

CHAPTER - I

INTRODUCTION

1.1 General Background

Geographically, Nepal is a land locked country with a total land area of 1,47,181 sq km. Nepal is bordered by China in the north and India in the south, west and east. It extends across the southern slope of the Himalayan between latitude of 26⁰22' north and longitude of 80⁰4' to 88⁰12' east. It is roughly rectangular and elongated in shape averaging about 85km in length (east-west) and 193km in width (north to south). The altitude ranges from 70m above sea level in the Terai region (south) to 8,848m at the peak of the world, Mount Everest ('Sagarmatha') in the north.

Topographically, the country is divided into three distinct geographical regions i.e. the Himalayan region, the Sub-Himalayan region and the Terai region. The Himalayan region contributes about 15 percent (22,077 sq.km) of the total area of Nepal and lies above the altitudinal range of 16000 ft (4800m) from the sea level (Amatya and Shrestha, 1967). The Sub-Himalayan region or mountainous region is located between the south of the Himalayas and the north of the Terai region with a chain of massive mountains running from west to east, which constitutes about 68 percent of the total area of Nepal lying in between 2000ft (600m) to 16000ft (480m). This part consists many basins, valleys and duns, among which Kathmandu valley and Pokhara valley are the familiar examples. The lower plain of Terai is a narrow belt of low land situated at an altitude between 70m to 600m. From sea level to Sub-Himalaya region, which is the most important one from the point

of view of agriculture. The Terai region including inner Terai represents about 25 percent of the total area of Nepal.

The climate of Nepal is not uniform due to the variation of altitude. The climate is varied ranging from the sub-tropical in Terai to the cold dry temperate in Himalayan region. The vertical variation causes much more contrast in the Nepalese meteorological variables, mostly temperature, moisture, winds and precipitation.

Due to the altitudinal effect, the temperature distribution in Nepal is not uniform. As such, lowlands like Terai and inner Terai parts and midlands are warmer and the hilly and the Himalayan regions are cooler. The temperature rises from March to July, while it decreases from October to January. The land structure, latitude, altitude, distance from the sea, wind, cloud and rainfall are the factors that create differences in the climate. On the whole, Nepal has monsoon climate which is dominating all the agro-cultural activities of the country. On the basis of temperature and condition of the precipitation, the climate of Nepal can be divided into five belts namely sub-tropical climatic region up to 1200m, warm-temperate climatic region between 1200-2100m, cool temperate region between 2100-3300m, alpine-climatic region between 3300-3500m and Himalayan desert climatic region above 5000m (Pandey, 1987).

1.2 Water Resources

A fundamental feature of the earth is an abundance of water, which covers 71 percent of its surface. Of the total water, about 97 percent remains in the seas as salt water and remaining 3 percent exists as fresh water in rivers, lakes, streams, reservoirs, underground water, polar and permanent glaciers etc. (Wetzel, 1983).

The water resources of Nepal are exclusively inland in nature which occupy about 2.27 percent of the world's water resources (MEN RIS 1996). It is approximately 3 percent of the total area of country in the forms of rivers streams, lakes, reservoirs village ponds, paddy fields, swamp lands and marshes (Swar and Bisgaard, 1996).

Table 1: Estimated Water Surface Area of Nepal

SN	Resources	Estimated Area Covarage (ha)
A	Natural resources	
i	River	3,95,000
ii	Lakes	5,000
iii	Reservoirs	1,500
B.	Ponds	6,220
C.	Marginal/Swamp's/Gholes etc	11,100
D.	Irrigated paddy field	3,98,000
	Total	8,16,820

Source: Country Profile Nepal 2004/'05 (2061/'062) .

1.2.1 Rivers of Nepal

Nepal has more than 6000 rivers and streams with total length of about 21000km. flowing from the north to the south. There are three major river systems in Nepal, which drain out the country. Each river system has seven main tributaries, fed with numerous branches and is subsequently called (i) the Sapta-Koshi, in the east, (ii) the Sapta-Gandaki, in the center and (iii) the Sapta-Karnali, in the west. Beside these, the Mahakali, the Karnali, the Kamala ,the Mechi, the Rapti, the Babai and the Tinau are also equally important rivers. All these river systems constitute about 48.35 percent of the total water area of Nepal (Table 1).

All these river systems drain into the Ganges system in India. The combined runoff through Nepalese rivers contributes 40 percent of the annual flow of the Ganges and 71 percent of the dry season flow (Abbas, 1982 cited in Shrestha, 1992).

Hydrologically, the rivers of Nepal can be divided into (i) purely rain fed rivers and (ii) snow plus rain fed rivers. The rivers of shorter lengths are seasonal and dry up from time to time. But in snow fed rivers, the melting of the snow in the Himalayas balances to check the further flow.

The rivers of Nepal loose their speed as they reach the southern plain of Terai region and deposit silt in the fertile foot plains. Some of the rivers are used in irrigation. Now most of the Mahabharat rivers have been tapped, such as the Kankai, the Kamala, the Bagmati and the Tinau (Shrestha, 1992)

1.3 Fishes and Fisheries of Nepal

1.3.1 Fish Diversity

There are 184 fish species belonging to 93 genera, under 31 families and 11 orders in the water bodies of Nepal (Shrestha, 2001, 2003). According to Rajbanshi (2005), there are altogether 187 species of fishes belonging to 10 orders, 30 families and 94 genera.

The fishes of Nepal are distributed from few meters of altitude in Terai to 3323m in Langtang khola situated in Langtang National Park (Shrestha, 1995). Among 184 fish species reported by Shrestha (2001), *Bagarius yarrelli* ('Gonch') is the largest fish found in Nepal, where as *Brachydanio rerio* ('Zebra') is the smallest fish of Nepal (Shrestha, 2001, Shrestha and Chaudhary, 2003).

1.3.2.1 Protection Status of Fishes:

Shrestha (1995) has enumerated a list of indigenous fish species of Nepal. According to new taxonomic revision, 89 species are common/occasional, 62 species are insufficiently known, 8 species are vulnerable, 1 species is endangered and 23 species are of rare status (Shrestha, 2001). The few vulnerable species are *Neolissocheilus hexagonolepis*, *Anguilla bengalensis*, *Tor putitora*, *Chagunius chagunio*, *Brachydanio rerio*, *Schizothorax richardsoni*, *Schizothoraichthys progastus*, *Psilorhynchus pseudecheinus* etc (NRDB). *Tor tor* is the only one endangered fish species found in Nepal (NRDB).

According to Shrestha (2001), there are 4 species which are known to be endemic. Rajbanshi (2001) has reported 7 endemic fish species from the cold water. Later, Rajbanshi (2005) listed only 3 endemic fishes while others are considered as synonymous. These are *Psilorhynchus pseudecheinus*, *Myersglanis blythi*, *Pseudeutropius murius*.

Shrestha (1998) has recommended ten species of fishes in Nepal as the indicator species. The indicator species are *Neolissocheilus hexagonolepis*, *Chagunius chagunio*, *Tor putitora*, *Tor tor*, *Brachydanio rerio*, *Schizothorax richardsoni*, *Schizothoraichthys progastus*, *Psilorhynchus pseudecheinus*, *Anguilla bengalensis* and *Myersglanis blythi* (Shrestha 2001).

1.3.2 Status of Fisheries

Fisheries are small but important sectors of agriculture in Nepal and play an important role in the economic development of the country. Fisheries activities in Nepal can be divided into culture fisheries and capture fisheries. Culture fisheries involves all activities where complete

or partial control of fish production cycle is under taken. The capture fisheries covers fish caught from natural water bodies, where little or no control measures are taken over the fish production cycle. At present, fisheries contribute about 2.25 percent of agricultural gross product, which amounts to 0.9 percent of the GDP of country (Country Profile Nepal, 2003/'04).

Being a landlocked country, fishery sector of Nepal is confined to inland water bodies. Fish culture and capture fisheries are popular and successful activities. The capture fisheries of Nepal are widely scattered but not organized. Fishermen living along the river use their traditional fishing gears for fish catching. Fish culture has a short history in Nepal. The capture fishery is popular from ancient time, where as culture fishery is being practiced in ponds, lakes and reservoirs and other natural water bodies.

It has been estimated that about 1,37,323 families are engaged in aquaculture and fisheries activities. About 5,06,124 people were being actively involved in this profession in the year 2004/'05 with total beneficiaries of 7,47,039. The per capita fish production rate in Nepal is 1676 gm/year, which is very low in comparison to other developed countries. The total fish production of Nepal is 42,463 metric ton per year. In which, aquaculture contributes 22,480 m ton and capture fisheries contribute 19,983 m ton. The national average annual retail price of fresh fish is NRs 111.98 (Country Profile Nepal 2004/'05).

Table 2: Area Coverage and Production from Aquaculture and Capture Fisheries in Nepal.

S.N.	Particulars	Area (ha)	Production (m t)
1.	Aquaculture	43,997	22,480
1.1	Pond Fish Culture	6,220	20,213
1.2	Paddy cum Fish Culture	277	111
1.3	Enclosure Fish Culture	100	130
1.4	Cage Fish Culture (m ³)	36,000	216
1.5	Fish Culture in Gholes	1,400	1,778
1.6	Fish Production in Public Sector	-	32
2	Capture Fisheries		19,983
2.1	River	3,95,000	6,951
2.2	Lakes	5,000	795
2.3	Reservoirs	15,000	356
2.4	Irrigated Paddy Field	3,98,000	6,830
2.5	Marginal Swamps/Ghools etc.	11,100	5,051

Source: Country Profile Nepal 2004/'05.

Besides the indigenous fish species, six exotic species of high commercial value have been introduced into the country. Out of which *Salmo trutta* and *Onchorhynchus mykiss* are cold water species. *Onchorhynchus mykiss* is being studied for commercial production in race- way ponds at Fisheries Research Center (FRC), NARC, Godawari. *Cyprinus carpio* (Common carp), *Ctenopharyngodon idella* (Grass carp), *Hypophthalmichthys molitrix* (Silver carp) and *Aristichthys nobilis* (Big head carp) are high value commercial fishes. These are being cultured along with three indigenous fish species namely *Labeo rohita* (Rohu),

Catla catla (Bhakur) and *Cirrhinus mrigala* (Naini) in different aquaculture production systems.

There are 3 high valued indigenous cold water fishes viz. *Schizothorax* sps. (Asala), *Neolissocheilus hexagonolepis* (Katile) and *Tor* sps. (Mahaseer) are being studied for high commercial production in Nepal.

1.4 Study Area

The Tinau river, originating from the Mahabharat range of Palpa district about 20km east of Tansen, is selected as the study area for the present study. It is a separate river from all the three major river systems of Nepal, lying at an altitude of about 100 m to 800 m from sea level. It flows to southern direction joining many feeder streams along its way through a valley called Mariphant. About 5 km south of Mariphant, it meets two feeder streams at Charchare namely Dumre and Suke. The Tinau river on its way towards south direction meets Sisne khola and Jhumsa khola at Jhumsa. After Jhumsa, it is also called Jhumsa river. The Tinau river then flows towards west and meets the largest feeder stream Dovan khola at Dovan. Before entering the Terai region, it meets another feeder stream called Chidiya khola at Siddhababa temple.

Tinau river bifurcates into two channels from Butwal, one flows straight to south direction and enter into India crossing Bethari, while another channel flows to south-west direction and is then known as Dano river. Both of these rivers again meet each other in India.

