scope to study on different aspects related to fish production and conservation.

6.1 Socio-Economic condition of fishermen:

It is one of the most important factors which enhance to set the better position of fish marketing in Dolalghat. Many people of Dolalghat depend on fishing. It is regarded as a main source to maintain the daily livelihood of the fishermen. Therefore, the socioeconomic condition of every promising fisherman in Sunkoshi is a question of paramount importance.

Based on general survey in study areas, it is noticed that they have their own locality at different places from Balefi to Dolalghat. Balephi, Sukute and Majhi gaon at Dolalghat are the main localities where fishermen are depending upon fishing. The major percentage of the total fishermen are equipped with a variety of fishing implements such as cast net (jal), ghorlung (scoop net), balchhi (Hook line), small seine net (tiyari) and so on. They make different types of nets themselves especially at the time of fishing season. The best fishing season for good sized fishes in Sunkoshi river system is regarded as from March to July every year. At that time, they become totally busy for fishing with different types of fishing gears. Mostly fishing is done at night. During a peak period of fishing season, a fisherman can collect fishes weighing 25 to 30 kg in a day while in slack period, the catch composition in average consisted less than 1.0 kg in a day. They sell most of the catch at local market at the rate of Rs. 120-150/kg. Mostly they sell fished to the local businessmen of the particular area. The good sized fishes of *Schizothorax* sps, *Acrossocheilus hexagonelepis*, *Garra gotvla*, etc. are smoked and are used during festivals or some certain occasions while the fry or fingerlings of those above mentioned fishes and *Puntius* sps, *Barilius* sps etc. are sundried which are used to prepare pickles or fired dishes. They sell these dried fishes at the rate of Rs. 300 – 400 per kg to the local businessman. Due to the declination of fish resources in rivers, most of the fishermen do the alternative job like labour/porter, collecting fodders from the

forest, breaking stones at river bank in daily wages while a few fishermen have their own land to carry out agriculture.

These are the major factors which may be responsible to have a poor socio-economic status:

1. **Education:** It is a prime factor. The high percentage of fishermen is uneducated. Most of them even do not know the facility of free primary education being provided in local prime school.

2. **Effect of Dam:** Because of the construction of dam, the large sized migratory fishes have been affected and have been gradually replaced by small fishes such as *Barilius*, *Noemacheilus* etc. During survey, it is concluded that the fishermen inhabiting Balephi are adversely affected from the fishing point of the view as compared to the fishermen who are living in higher reaches of Sunkoshi River or lower reaches of Sunkoshi river at Dolalghat. According to the fishermen, people at lower reaches check the upward migration of fishes such as *Schizothorax* sps, *Tor putitora*, etc by creating a diverting channel, poisoning, blasting etc and similarly the migration of fishes to downward stream from higher reaches is physically checked by dam.

CHAPTER SEVEN

7.0 Recommendation

From present study of fishes at Doalghat area, the important hill stream fishes found in Sunkoshi and Indrawati river were asla, katle, mahseer, gonjh, sidre, sahar, faketa, lohari, kavre, chale, buduna, hile, kabre, etc.

According to the paper published by Directorate of Fishery Development, each person in our country consumes 4.5 kg animal protein in a year, in which 0.20 kg (4-5%) is provided by fish. For developments of human beings, one must have enough protein in diet. According to the report of F.A.O. the developing country like Nepal, can produce protein at a very cheap cost and in short period of time from fish. So, fish production in sufficient amount can fulfill the protein requirements.

General attention should be given in:

1. Scientific technique should be applied to catch the fish.
2. Local fisherman should have good apparatus (solar dryer) for preservation.
3. River must be kept neat & clean.
4. Hormonal breeding should be practiced for rapid propagation of the local & exotic fishes. Fries of the fishes should provide to local fishermen at reasonable price.
5. Ecological balance of fish population should be mentored by pilot studies.
6. Fishing should avoid in breeding season.
7. Fishermen should have alternative source of income.

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Appendix 1. Rainfall of Dolalghat

Year	Jan	Feb	Mar	Apr	May	Jun	Jul
	Aug	Sep	Oct	Nov	Dec		
2004	10.5	1.5	3.2	85.1	110.6	107.7	243.2
	167.4	112.0	27.9	11.9	0.0		
2005	41.7	6.8	39.9	21.4	47.2	136.3	177.6
	352.8	91.1	76.5	0.0	0.0		
2006	0.0	0.0	23.8	113.7	106.2	123.9	211.0
	262.4	134.2	45.8	1.0	DNA		

DNA = Date not available

Source = Dept. of Hydrology & Metereology, Babarmahal

Appendix 2. Temperature, 2004

Month	Tmax (c)	Tmin (c)
Jan	20.1	4.8
Feb	23.7	6.2
Mar	DNA	DNA
Apr	30.6	14.7
May	31.7	17.6
Jun	32.2	21.0
Jul	30.3	21.8
Aug	32.5	22.9
Sep	31.3	21.5
Oct	29.1	15.4
Nov	25.6	9.0
Dec	22.9	6.1

2005

Month	Tmax (c)	Tmin (c)
Jan	19.6	6.2
Feb	DNA	DNA
Mar	DNA	DNA
Apr	31.6	12.2
May	32.9	16.3
Jun	33.8	21.3
Jul	32.5	22.7
Aug	31.8	22.8
Sep	32.4	21.7
Oct	29.7	15.9
Nov	25.9	10.3
Dec	22.4	5.4

2006

Month	Tmax (c)	Tmin (c)
Jan	23.9	2.7
Feb	26.9	9.5
Mar	29.0	9.4
Apr	29.8	13.8
May	31.2	19.0
Jun	32.3	21.7
Jul	32.7	23.3
Aug	32.8	22.7
Sep	31.3	21.0
Oct	28.9	15.3
Nov	25.7	10.3
Dec	22.5	7.2

DNA= Data not available

Source = Dept. of Hydrology & Meteorology, Babarmahal