Tinau river makes a journey of about 95 km in Nepal and passes to India. The present study covers about 51 km from Mariphant to Bethari which includes valley, hilly region as well as Terai-region. It makes

terraces of about 200 m side ways at some place in the hilly region. The main stream is narrow in the northern region due to the presence of hard and strong rocks on the bank which has comparatively more depth and looks like gully but on reaching the Terai region, it gets elaborated width towards south direction.

A number of villages are situated in the bank of the Tinau river including a town Butwal. Water resources in the Tinau river have been utilized for drinking, washing, bathing, hydro electricity and irrigation purposes. A hydropower dam has been constructed at Dovan VDC of Palpa district, about 3.5 km away from Butwal in 2022 BS producing 1024 kw hydroelectric power.

1.4.1 Study Sites

Before starting regular sampling programs, surveying techniques were followed up for the fixation of stations at the suitable place. For the present study, five stations were selected taking into account of the altitudinal variation, human settlements, confluences of other tributaries, dam sites etc. Which are as follows from north to south direction.

1.5 Plan of the Study

1.5.1 Objectives of the Study

The main objectives of the present study are as follows:

- J To study the existing ichthyofauna and their distribution pattern in the Tinau river.
- J To study the physicochemical and biological parameters in relation to the fish distribution, abundance and frequency occurrence in Tinau river.

- J To study the socioeconomic status of the fishermen of the Tinau river.
- J To study and identify the fishing implements used in Tinau river.
- J To study the impact of dam on fish distribution in the Tinau river.

1.5.2 Justification of the Study

The Tinau river is one of the important river of western Nepal, which is originated in Palpa and flows independent of other major river system of the country. It is fed by several feeder streams during its journey passing through Rupandi district, which includes Butwal- one of the largest cities of Nepal. It provides a good habitat for fishes as well as other aquatic fauna and flora. Apart from this, it is also important for irrigation purpose. From Butwal, it bifurcates into two channels known as Chhattis Mauja and Soraha Mauja. Soraha-Chhattis Mauja Irrigation Canal Scheme is one of the popularly known schemes of Nepal built and managed under community level. This scheme was built about 150 years ago and it is said that it took 3 years to be operated. The main canal is about 24km (12km Saraha- Mauja kulo and 12km Chhattis- Mauja kulo) long (WECS, 1985). Chhattis- Mauja flows directly to south direction irrigating the southern region of the Rupandehi district where as the Soraha- Mauja flows west direction irrigating west southern part of the Rupandehi district. About 2,815 hector areas are irrigated from Tinau river covering 14 VDCs (District Profile 2057B S, Rupandehi).

Very little attempts have been made so far to explore the aquatic biodiversity and fishery resources in this river. The present status of economically important fish species, market situation, fishing activities socio-economic conditions of fishermen are unknown. The fishery

resources and fish production might be declined due to industrial pollution, illegal fishing practices, heavy flooding etc. According to the locals there is serious declination of fish population due to construction of dam obstructing the way for migratory fishes.

This dissertation work is hoped to be a small leap to explore baseline information of fishes and fishery resources of Tinau river.

1.5.3 Limitation of the Study

Although, the present study has attempted to cover most of the subject matters related to the main objectives, it has its own limitations. These are mainly due to lack of enough time and financial source. Following are some limitations of the present study-

- J A detail comparative study on status of some fish fauna before and after dam construction as the impacts of dam couldn't be performed. This is mainly due to lack of feasibility study in Tinau river regarding the environment impact assessment of hydro-dam construction.
- J A regular seasonable sampling throughout the year couldn't be performed due to lack of excess time. So, the whole field study was performed within about eight months covering more or less three major seasons.
- J Study on ecological behaviour of some important fishes couldn't be performed.

CHAPTER - II

LITERATURE REVIEW

The oldest documented report on fishes of Nepal dates back to 1793 A D by Colonel Krikpatrik. In his book on Nepal, he reported fishes like *Tor* sps. (Sahar) from Rapti river, *Amphipnious* sps. (Edl), *Schizothoraicthys* sps. (Asala) and *Barilius* sps. (Faketa) from Tadi khola. He also described the fishing methods in Rapti river. However, the credit of first scientific report on the fish fauna of Nepal goes to Hamilton, who gave a valuable authentic information about the fishes of Nepal in his book entitled "An Account of the Fishes Found in the River Ganges and its Tributaries" in 1822 A.D. Further, he reported 24 fish species from the Koshi river and 2 species from Rapti river of Nepal.

Gunther (1861), reported some cold blooded vertebrates including fishes collected by Hodgson in Nepal. Day (1886), mentioned the distribution of some fresh water fishes of Nepal in his historical work- "Fishes of India, Barma and Ceylon". Boulenger (1907), reported a collection of Nepalese fishes and western Himalayan fishes. Regan (1907), reported a small collection of Nepalese fishes. Hora (1937), obtained a collection of fishes from Nepal through Colonel Bailey, which includes 158 specimens of 22 species. Menon (1949, 1954) collected fishes from the Koshi-Himalayan region belonging to 11 families comprising 26 genera and 52 species. He also provided informative description of zoo-geography of the fishes of Nepal. Taft (1955), submitted a report on his survey of fishes of Nepal and collected 94 species of fishes from Kathmandu and adjoining areas. De Witt (1960), examined and prepared a checklist of 192 species of fishes belonging to 21 families collected during California- Hialayan- Expedition to Makalu.

Other important ichthyologists, who have studied the taxonomy of fresh water fishes and described some of the fishes of Nepal are Shaw and Shebbeare (1937), Mishra (1959), Das (1967) and Shrivastava (1968).

Most of the above mentioned studies were mainly based on taxonomic point of view and did not consider the ecology and behaviour of fishes. Dibbs (1965) studied various aspects on development of fisheries in Nepal. Thapa and Rajbansi (1968) studied the ecology of hill stream fishes of Nepal. Majupuria and Shrestha (1968) published a paper on fresh water fishes and fisheries of Nepal. Majupuria (1969) introduced a paper on socio-economic condition of fishermen of Kathmandu valley. Bhatta and Shrestha (1975) have studied the fish fauna of Suklaphanta and listed 27 species of fishes. Ferro and Swar (1978), made survey on biological and limnological condition of lakes and natural waters in Pokhara valley with reference to the existing fish population, their feeding habits and biology. Shrestha (1979) studied the resource biology and aquatic ecology of fresh water fishes of Kathmandu valley with particular reference to fish production, marketing, management and conservation. Masuda and Karki (1980) provided a check list of fish fauna of Trishuli river, in which they have reported 6 families, 16 genera and 28 species. Shrestha (1981), in his book- "Wild Life of Nepal" commented on ecology, distribution and biology of the fishes of Nepal. Shrestha (1970-1986) has worked extensively on the fish fauna of Nepal and published her findings in various journals. She has published a book entitled- "Fishes, Fishing Implements and Methods of Nepal" in 1994. Shrestha (1995), enumerated the fishes of Nepal to a total of 185 species representing 79 genera, 31 families and 11 orders. In 1998, she has reported 186 fish species with the finding of *Puntius phutunio*. In 2001, she published a paper entitled "Taxonomic Revision of Fishes of Nepal"

reporting a total of 182 species belonging to 93 genera under 31 families and 11 orders. Later, she again revised her work in 2002/'03 and reported the total number of fishes of Nepal is 184 species with the inclusions of *Dipticus maculatus* and *Bagarius bagarius*.

Karma (1993), Mandal (1995), Sharma (1996), Chaudhari (1999) and Shrestha (2005) studied on the fish diversity and fishery resources of Tinau, Budhkhola, Trisuli and Tadi rivers and reported 36,35,68,29 and 18 fish species respectively. Recently, Rajbanshi (2005), has published occasional paper of NAST where he reported 187 fish species under 10 orders, 30 families and 94 genera.

Despite a large number of contributions cited above, much remain to be done on the ecology and behaviour of fishes living in the hill streams and their relationship with water quality. Thus, the present study entitled – "Study on Fish Diversity and Fishery Resources of the Tinau River" is carried out to contribute further knowledge about the fish fauna and productivity of Tinau river. It is hoped that this study will help in planning, conserving and management for the intensive aquaculture development of the fresh water hill streams.

CHAPTER - III

MATERIALS AND METHODS

3.1 Study Period

The field study was carried out for about one year from July 2006 to March 2007 with almost four seasons. Each sampling site was visited in the month of August, December and March.

3.2 Study Area

The present study was carried out in the Tinau river. It is originated from the Mahabharat range and flows southward to meet the Ganges in India draining Palpa and Rupandehi districts of Nepal.

3.2.1 Selection of Study Sites

A preliminary survey on morphometry and environment of river was conducted for the present study. Five sampling stations were selected taking into account the altitudinal variation, human settlements, confluences of other tributaries, dam site etc. The selected stations (Map No 2 ,Plate I) from north to southward direction are Damkada (Mariphant) -station I, Charchare- station II, Dovan-station III, Butwal- station IV and Bethari-station V.

3.2.2 Description of Sampling Stations:

(i) Station I- Damkada:

Station I was fixed at Damkada (Mariphant), Palpa district with an altitude of 684 meter. This was the upper most station with less interference of human beings (Plate I, Photo 1). The river bed is

composed of mud, sand and gravels. This is a plain valley region, where the average velocity of water is 0.54 m/s. The river water at this station remains clear through out the year except monsoon, during which this valley gets flooded. The water temperature varies in between 16.5⁰C to 29⁰ C

iii) Station II- Charchare

Station II was fixed at Charchare about 5km down from Damkada at the confluence point with Dumre (Plate I, Photo 2). The characteristics of the Tinau at this station are pools and rapids. The river bed is composed of sand, gravels, boulders and bed-rocks. The average velocity of water is 1.69 m/s The water temperature varies from 16.5⁰C to 31⁰C at this station, which lies at an altitude of 574m.

(iii) Station III – Dovan

Station III was fixed at Dovan with an altitude of 250m, situated about 5km north of Butwal. It was fixed at the confluence of main stream to a feeder stream called Dovan- the largest tributary mixing to the Tinau river (Plate I, Photo 3). Average width of the river bed at this station is about 90 m. The water colour remains transparent and clear throughout the year except monsoon. The average velocity of water at this site is 0.54 m/s .The water temperature ranges between 17⁰C-29⁰C. The river is broken into pools and rapids, which provide a good habitat for fishes. The river bed consists of gravels, sands, pebbles, boulders and bed rocks. Some amount of mud and detritus are also present at the bank of the river. A dam has been built at this station to generate hydro electric power.

(iv) Station IV – Butwal

Butwal is the headquarter of Lumbini zone and is situated at an altitude of 188 meter above the sea level. This place was chosen as station IV, which is the junction of hilly and Terai region. After entering the Terai region, the river expands widely (Plate I, Photo 4). The velocity of water gradually starts decreasing from this place towards Bethari (Station-V). The water is clear and more transparent through out the year except monsoon. The water temperature variation at this station is 17⁰C to 26.5⁰C. The average velocity of water at this station is 1.62m/sec. Some pools and rapids are also present at this station and this station has good sheltering place for fishes. The river bed consists of silt, sand gravels pebbles, boulders and bed-rocks. From this place, the Tinau river bifurcates into two channels, one straight towards southward and another to the south west direction which are called Tinau and Dano respectively.

(v) Station V- Bethari

Bethari is situated about 5 km west of Bhairahawa, the headquarter of Rupandehi district. It is situated at an altitude of 107 m above the sea level and lies in the plain of Terai (plate I Photo 5). The average velocity of water is low viz. 0.37m/s. The transparency value of the river water temperature was found to be 61.92 cm., which is very low than other stations. The average water temperature was found to be 18⁰C to 32.5⁰C. There are no pools and rapids. The river bed consists of mud, silt, sand, clay and detritus.

3.3 Sources of Data Collection

The primary data were collected by using tools and techniques like direct observations, interviews with fishermen/local people and by use of

questionnaires. Secondary data were also collected from different reports, journals, research papers and dissertations.

Questionnaires were implemented to collect the information regarding changing pattern of the river with fish distribution, general environment of the river like the lowering of water level, severe land erosion, siltation, severe flood etc. Visits were conducted frequently to study the fishing implements and methods used in the Tinau river as well as socio economic status of local fishermen.

3.4 Collection and Identification (Diversity) of Fishes:

The fishes were collected from sampling stations viz. Damkada (Mariphat), Charchare Dovan, Butwal and Bethari (Map No 2) by employing local fishermen to find out the systematic position, average abundance and distribution pattern of fishes of the Tinau river. However, fishes were also collected from local markets to find out the diversity of fishes. The places between Charchare and Butwal is most important from fisheries point of view, specially for hill stream fishes, because it is provided with gravels, pebbles and boulders on the river banks. It provides the spawning ground for different types of fishes. The habitat conditions like the spawning ground, shelter, characteristic features of river bed have been recorded during the field trips.

Various kinds of locally prepared fishing nets were used for fish catching viz. cast nets etc. Scoop nets were used for capturing fingerlings and small fishes. To collect fishes from deep pools, hook lines were used.

The measurement of morphometric characteristics of all the collected fishes were performed in the field itself. The qualitative and quantitative assessment of fish catch were also done. After ecological

observations, the collected specimens were fixed in 10 formaldehyde and preserved in 5% formaldehyde.

The collected fish specimens were identified by using standard method of taxonomy after Shrivastava (1968), Day (1978), Shrestha (1981), Jayaram (1981), Talwar and Jhingran (1991), Shrestha (1994), Jayaram (1999) and Shrestha (2001).

3.5 Study on Distribution Pattern and Frequency Occurrence

The upper reaches of Tinau river starts from Butwal to Damkada (Mariphat) with an altitudinal differences from 188m to 684m, which includes hilly region. Similarly, the lower reaches lies below Butwal (188m) to Bethari (107m) in the Terai region. The distribution pattern of fishes are in accordance to the different characteristics of upper and lower reaches of the Tinau river.

All the collected fishes were counted species-wise from each sampling station in each field trip. The records on number of different fishes were compiled after the field visits to obtain the total number of specimens of a particular species at different sampling stations i.e. distribution pattern.

Frequency occurrences for different species of fishes were obtained by using simple mathematical formula -

Frequency occurrence (%) =

$$\frac{\text{Total number of fishes of all species collected from all stations during whole study period}}{\text{Total number of fishes of that species collected from all stations during whole study preiod}} \times 100$$

3.6 Analysis of Physical Parameters of Water

Physical properties of water in any aquatic system are largely regulated by the existing meteorological conditions and chemical properties. Some of the physical parameters of Tinau river were analyzed during the present study. This was done seasonally with the help of APHA (1976), Adoni (1985) and Trivedy and Goal (1986). The important parameters studied are.

3.6.1 Water Colour

Simple method was used to determine the colour of Tinau river. A beaker of water from the river was taken out and placed on a white paper and the colour was observed.

3.6.2 Water Velocity

The velocity of the river water was measured seasonally. A distance of ten meter was measured on a river section and marked. The current velocity of water was measured and calculated from different sampling station by simple method of timing a float with a stop watch (Adoni et al, 1985). It was measured in the unit of m/s.

3.6.3 Temperature

The water temperatures were recorded by using a standard mercury thermometer. The measuring was done simply by dipping the bulb of thermometer inside the water surface avoiding the direct sunlight.

3.6.4 Transparency

The transparency was measured by using a transparency meter, which is based on Sechhi disc method. The Sechhi disc is a metallic plate

of 20 cm diameter with four (alternate black and white) quadrants on the upper surface and a hook in the center to tie a graduated rope. The Secchi disc was lowered in the pool region of the river water and the depth was noted, at which it just disappeared. Then the disc was slowly raised upward to note the depth at which it reappeared. The calculation was done by applying the following formula after APHA (1998) -

$$\text{Transparency} = \frac{\text{Just disappearance (depth)} + \text{Just reappearance (depth)}}{2}$$

3.6.5 Turbidity

Turbidity of the river water is inversely proportional to the transparency. Therefore, the turbidity of the river water was calculated by using transparency value into the following equation given by APHA (1998)

$$\text{Turbidity (x)} = \frac{1000}{1.568Y^{1.275}}$$

Where,

X = Turbidity and

Y = Transparency

3.7 Analysis of Chemical Parameters

Water samples were collected tri-monthly from every sampling stations of the Tinau river during the study period. The water samples were taken directly from the surface water in the polythene bottles without any bubbles of air. The chemical analyses of waters were carried out using the standard methods of Adoni (1985), Tridebi and Goal (1986) and APHA (1998).

3.7.1 Hydrogen Ion Concentration (pH)

The pH of water is negative logarithm of hydrogen ion concentration. A battery operated electrical pH meter was used to record the pH of water during the study period at every sampling stations. Hydrogen Ion concentration (pH) of water was analyzed immediately at the spot.

3.7.2 Dissolved Oxygen (DO)

Winkler's method was used to determine the dissolved oxygen of river water. Water samples were collected in BOD bottles without bubbles. Then 2ml of alkaline Potassium Iodide solution was added in it and shake well. Thus, brown precipitation was obtained, which was dissolved by adding 2ml of concentrate Sulphuric acid. Then, sample solution was titrated against Sodium thio sulphate solution (0.025N). The calculation was done by using following formula after Tribedi and Goal (1986).

$$\text{DO (Mg/l)} = \frac{(\text{ml} \times \text{N}) \text{ of Na}_2\text{S}_2\text{O}_3 \times 8 \times 1000}{V_2 \frac{(V_1 - V)}{V_1}}$$

Where,

V_1 = Volume of BOD bottle

V_2 = Volume of the part of content titrated

V_3 = Volume of M_nSo_4 and KI added

3.7.3 Total Alkalinity

Few drops of Phenolphthalein indicator were added to 50ml. of sample water in a conical flask. Then, it was titrated against 0.1N HCl solution until the colour disappears at the end point. This is

Phenolphthalein Alkalinity (PA). Then 2-3 drops of methyl orange was added to same sample and continue to titrate further till yellow colour changes to pink at the end point. This is total alkalinity. This can be calculated by following formula after Tribedi and Goal (1986).

$$\text{TA as CaCO}_3 \text{ (mg/l)} = \frac{(\text{ml} \mid \text{Normality}) \text{ of HCl} \mid 50 \mid 1000}{\text{ml of sample used}}$$

3.7.4 Total Hardness

It is the total amounts of salts present in the water (i.e. salts like chlorides and sulphates of calcium and magnesium). The total hardness of water was measured by EDTA titrimetric method. 50ml of sample water was taken in a conical flask and 20 ml of Ammonium buffer solution and 200mg of erichrome black indicator was added in it. Hence wine-red pink colour appeared. Then it was titrated against 0.01 M of EDTA solution until a blue colour appeared at end point.

It can be calculated by using following formula after Tribedi and Goal (1986).

$$\text{Total hardness (mg/l)} = \frac{\text{ml of EDTA used} \mid 1000}{\text{ml of sample used}}$$

3.7.5 Free Carbon dioxide

Free carbon dioxide present in the water was analyzed by titrating water sample against a strong alkali (NaOH). Phenolphthalein indicator was used in titration and calculation was done by using following formula of Tribedi and Goal (1986) -

$$\text{Free CO}_2 \text{ (mg/l)} = \frac{(\text{ml} \mid \text{Normality}) \text{ of NaOH} \mid 44 \mid 1000}{\text{ml of sample used}}$$

3.8 Analysis of Biological Parameters

The biological parameters are mainly planktons which are the free floating and drifting microscopic organisms having natural buoyancy capacity. The planktons are mainly of two types viz. plant forms called phytoplanktons and animal forms called zooplanktons.

For the collection of planktons, the plankton net (Wisconsin's planktons net of mesh size 75 micron and 20cm diameter) was used. 10 liters of water was collected in a bucket and poured into the plankton net. The plankton was remained at the cap of plankton net. Then, it was collected in a petridish and diluted by adding 20 ml of distilled water. Those samples were preserved in 5% aqueous formaldehyde solution. Samples were brought to the laboratory of Directorate of Fisheries Development(DoFD), Balaju. The identification of zooplanktons and phyto planktons were done after Edmondson (1965).

3.9 Statistical Analysis of Ichthyofauna

The co-efficients of correlation between some important physico-chemical parameters of water with composition of fish species in Tinau river has been calculated by using Karl-Pearson's method (Gupta 1989).

$$\text{Correlation coefficient (r)} = \frac{N\phi XY - \phi X \cdot \phi Y}{\sqrt{N\phi X^2 - (\phi X)^2 \cdot N\phi Y^2 - (\phi Y)^2}}$$

$$\text{Probability Error (P Er)} = 0.6745 \times \frac{1-r^2}{\sqrt{N}}$$

Probable error is useful in interpreting Karl-Pearson's co-efficient of correlation.

3.10 Fishing Appliances and Methods

Fishing appliances in Tinau river were studied during field visit through direct observation, photography and interviews with fishermen. The collected data were compiled with the help of Shrestha^I (1994) and Shrestha^{II} (1995).

For the direct observations on fishing methods and conditions of habitat, regular visits were conducted on the various sections of the Tinau river. In each visit, data were gathered on fish collection and made observations on the fishing practices and recorded different gears and appliances used by the fishermen for fish catching.

3.11 Socioeconomic Condition of Fishermen

Different sets of questionnaires were developed and distributed to the local fishermen living near the bank of Tinau river for the collection of informations about socioeconomic condition, fishing implements, fish market, demographic status of fishermen and other all related informations.

3.12 Some Hazards to Fish Life

The probable hazards to the life of fishes like chemical pollution, loss of habitats, use of destructive fishing methods, construction of dam, lack of public awareness etc were studied during this study period. Attempts were done to identify the major problems among them responsible for the declination of fish population in Tinau river.

^I Shrestha, Jiwan

^{II} Shrestha, T. K.

CHAPTER - IV

OBSERVATION / RESULT

4.1 Fishery Resources of Tinau River

4.1.1 Species Diversity

The Tinau river provides a habitat for fresh water fishes of diverse types, viz. snow trout, cat fishes, stone loaches, sucker heads, barbs, mahaseer, eels etc. 32 species were reported from the Tinau river during the present study, which includes 4 orders, 11 families, 11 sub families, 24 genera and 32 species (Table 3).

According to local fishermen, some other species namely *Schizothorax* sps. (Asala), *Notopterus* sps. (Golai), *Xenontedon cancila* (kauwa), *Chanda* sps. (Hile/Channari) are also found in this river. Unfortunately, these were not found and could not be collected during the present study period. Shrestha reported *Cyclocheilichthys apogon*, *Tor tor* and *Bagarius yarelli* in 1981. Sharma (1996) and Shrestha (2005) reported *Schistura devdevi*, *Chela lebuca* and *Channa orientus*. These species were not found during the present study period. These have been listed in the Table 4

Table 5 explains the species diversity of fishes in Tinau river, their local names and conservation status. Among them *Barilius* sps., *Channa* sps., *Schistura* sps., *Puntius* sps. and *Lepidocephalus* sps. were found most common. *Puntius ticto*, *Brachydanio rerio* were found as the rare species. The status of fishes is based on catching efforts (abundance) during study periods and interviews with local fishermen.

Table 6 shows the major groups of fishes found in Tinau river during the present study period.

Table 3: List of Fishes Collected from Tinau River

S.N.	Scientific Name	Local name	Status
1	<i>Amblyceps mangois</i>	-	Few
2	<i>Aspidoparia morar</i>	Morar	Few
3	<i>Acanthocobitis botia</i>	Gadela	Common
4	<i>Barilius bendelesis</i>	Fageta	Few
5	<i>Barilius barna</i>	Fegata	Common
6	<i>Barilius barila</i>	Faget	Common
7	<i>Botia lohachata</i>	Baghia	Few
8	<i>Chagunius chagunio</i>	Patherchatti	Few
9	<i>Channa punctatus</i>	Hile	Common
10	<i>Cirrhinus reba</i>	Naini	Common
11	<i>Colisa fasciatus</i>	Khoste	Few
12	<i>Brachydanio rerio</i>	Bhitti	Rare
13	<i>Esomus danricus</i>	Darai	Common
14	<i>Garra gotyla</i>	Buduna	Few
15	<i>Garra annandalei</i>	Buduna	Few
16	<i>Glossogobius giuris</i>	Keuchi	Few
17	<i>Heteropneustes fossilis</i>	Singhi	Few
18	<i>Labeo calbasu</i>	Rohu	Common
19	<i>Labeo coeruleus</i>	Rohu	Common
20	<i>Lepidocephalus guntea</i>	-	Common
21	<i>Macrognathus pancalus</i>	Gainchi Bam	Occasional
22	<i>Mastacembalus armetus</i>	Bam	Occasional
23	<i>Mystus vitatus</i>	Tengra	Occasional

24	<i>Mystus bleekeri</i>	Tengra	Occasional
25	<i>Neolissocheilus hexagonolepis</i>	Katle	Few
26	<i>Schistura rupicola</i>	Gadela	Common
27	<i>Schistura beavani</i>	Gadela	Common
28	<i>Salmostoma baciala</i>	Suhiya	Common
29	<i>Puntius conchoniis</i>	Sidre	Common
30	<i>Puntius ticto</i>	Sidre	Rare
31	<i>Putius sophore</i>	Sidre	Common
32	<i>Wallago attu</i>	Buhari	Occasional

Table 4: List of Fish Species Reported Early (Secondary Sources)

S.N.	Scientific Name	Local name	Secondary source
1	<i>Tor tor</i>	Sahar	Shrestha (1981)
2	<i>Bagarius yarelli(bagarius)</i>	Gonch	Shrestha (1981)
3	<i>Schistura devdevi</i>	Gadela	Shrestha (1996)
4	<i>Channa orientus</i>	Hile	Shrestha (1996)
5	<i>Chela lebuca</i>	Bohiye	Shrestha (2003)
6	<i>Cyclocheilichthys apogon</i>	Paithe	Local fishermen
7	<i>Notopterus notopterus</i>	Golhai	Local fishermen
8	<i>Shizothorax sps.</i>	Asala	Local fishermen
9	<i>Xenontedon cancila</i>	Kanwa	Local fishermen
10	<i>Chanda sps.</i>	Channa/Hile	Local fishermen

Table 5: Major Groups of Fishes of Tinau River

S.N.	Group	Scientific names of fishes	Local name
1	Major carps	<i>Neolissocheilus hexagonolepis</i> ,	Katle
		<i>Chagunius chagunio</i>	Patherchatti
		<i>Cirrhinus reba</i>	Naini
		<i>Labeo calbasu</i>	Rohu
		<i>Labeo coeruleus</i>	Rohu
		<i>Aspidoparia morar</i>	Morar
2	Barbs	<i>Puntius conchonius</i>	Sidre
		<i>p. sophore</i>	Sidre
		<i>p. ticto</i>	Sidre
		<i>Esomus danrius</i>	Darai
		<i>Brachydanio rerio</i>	Bhitte
3	Minnows	<i>Salmostoma baciala</i>	Suhiya
		<i>Barilius barila</i>	Fageta
		<i>B. barna</i>	Fageta
		<i>B. bendelisis</i>	Fageta
4	Loaches	<i>Acanthocobitis botia</i>	Gadela
		<i>Lepidocephalus guntea</i>	-
		<i>Schistura beavani</i>	Gadela
		<i>S. rupicola</i>	Gadela
		<i>Botia lohachata</i>	Baghi
5	Cat-fishes	<i>Wallago attu</i>	Buhari
		<i>Mystus bleekeri</i>	Tengra
		<i>M. vitatus</i>	Tengra
6	Live fish	<i>Heteropneustes fossilis</i>	singhi
7	Spiny Eels	<i>Mastacembelus armatus</i>	Bam
		<i>Macragnathus pancalus</i>	Gainchi
8	Perch	<i>Colisa fasciatus</i>	Khosta
9	Murrels	<i>Channa punctatus</i>	Hile

4.1.2 Systematic Position of Ichthyofauna of Tinau River

The collected specimens were identified and given proper systematic positions as described below after Jayaram (1999).

Order – Cypriniformes

Family – Cyprinidae

Sub-Family – Cyprininae

Tribe – Labeonini

Sub -Tribe– Labeones

Genus – *Cirrhinus* Cuvier, 1817

Species – *Cirrhinus reba* (Hamilton – Buchanan) 1822

Genus – *Labeo* Cuvier, 1817

Species – *Labeo calbasu* (Hamilton – Buchanan) 1822

Labeo coeruleus (Day) 1878

Tribe – Systomini

Sbtribe – Poropunti

Genus – *Chagunius* Smith, 1945

Species – *Chagunius chagunio* (Hamilton-Buchanan) 1822

Subtribe – Systomi

Genus – *Puntius* (Hamilton – Buchanan) 1822

Species – *Puntius conchonius* (Hamilton-Buchanan) 1822

Species- *Puntius sophore* (Hamilton-Buchanan) 1822

Species – *Puntius ticto* (Hamilton-Buchanan) 1822

Tribe – Cyprinini

Subtribe – Tores

Genus – *Neolissocheilus* Rainboth, 1985

Species – *Neolissocheilus hexagonolepis* (Mc Clelland) 1839

Sub family – Rasborinae

Tribe – Oxygasterini

Genus – *Barilius* (Hamilton-Buchanan) 1822

Species – *Barilius barila* (Hamilton-Buchanan) 1822
Species – *Barilius barna* (Hamilton-Buchanan) 1822
Species – *Barilius bendelisis* (Hamilton-Buchanan) 1822
Genus – *Aspidoparia* Heckel, 1843
Species – *Aspidoparia morar* (Hamilton-Buchanan) 1822
Genus – *Salmostoma* Swainson, 1839
Species – *Salmostoma baciala* (Hamilton-Buchanan) 1822

Tribe – Danionini

Genus – *Brachydanio* Werber and de Baeaufort, 1916
Species – *Brachydanio rerio* (Hamilton-Buchanan) 1822
Genus – *Esomus* Swainson (1839)
Species – *Esomus danricus* (Hamilton-Buchanan) 1822

Subfamily – Garrinae

Genus – *Garra* (Hamilton-Buchanan) 1822
Species – *Garra gotyla* (Gray) 1832
Species – *Garra annandalei* Hora, 1921

Family – Balitoridae

Subfamily – Noemacheilinae

Genus – *Acanthocobitis* Peters, 1861
Species – *Acanthocobitis botia* (Hamilton-Buchanan) 1822
Genus – *Schistura* Mc Clelland, 1839
Species – *Schistura beavani* Gunther, 1868
Species – *Schistura rupicola* Mc Clelland, 1839

Family – Cobitidae

Subfamily – Botinae

Genus – *Lepidocephalus* Bleeker, 1859
Species – *Lepidocephalus guntea* (Hamilton-Buchanan) 1822

II Order- Siluriformes

Family – Amblycipidae

Genus – *Amblyceps* Blyth, 1858

Species – *Amblyceps mangois* (Hamilton-Buchanan) 1822

Family – Bagridae

Subfamily – Bagrinae

Genus-*Mystus* Scopoli, 1777

Species – *Mystus vittatus* (Bloch) 1797

Species – *Mustus bleekeri* (Day) 1878

Family – Siluridae

Genus – *Wallago* Bleeker 1851

Species – *Wallago attu* (Schneider) 1801

Family – Heteropneustidae

Genus – *Heteropneustes* Muller, 1840

Species – *Heteropneustes fossilis* Bloch, 1785

Family – Belontiidae

Subfamily – Trichogasterinae

Genus – *Colisa* Cuvier, 1831

Species – *Colisa fasciatus* (Schneider) 1801

Family – Gobiidae

Subfamily – Gobiinae

Genus – *Glossogobius* Gill, 1839

Species – *Glossogobius giuris* (Hamilton-Buchanan) 1822

IV. Order – Synbranchiformes

Family- Mastacembilidae

Subfamily – Mastacembilinae

Genus – *Mastacembelus* Scopoli, 1777

Species – *Mastacembelus armatus* (Lacepede) 1800

Genus – *Macrogathus* (Lacepede) 1800

Species – *Macrogathus pancalus* (Hamilton- Buchanan)

1822

4.1.3 Distributional Pattern and Frequency Occurrence

The upper reaches of Tinau river lies from Butwal to Damkada (Mariphat) with an altitudinal difference from 188m to 684m, which includes hilly region. Similarly, the lower reaches lies from Butwal (188m) to Bethari (107m) in the Terai region. The distribution pattern of fishes are according to the different characteristics of upper and lower reaches of the Tinau river.

Table 8 explains the distribution pattern of different species of fish fauna in Tinau river. Only 11 species of fish were reported from station i)- Damakada. Among them, the dominant species of fishes were *Puntius sophore* and *Puntius conchoni*, where as *Mastacembalus armatus* was occasionally found. *Heteropneustis fossilis* and *Garra gotyla* were found few in number. At station ii)- Charachare, 11 species were found. Among them *Schistura* sps. and *Lepidocephalus guntea* were commonly found species. At station iii)- Dovan, 6 species were found. Among them, *Lepidocephalus* sps, *Schistura* sps. and *Barilius* sps. were found dominants. At station iv)- Butwal also, *Barilius* sps., *Garra* sps. and *Puntius* sps. were commonly found. According to fishermen, 'Bam - machha' (*Mastacembelus* sps.) are also found under large bed-rocks. But, there could not be found so during the present study period. This site was found using extensively for bathing and washing purposes. So, the hardness of water was found more at station v) – Bethari. 21 species under 13 genera were found there. Among them, *Puntius* sps. is very common fish found in this area.

Table 6: Distribution Pattern, Abundance and Frequency Occurrence (%) of Different Species of Fishes in Tinue River

Family	Scientific Name	Local Name	No. of specimen in station						Frequency occurrence (%)	Abundance
			I	II	III	IV	V	Total		
Cyprinidae	<i>Barilius barila</i>	Fageta	2	12	-	-	15	29	3.25	Common
	<i>B. bendelisis</i>	Fageta	-	4	10	-	2	16	1.80	Few
	<i>B. barna</i>	Fageta	2	3	-	-	2	7	0.79	Common
	<i>Cirrhinus reba</i>	Naini	-	-	-	-	20	20	2.26	Common
	<i>Brachydanio rerio</i>	Raiya	-	-	9	10	-	19	2.08	Few
	<i>Esomus danricus</i>	Darai	-	-	-	-	35	35	3.96	Common
	<i>Garra gotyla</i>	Buduna	10	3	-	-	-	13	1.47	Few
	<i>G. annandalei</i>	Buduna	8	-	-	-	-	8	0.90	Few
	<i>Puntius conchoniuis</i>	Sidre	15	10	35	20	50	130	14.72	Common
	<i>P. ticto</i>	Sidre	-	4	-	-	-	4	0.46	Rare
	<i>P. sophore</i>	Sidre	10	8	30	3	25	76	8.61	Common
<i>Labeo calbasu</i>	Rohu	-	-	-	-	15	15	1.69	Common	

	<i>L. coeruleus</i>	Rohu	-	-	-	-	10	10	1.09	Common
	<i>Chagunius chagunio</i>	Patherchatti	-	-	-	-	9	9	1.02	Few
	<i>Neolissocheilus hexagonolepsis</i>	Katle	-	-	-	-	5	5	0.57	Few
	<i>Aspidoparia morar</i>	Morar	-	-	-	-	4	4	0.46	Few
	<i>Salmostoma baciala</i>	Suhiya	-	-	-	-	7	7	0.79	Common
Balitoridae	<i>Acanthocobitis botia</i>	Gadela	-	15	-	-	13	28	3.17	Common
	<i>Schistura beavani</i>	Gadela	-	20	-	-	-	20	2.26	Common
	<i>S. rupicola</i>	Gadela	-	10	15	-	-	25	2.83	Common
Cobitidae	<i>Botia lohachata</i>	Baghi	10	-	-	-	-	10	1.09	Few
	<i>Lepidocephalus guntea</i>	-	10	10	15	25	20	80	9.06	Common
Amblycipidae	<i>Amblyceps mangois</i>	-	-	-	-	4	-	4	0.46	Few
Bagridae	<i>Mystus vittatus</i>	Tengra	-	-	-	-	15	15	1.69	Occasional
	<i>Mystus bleekeri</i>	Tengra	-	-	-	-	12	12	1.36	Occasional
Siluridae	<i>Wallago attu</i>	Buhari	-	-	-	-	5	5	0.57	Ocassional
Heteropneustidae	<i>Heteropneustes fossilis</i>	Singhi	13	-	-	-	-	13	1.47	Few

Channidae	<i>Channa punctatus</i>	Hile	65	-	-	-	-	70	7.93	Common
Belontiidae	<i>Colisa fasciatus</i>	Khoste	-	-	-	-	10	10	1.13	Few
Gobidae	<i>Glossogobius giuris</i>	Keuchi	-	-	-	-	9	9	1.02	Few
Mastacembilidae	<i>Mustacembelus armatus</i>	Bam	8	-	-	-	-	8	0.90	Occasional
	<i>Macrognathus pancalus</i>	Gainchi	-	-	-	-	5	5	0.57	Occasional
	Total No.of Fish Species	-	11	11	6	6	21	32	-	-
	Total No. of Fishes	-	15	99	11	67	28	721	-	-
			3		4		8			

Table 7: Seasonal Distributional Pattern of Fish-Species in Different Stations of Tinau River

S.N.	Scientific Name	August 2006					December 2006					March 2007				
		Sampling stations					Sampling stations					Sampling stations				
		I	II	III	IV	V	I	II	III	IV	V	I	II	III	IV	V
1	<i>Aspidoparia morar</i>	-	-	-	-	+	-	-	-	-	-	-	-	-	-	+
2	<i>Amblyceps mangois</i>	-	-	-	+	-	-	-	-	-	-	-	-	-	+	-
3	<i>Barilius bendelesis</i>	-	+	+	-	+	-	+	-	-	-	-	-	+	-	-
4	<i>Barilius barna</i>	-	+	-	-	+	+	-	-	-	-	-	+	-	-	-

5	<i>Barilius barila</i>	-	-	+	-	+	+	+	-	-	-	-	-	+	-	-
6	<i>Botia lohachata</i>	+	-	-	-	-	-	-	-	-	-	+	-	-	-	-
7	<i>Brachydanio rerio</i>	-	-	-	+	-	-	-	-	+	-	-	-	+	+	-
8	<i>Chagunius chagunio</i>	-	-	-	-	+	-	-	-	-	+	-	-	-	-	-
9	<i>Channa punctatus</i>	-	-	-	+	-	+	-	-	-	-	+	-	-	-	-
10	<i>Cirrhinus reba</i>	-	-	-	-	+	-	-	-	-	+	-	-	-	-	-
11	<i>Colisa fasciatus</i>	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-
12	<i>Esomus danricus</i>	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-
13	<i>Garra gotyla</i>	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
14	<i>Garra annandalei</i>	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
15	<i>Glossogobius giuris</i>	-	-	-	-	+	+	-	-	-	+	-	-	-	-	+
16	<i>Heteropneustes fossilis</i>	+	-	-	-	-	-	-	-	-	-	+	-	-	-	-
17	<i>Labeo calbasu</i>	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-
18	<i>Labeo coeruleus</i>	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-
19	<i>Lepidocephalus guntea</i>	-	+	+	+	+	+	-	-	-	-	+	-	+	+	-
20	<i>Macrornathus pancalus</i>	-	-	-	-	+	-	-	-	-	+	-	-	-	-	-
21	<i>Mastacembelus armetus</i>	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
22	<i>Mystus vitatus</i>	-	-	-	-	+	-	-	-	-	+	-	-	-	-	-

23	<i>Mystus bleekeri</i>	-	-	-	-	+	-	-	-	-	-	-	-	-	-	
24	<i>Neolissocheilus hexagonolepis</i>	-	-	-	-	-	-	-	-	-	+	-	-	-	-	
25	<i>Acanthocobitis botia</i>	-	+	-	-	-	-	-	-	-	+	-	-	-	-	
26	<i>Schistura rupicola</i>	+	-	+	-	-	-	-	+	-	-	+	-	+	-	
27	<i>Schistura beavani</i>	-	+	-	-	-	-	-	-	-	-	-	-	-	-	
28	<i>Salmostoma baciala</i>	-	-	-	-	+	-	-	-	-	-	-	-	-	-	
29	<i>Puntius conchoniis</i>	+	+	+	+	+	-	-	+	+	+	+	+	-	-	
30	<i>Puntius ticto</i>	-	+	-	-	-	-	-	-	-	-	-	-	-	-	
31	<i>Putius sophore</i>	+	-	+	+	+	+	+	+	-	+	-	+	+	-	
32	<i>Wallago attu</i>	-	-	-	-	-	-	-	-	-	+	-	-	-	-	
	Total No. of species (Diversity)	8	7	6	6	17	7	3	3	3	12	6	3	6	3	4

'+'=Present, '-'=Absent

'-'=

Table 8 shows the species wise frequency occurrence of the fishes in the Tinau river. About 14.72 % of total catch composition was constituted by *Puntius conchoni*, 9.06% by *Lepidocephalus guntea*, 8.61% by *Puntius sophore* and 7.93% by *Channa punctatus*. Rest of the fish species formed about 59.68% of total catch.. Table 10 shows station wise fish composition, which has been also clarified by figure 1 a) and b).

Figure 1 (a) : Pie-Chart Showing Station-Wise Fish Composition (%) by Total Number of Fishes in Tinau River

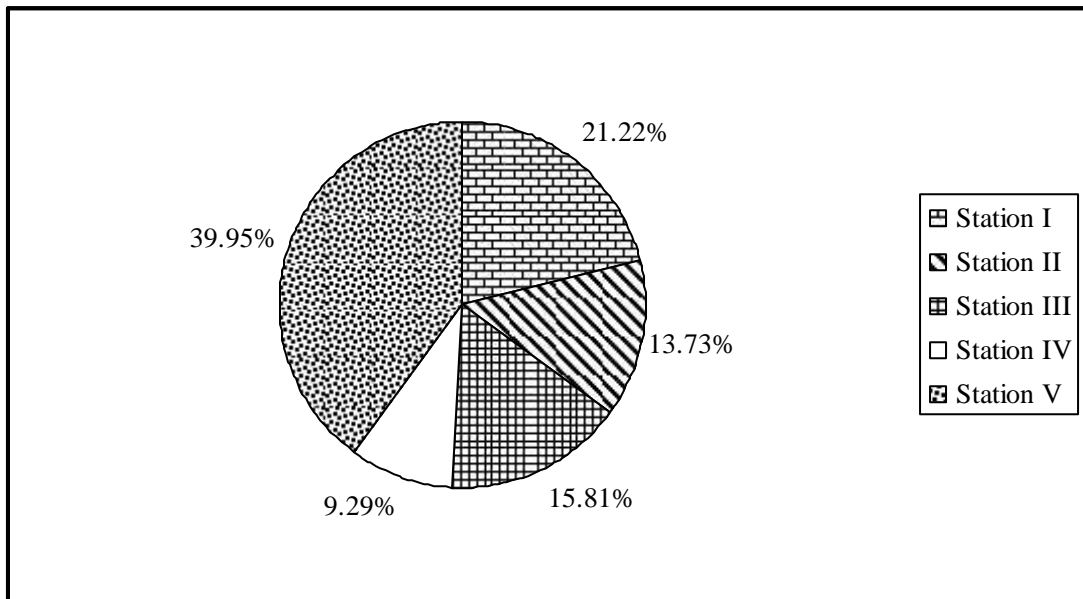
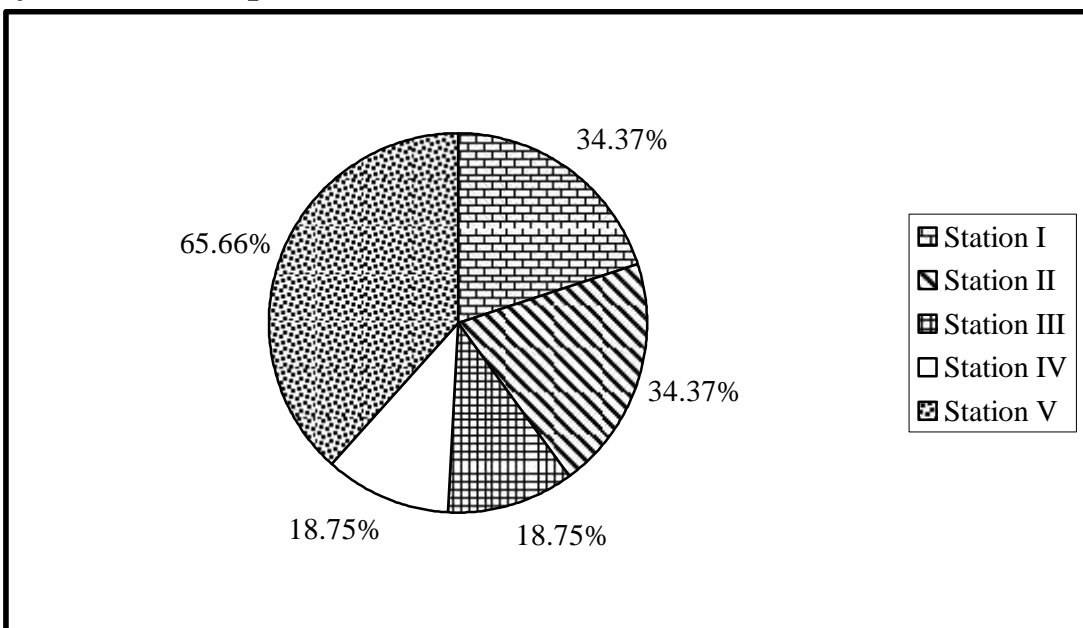


Figure 1(b) : Pie-Chart Showing Station Wise Fish Composition (%) by Number of Species in Tinau River.



4.1.4 Abundance and Fish Species Composition:

Table- 11 shows the order-wise fish species composition and the abundance of a particular species. It shows, 68.75% of recorded fish species fall under the order- Cypriniformes, 6.25% in Synbranchiforms.

Table-12 indicates the family-wise fish species composition (number of species in a family). According to which, 53.12% of recorded fish species are under the family Cyprinidae, 9.37% under Bolitoridae .25% under Bagridae and 6.25% under Mastacembilidae. Others constitute a total of 18.75 % about 3.12% under Siluridae, 3.12% under Heteropneustidae, 3.12% in Channidae ,3.12% under Belontidae and 3.12% under Gobidae).

On considering the total caught number of fishes, the family-wise fish abundance or fish composition by percentage is 56.45% for Cyprinidae, 10.13% for Bolitoridae, 12.49% for Cobitidae, 3.75% for Bagridae, 9.71% for Channidae, 1.81% for Heteropneustidae, 1.81% for Mastacembilidae, 1.39% for Belontidae, 1.25% Gobidae, 0.70% for Siluridae and 0.56% for Amblycipidae.

Table 8: Station-wise Fish Composition (%) by Number of Species and Total Catch Number of Fishes in Tinau River

Sampling Station	Fish Composition by Total No. of Species (%)		Fish Composition by Total Catch Number (%)	
I	11	34.37	153	21.22
II	11	34.37	99	13.73
III	6	18.75	114	15.81
IV	6	18.75	67	9.29
V	21	65.66	288	39.95
Total	32	100	721	100

Table 9: Order-Wise Fish Species Composition in Tinau River

S.N	Order	No. of Fish Species	Species Composition %
1	Cypriniformes	22	68.75
2	Siluriformes	5	15.62
3	Perciformes	3	9.37
4	Synbranchiformes	2	6.25
Total		32	100

Table 10 Family-Wise Fish Species Composition in Tinau River

S.N	Family	No. of Fish Species	Species Composition %
1	Cyprinidae	17	53.12
2	Balitoridae	3	9.37
3	Cobitidae	2	6.25
4	Bagridae	2	6.25
5	Mastacembilidae	2	6.25
6	Others	6	18.75
Total		32	100

Table 11: Fish Composition (%) by Total Catch in Different Families of Fishes in Tinau River

S.N	Family	Total Caught No. of Fishes	Species Composition %
1	Cyprinidae	407	56.45
2	Balitoridae	73	10.13
3	Cobitidae	90	12.49
4	Bagridae	27	3.75
5	Mastacembilidae	13	9.71
6	Channidae	70	1.81
7	Heteropneustidae	13	1.81
8	Others	28	3.88
Total		721	100

Figure 2: Pie Chart Showing Order Wise Fish Species Composition in Tinau River

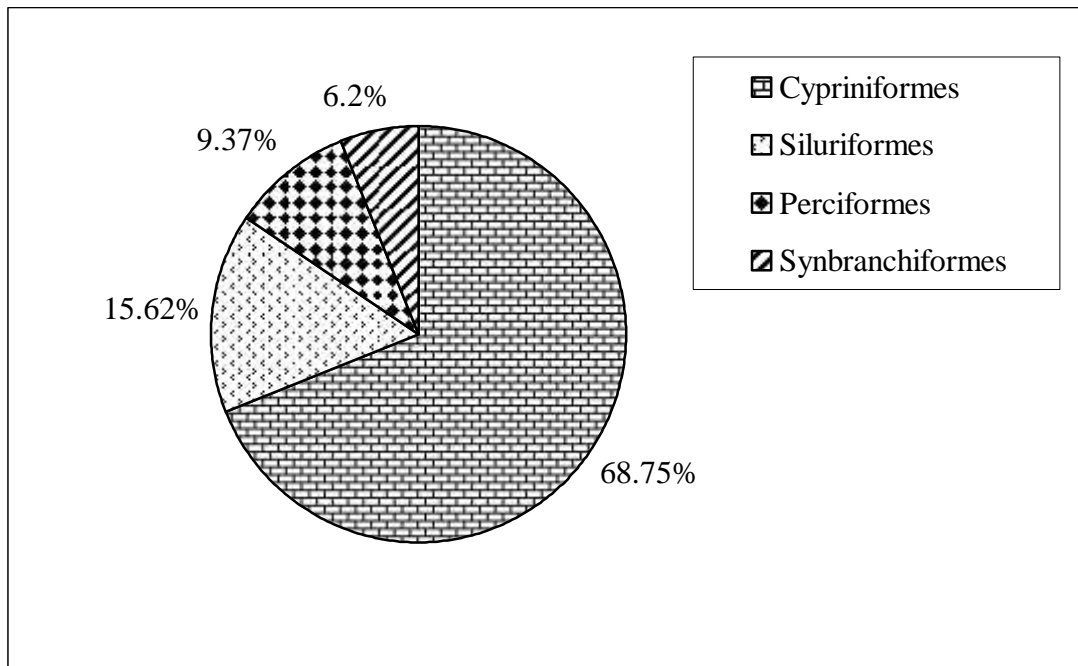


Figure 3: Pie-Chart Showing Family-Wise Fish Species Composition in Tinau River

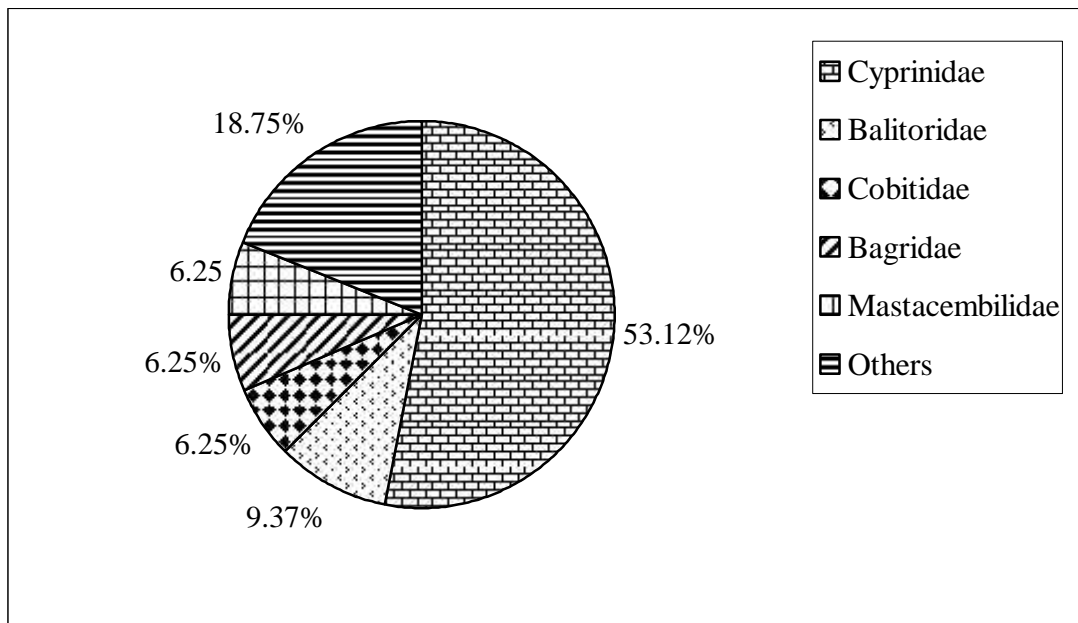
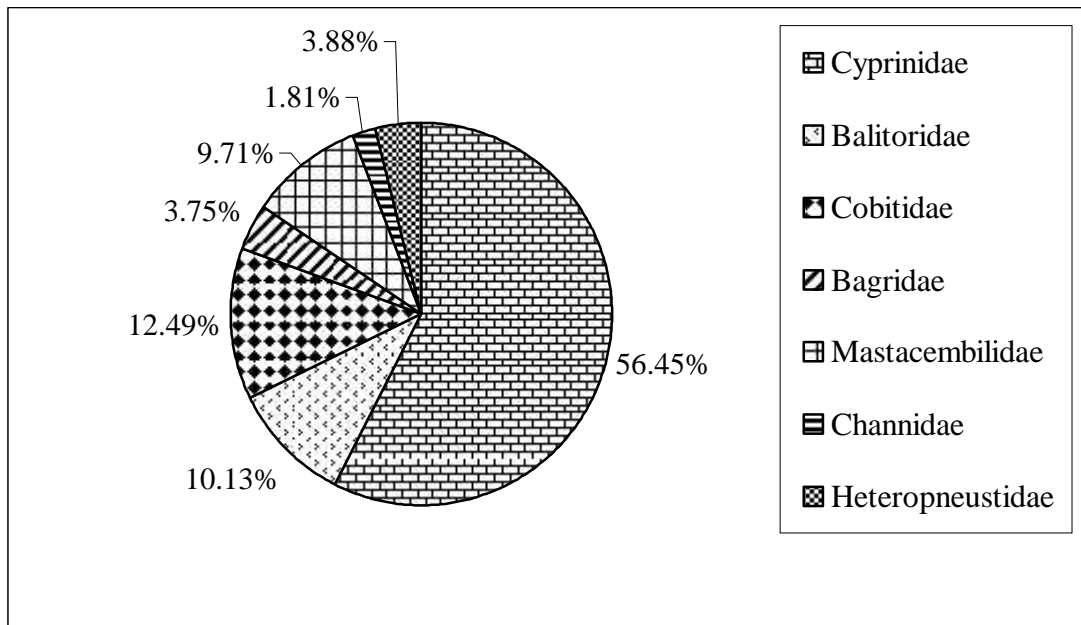


Figure 4: Pie Chart Showing Fish Composition (%) by Total Catch in Different Families of Fishes in Tinau River



4.2 Fishing Appliances and Methods Used in Tinau River

From the general survey on fishing appliances and techniques used in Tinau river, it was found that there are varied kinds of fishing appliances and methods are being used in fish catching by local fisher flock. Most of the methods used in Tinau river are seasonal.

All of the fishing practices can be divided into two groups, namely conventional and non-conventional fishing methods. Conventional fishing methods include almost all traditional fishing practices. In this method, fishing is done by using fishing gears like netting, hook and line, trapping devices etc., as well as without gear like fishing with hands. Recently developed fishing practices are called conventional fishing methods like use of explosive, use of chemical poison etc. Most of these fishing practices are destructive. Following methods were observed during the present study period.

4.2.1 Diversion of River Channel ('Duwalo Thunne')

This method was found occasionally used in Tinau river, for which the river is made dry, deflecting the flow of water to one of the either side from the main river bed by constructing rough dam made up of stone, sand and branches of the tree. At the distal end of diverted channel a bamboo fish trap ('Dhadiya' 'Doko' or 'Ghorlang' etc.) is set so as to trap the fishes escaped from main river. Then the fishes are caught with bare hands with the help of scoop nets.

But in the pools and rock crevices, some herbaceous poisons like leaves of 'Khirro' (*Sapium* sps.), bark of 'Kafal' (*Myrica esculanta*), stem of 'Siudi' (*Cactus* sps.) or chemical poisons like malathion and metacids are also used.

4.2.2 Use of Poisons

Use of poison is a non-conventional fishing practice used in small channels of Tinau river and its feeder streams. This method is known as 'Bish Halne'. The roots, barks or leaves of plants are crushed and mixed with sand and thrown into stagnant water body. Dose is calculated roughly according to the area of water body. The fishes are either killed or paralyzed by poisons. The poisoned fishes float on the water surface and are collected by hands or with the help of scoop net.

In table 14, some of the plants have been listed with their scientific names, which were found using as fish-poisons in Tinau river during the present study period.

Table 12: List of Plants Used as Fish Poisons.

S.N	Scientific Name	Local Name	Parts Used
1	<i>Sapium insignes</i>	'Khirro'	Leave
2	<i>Euphorbia royleana</i>	'Siudi'	Leave
3	<i>Arage americana</i>	'Ketuki'	Leave/shoot
4	<i>Madhuca indica</i>	'Mahuwa'	fruit
5	<i>Polygonum hudropiper</i>	'Pire sanewar'	Leave
6	<i>Buddleia asiatica</i>	'Bhimsen pati'	Leave/shoot

Beside plant poisons, the chemical poisons are also used for fishing in this area. The chemical was mixed with water in a bucket and used by spreading in all sides of pool area of water body. The commonly used chemical poisons are:

- a) Thiodine
- b) Malathion
- c) DDT (Dichloro Diphenyl Trichloroethane)
- d) BHC (Benzene Hexachloride)

4.2.3 Electro-Fishing

In this method, electricity is applied to catch fishes. The electric current is passed into the water body which kills most of the aquatic fauna. This method was found used by occasional fishermen. In this method, an electric field is created in water between two electrodes-anode and cathode. The fishes between these two electrodes get affected and paralyzed by a electric shock and later they are collected by nets or bare hands.

4.2.4 Fishing by Arrow ('Ban Hanne')

This method was found used in shallow and clear water bodies. It is made up of thin iron plate making a shape of arrow. This is used to kill 'Gadela' (*Schistura* sps.) and 'Hile' (*Channa* sps.).

4.2.5 Nets ('Jal')

A net is basically a piece of webbing in which the twins are intersected into regular meshes, given a certain form. In the past, nets were prepared by the local fishermen themselves from the fibers extracted from the thistle plant known as 'Allo' but now nylon threads are used for constructing nets. It has been observed that there were following types of nets implemented.

a) Cast Net

Cast net is a large type of net which is used to catch large and medium sized fish. It is known as 'Jal'. The mesh size is about 15-20mm. Along the circumference, pieces of iron are attached to make the net sinkable in water. A long rope is tied to the center of the net. While throwing the net, the fishermen keeps the rope in left hand and throws it with a jerk into water by right hand. It was found mostly used in stations-iii, iv and v.

b) 'Bhureli Jal'

It is similar to cast net in shape and texture but it has smaller meshes of size from 5 to 15mm. This practice is harmful as very small sized fishes or juvenile fishes are also collected destructing whole fishery resources.

c) Drag-Net

Drag net is rectangular in shape. This net is operated by two persons. It is generally used in monsoon period to catch *Puntius* sps., *Barilius* sps. and *Esomus danricus*.

e) 'Helka'

'Helka' is bag like structure supported by wooden frame having elliptical or half circle shape. It is mostly used in shallow stagnant water-bodies in Terai region. Generally, loaches are caught by this net.

f) Scoop-Net

This net was also found used in Terai region as an accessory tool to collect poisoned/paralyzed fishes. It is circular in structure with wooden frame. A single person can operate this net easily.

4.2.6 Fishing Rod ('Balchi- Hanne')

Fishing rods are locally known as 'Balchhi-Hanne'. It consists of three parts: hook, line and rod. Hook ('Balchhi') is prepared generally by the fishermen themselves from the rims of umbrella, but now a days, it is available readymade in the market. Fine nylon thread is tied at curved tip of the rod and a hook at the distal end of thread. Different types of baits are fixed to the hook. Generally, earthworms, insects, small fishes etc. were found used as baits in this river. This method is used to catch the fish like *Mustus* sps., *Wallago* sps. and *Channa* sps.

Besides these, Bamboo implements like 'Dhadiya', 'Khunga', 'Chhanchhruk' etc. Dynamiting and Rock- striking were also found used in Tinau river during the present study period.

4.3 Socioeconomic Status of Fishermen

A set of questionnaires was developed and administered to local inhabitants of villages located near Tinau river, such as Damkada, Charchare, Dovan, Butwal and Bethari to know the socioeconomic status of local fishermen. The information obtained were analyzed critically and the conclusions were made, which are described below.

Fishermen of Tinau river are locally known as 'Majhi' and 'Mallah', who are generally inhabiting the places near the bank of the river, which includes the castes 'Majhi', 'Tharu', 'Magar', 'Dunuwar', 'Darahi', 'Dhimal' etc. In Terai, they live by making their separate territories. Fishermen of Terai region were found dominated by the people of higher caste and they got a lot of social harassment from the other communities, and they are considered as the lower caste. Although, the fishermen of hilly region near Tinau river, where 'Magars' are mostly involved in fishing activities, were not found facing such social discriminations.

The fishermen community is poor and illiterate. About 70 percent of total fishermen of Tinau river were found illiterate, rest have their education up to ten class. 'Mallahas' are more illiterate than 'Majhis'. Fortunately, the trend has been changed. The fishermen have found started to send their children to the school. Now a days, about 80 percent of the children of fishermen go to school. Rest are not going to schools due to either financial constraints or involved in caring children younger than themselves as the majority of fishermen consist of large sized family, not less than six members. Daughters were found extensively exploited in house works. Most of them (56%) were found having no ideas about family planning. Majority of the fishermen have their family-sizes of 6-11 members.

The fishermen of Tinau river may be classified into three categories namely occasional fishermen, part time fishermen and full time fishermen. During the present study, 23% were found full time, 35% as part time and 42% as occasional fishermen. Most of the fishermen of station 'iii' and 'v' were found full time fishermen. They belong to 'Mallaha' and 'Majhi' castes.

Fishing activities continue throughout the year except the monsoon season, during which they are engaged in agriculture. Local fishermen make different types of fishing implements during their leisure period using local plant fibers and nylon. According to local fishermen, the best season for fishing is from March to July, for fishing good sized fishes. Full time fishermen capture 100 to 110 kg fishes annually. The fishermen who engaged partly in fishing activities capture 55-65 kg/year and occasional fishermen capture less than 15 kg annually. They sale 90% of total catch at local markets at the rate of Rs 80 – 120/kg. The monthly income of each is about Rs 2,000 to 3,000 depending upon fishing season. The rest catch is either consumed by family or dried for future use. They also sale the dried or preserved fishes at the rate of Rs 200/ kg.

Although the main job of fishermen was found fish catching, they don't depend for their livelihood solely on the fish catch, but they also have some their own land (average of 0.26 ha per family), where they cultivate to grow agricultural products. 23% of fishermen told that many of their household problems were being fulfilled by fishing. During off-seasons, some fishermen work as labour also. The females are engaged in household affairs, preparing bamboo basket implements, collection of firewood' making dung cakes, cleaning houses, caring children etc.

Local fishermen themselves make different types of fishing implements, especially during leisure periods with the help of locally available plant fibers, bamboo and nylon strings.

During the study period, it was found that there was no fixed market. Fishes were generally sold to meat and vegetable shops. Fishermen sold fishes by wandering from one to another place. They use bag, sack and wicker basket to carry fishes by themselves. But, it had been also noticed that there were some fish shops and fish markets in Butwal and Bhairahawa.

4.4 Major Hazards for Fish Life in Tinau River

The Tinau river support at least 32 species of biologically diverse ichthyofauna with predominance of family Cyprinidae. During the present of study, some serious problems were observed in this river regarding fish conservation and management. Some of the major problems have been identified responsible for the declination of fish population in Tinau River.

4.4.1 Environmental Problem

A large number of environmental factors such as deforestation, land slide, soil erosion, flood, silt deposition and chemical pollution due to discharge of industrial wastes have changed the natural environment of the Tinau river. Thus the natural habitats have been destroying in this river.

a) Pollution

The municipal sewage and industrial wastes were found directly discharged into this river, particularly in Butwal area (sampling station

iv). Increasingly utilization of chemical pesticides like Aldrin, Thiodine, BHC and Malathion in the sloppy agricultural lands of Palpa district and lateral side- fields in Terai region might be another potential hazard for the declination ichthyofauna in Tinau river.

b) Landslide and Flood

Siddhababa area near the station iv (Butwal) is known as the prone area for land slide in the way of Tinau river. Beside this, there are large number of areas in the hilly region at both lateral sides of Tinau, which are found flowing down every year into the river. The Siddhartha highway lies on one side of this river almost all the way from Damkada (Station i) to Butwal (station iv). Road construction along the side of river is also a main factor of landslide and siltation of river.

The villagers are converting the forests and steep slopes along the river side into the agricultural land. Such deforestation resulted a heavy soil erosion during monsoon season, which effects river ecology and fishes indirectly, as their breeding and nursery ground is being destroyed.

Similarly, flooding due to blockage of the way of river flow due to landslide or flood due to heavy rainfall is another important factor which effects river ecology. Flooding destroys not only the nursery and breeding ground, it also destroys the feeding substances in the substratum.

4.4.2 Use of Destructive Fishing Methods

In Tinau river, some of the fishermen were found operating destructive fishing methods like stream poisoning in diverted river channel and its tributaries and dynamiting in pools. Such activities effect whole aquatic ecosystem. These types of fishing methods killed all types

and sizes of fishes and other aquatic organisms and also destroy the breeding habitats of the fishes.

4.4.3 Lack of Awareness

Lack of awareness about the importance of riverine fishery resources and ecology is another major problem in conservation and management of it. Uneducated fishermen are not aware of the long time impacts of destructive nature of fishing like bombing, poisoning, diversion of channel, irrational fishing viz. by using net with very small mesh sizes, fishing on breeding season, fishing of some endangered species etc. During the study period, the fishermen were found surprised and puzzled on hearing the legal provisions of aquatic life conservation act.

4.4.4 Effect of Hydro-Dam

The hydro-dam of Tinau river is located at Dovan, about 4km away from Butwal, which was constructed for the production of hydro electricity of 1000 kilowatt in 2022 B.S. by Butwal Power Company. It was hand overed to Nepal Electricity Authority in 2037 B.S. There is single iron gate especially used to direct the flow of water towards the turbine through tunnel. The power house is located near the Siddhababa temple, which is approximately 1 km away from the dam.

The effect of dam in Tinau river is more pronounced and has affected the abundance and distribution of fish population in the river. The dam in this river has obstructed the seasonal migratory fishes ascending from the Terai as well as local migratory fishes descending from the lower parts of hilly region. According to local people and fishermen, before the establishment of dam in the river, schools of

'Gonch' (*Bagarius* spp.), 'Raja Bam' (*Angrilla bengalensis*) and 'Jalka poor' (*Clupeisoma garua*) used to visit the upstream area above the dam frequently but now they are not seen such. Before 7-8 years ago, 'Sahar' (*Tor* spp.) was caught above 5-6 kg in weight. Unfortunately, it was not found during the present study period. According to local fishermen, it is found occasionally only in very small size (up to 200-250gm) in monsoon season.

The dam is generally disadvantageous to current loving and migratory fishes and also has reduced the surface area of fishing water to downstream. At the place of dam, the course of river channel has been diverted towards the west bank of river where the tunnel have been made and there is absence of reservoir. The dam is not provided with fish ladder and other by pass facilities to enhance upstream migration of fishes. Many migratory fishes can not cross the physical barrier of the dam hence their upstream migration have been blocked. Hence, dam created great problem to current loving and migratory fishes.

The fishes which inhabit downstream are not affected but have got a good hydro biological conditions, such as 'Gadela' (*Schistura* spp.). 'Fageta' (*Barilius* spp.) and 'Sidre' (*Puntius* spp.). They are found increased rapidly due to the absence of large predatory fishes. As a result, abundance of large sized migratory fishes have been replaced by small fishes and played negative role in fishing occupation.

Environmental Impact assessment (EIA) of this project before establishment of hydro dam was not conducted. Only engineering feasibility study was performed. The comparative study on fish diversity before and after dam couldn't be performed due to lack of detail information about fishes before dam construction, as this should be

included in environmental impact assessment (EIA), if conducted. There is no doubt that the Tinau river system has undergone many changes in structure and function of natural water courses as well as its physical, chemical and biological characteristics.

4.5 Water Quality Analysis of Tinau River

4.5.1 Physical Parameters

4.5.1.1 Water Temperature

The temperature of water plays an important role in the distribution of flora and fauna in the river. Table 15 explains the conditions of surface water temperature at all sampling stations in the Tinau river. The surface temperature was recorded to be the lowest as 19.5⁰C in December at the stations iv) Butwal. The highest surface water temperature recorded was 29⁰C at station v) Bethari. The average temperature for all sites was 25.30⁰C.

4.5.1.2 Water Velocity

The water velocity is one of the important factors for determining the form and distribution pattern of fish fauna. It was found in the range of 0.36 m/s to 1.65 m/s. The highest velocity was recorded at station ii)- Charchare (1.65 m/s) in the month of August, where as the lowest was recorded as 0.36 at station v)- Bethari. The average velocity of this river was found to be 1.07m/s. (Table 15).

4.5.1.3 Transparency

The transparency of the river water remained high throughout the study period, except monsoon. In the monsoon, the transparency decreased to minimum level at all five stations. The lowest transparency value was recorded as 65cm at station v)- Bethari in July. The highest value recorded was 78 cm at station i)- Bethari in the month of March (Table 14).

Table 13: Water Quality Analysis of Tinau River

S.N.	Parameter	Unit	August					December					March					Average ($\phi X/N$)
			I	II	III	IV	V	I	II	III	IV	V	I	II	III	IV	V	
1	Temperature	^o C	28.0	28.5	28.0	28.5	28.5	21.0	20.5	22.0	22.0	23.5	26.5	26.5	26.0	27.0	29.0	25.30
2	Water velocity	m/s	0.68	1.65	1.60	1.50	0.46	0.40	1.35	1.35	1.30	0.32	0.51	1.50	1.55	1.62	0.36	1.07
3	Transparency	cm	74.0	77.0	75.0	76.0	72.0	75.0	77.0	75.0	73.0	67.0	78.0	76.0	72.0	70.0	65.0	73.46
4	pH	-	8.2	8.4	8.2	8.4	8.3	8.2	8.3	8.3	8.3	8.4	8.4	8.2	8.2	8.3	8.3	8.3
5	Dissolved O ₂	mg/l	8.10	8.51	8.10	8.92	7.70	7.29	7.29	7.70	7.29	6.49	6.89	4.49	6.08	6.89	6.08	7.18
6	Free CO ₂	mg/l	8.00	9.00	7.99	7.99	7.99	9.99	7.99	7.99	8.99	8.99	7.99	7.99	9.99	7.99	10.00	9.05
2	Total Alkalinity	mg/l	30.03	28.02	26.06	26.06	34.03	30.03	34.03	34.03	36.03	50.05	30.03	28.02	30.03	26.02	36.03	31.90
8	Total Hardness	mg/l	102	107	123	102	109	162	164	166	158	200	150	154	178	174	202	150

4.5.2 Chemical Parameters

4.5.2.1 Hydrogen Ion Concentration (pH)

The pH of water at all five stations was found alkaline throughout the study period. The highest value recorded was 8.4 and lowest value 8.2. The pH value fluctuated through out the study period in all the sampling stations, but the variation range was 0.6 (Table 15).

4.5.2.2 Dissolved Oxygen (DO)

The range of dissolved oxygen concentration of Tinau river was 4.49 mg/l at station ii)- Charchare in the month of March to 8.92 mg/l at station iv)- Butwal in the month of August. The overall dissolved oxygen value was 7.18 mg/l (Table 15).

4.5.2.3 Free Carbon Dioxide

The free carbon dioxide in the water of Tinau varied from 7.99 mg/l to 11.99mg/l. The highest value was recorded as 10.00 mg/l at the sampling station v)- Bethari during the months of March. The lowest value recorded was 7.99 mg/l at different stations many times. Average value was 9.05 mg/l.

4.5.2.4 Total Alkalinity

Total alkalinity of water body depends upon the location, season, plankton population and the nature of bottom substratum or bottom deposits. The total alkalinity of this river was found in the range of 26.02 mg/l to 50.05 mg/l. The maximum value was recorded at station v)- Bethari and the minimum at station iv)- Butwal. The average total alkalinity was found to be 31.90mg/l (Table15).

Usually, natural water resources of Nepal contain more than 100mg/l of the total hardness (Lind 1974 cited by Karna 1993). During the present investigation period, the highest value of total hardness was found 200 mg/l in March at the station v)- Bethari. The lowest recorded value was 54 mg/l at stations i) and iv) in August (Table15).

4.5.3 Analysis of Biological Parameters

Planktons include the free floating minute plants and animals that have very feeble locomotary organs and simply drift with water current. They are of two types namely phytoplanktons and zooplanktons.

4.5.3.1 Phytoplanktons

The phytoplanktons are the primary producers in the river ecosystem, which usually include chlorophyll bearing organisms and are responsible for photosynthesis.

During the present study, a total of 16 species of phytoplanktons under 10 families and 14 genera were recorded. The dominate species found during the study period were *Spirogyra* sps. and *Synedra* sps. (Table 16)

4.5.3.2 Zooplanktons

The zooplanktons are the minute animals, which form the secondary trophic level in the aquatic ecosystem. The zooplanktons feed on phytoplanktons and which in turn are feed by the consumers of higher trophic level like larvae of fishes and fishes etc.

During the present study period, very few zooplanktons were recorded, which are related to the groups like Rotifera, Cladocera and Copepoda (Table 16)

Table 14: Occurrence and Distribution Pattern of Planktons in Tinau River

S.N.	Family	Name of Plankton	Sampling sites				
			I	II	III	IV	V
A	Phytoplanktons						
1	Ulotrichaceae	<i>Urothrix</i> sps.	-	+	-	+	+
2	Zygnemataceae	<i>Spirogyra rhisobrancalis</i>	+	+	+	+	+
		<i>S. singularis</i>	-	+	-	+	-
3	Desmidiaceae	<i>Closterium</i> sps.	+	-	-	-	-
		<i>Cosmarium</i> sps.	-	+	-	+	-
4	Gloeodiniaceae	<i>Gloeodium</i> sps.	+	-	-	-	-
5	Coscinodiscaceae	<i>Melosira</i> sps.	-	+	-	+	-
6	Fragilariaceae	<i>Fragilaria</i> sps.	+	+	+	+	+
		<i>Synedra</i> sps.	+	+	+	+	-
7	Naviculaceae	<i>Gyrosigma</i> sps.	+	-	-	-	-
		<i>Naricula</i> sps.	-	+	-	-	-
		<i>Caloneis</i> sps.	-	-	-	+	-
8	Cymbellaceae	<i>Cymbella sistula</i>	+	+	+	+	-
		<i>Cymbella tumida</i>	+	+	+	+	+
9	Nitzschiaceae	<i>Bacillaria</i> sps.	+	+	+	+	-
10	Surirelaceae	<i>Surirella</i> sps.	-	-	-	+	-
B.	Zooplanktons						
11	Copepoda	<i>Cyclops</i> sps.	+	-	+	+	-
12	Cladocera	<i>Daphnia</i> sps.	+	+	+	+	-
13	Ostracoda	<i>Cypris</i> sps.	+	-	-	+	+

+= Present, - = Absent

4.6 Major Ichthyofauna and Their Statistical Analysis

The family Cyprinidae alone formed 56.45 % of the total number of collected fish fauna. Four families viz. Cyprinidae, Cobitidae, Balitoridae and Channidae formed 88.78 % of the total caught number, while rest of the families viz. Bagridae, Mastacembilidae, Heteropneustidae etc formed 11.22 %. The statistical analyses for the coefficient of co-relation between different physico-chemical parameters with number of fish species collected from each station was obtained by using Karl Pearson's Correlation Coefficient. Probability error for each coefficient was also calculated for different sampling sites.

The Correlation Co-efficient value between altitude and fish species diversity was found to be highly negative (-0.29). Similarly, total number of fishes (abundance) was also found negative with altitude. Correlation co-efficient value between fish diversity and free Carbondioxide was also found slightly negative (-0.16). Correlation coefficient between fish diversity and water velocity was found negative (-0.69). Total hardness also showed negative correlation with fish diversity (-0.50). On the other hand, positive correlation was found between fish diversity and parameters of water like total alkalinity, pH and dissolved oxygen (DO) viz. 0.71, 0.37 and 0.38 respectively (Table 18).

Table 15: Fishery Resources and Physicochemical Parameters of Tinau River

Site	Fish Abundance (Total No. of Fishes 'x ₁ ')	Fish Diversity (Total No. of Species 'x ₂ ')	Average Temperature (°C) 'y ₁ '	Average velocity (m/s) 'y ₂ '	Average Transparency (m)' y ₃ '	Average pH 'y ₄ '	Average Dissolved Oxygen (mg/l) 'y ₅ '	Average Free CO ₂ (mg/l) 'y ₆ '	Average Total Alkalinity (mg/l) 'y ₇ '	Average Total Hardness (mg/l) 'y ₈ '	Altitude (m) 'y ₉ '
I	153	7.00	25.16	0.53	75.66	8.26	7.42	9.32	30.03	138.00	684
II	99	4.33	25.16	1.50	76.66	8.30	6.76	8.65	30.02	141.656	574
III	144	5.00	25.33	1.50	74.00	8.23	7.30	8.99	30.04	155.66	250
IV	67	4.00	25.84	1.47	73.00	8.33	7.70	8.65	29.37	144.66	188
V	288	11.00	27.00	0.38	68.00	7.33	6.7	9.99	40.02	170.33	107
Total	721	31.33	128.49	5.38	367.32	41.45	35.93	45.6	159.48	750.31	1803

Table 16: Correlation Between Some Physicochemical Parameters and Fish Diversity of Tinau River

S.N.	Variants	Correlation Coefficient (r)	Probability Error (P. E.(r))
1	Water Temperature vs. Number of Fish Collected	0.62	0.18
2	Water Temperature vs. Species Diversity of Fishes	0.59	0.19
3	Water Velocity vs. Species Diversity of Fishes	-0.69	0.19
4	Transparency vs. Species Diversity of Fishes	-0.59	0.19
5	pH of Water vs. Species Diversity of Fishes	0.37	0.26
6	Dissolved Oxygen vs. Species Diversity of Fishes	0.38	0.28
7	Free CO ₂ vs. Species Diversity of Fishes	-0.16	0.01
8	Total Alkalinity vs. Species Diversity of Fishes	0.71	0.14
9	Total Hardness vs. Species Diversity of Fishes	-0.50	0.22
10	Altitude vs. Species Diversity of Fishes	-0.29	0.19

Note: 'r' = Correlation Coefficient, 'P. Er.' = Probability Error

CHAPTER - V

DISCUSSION

A river and its watershed are normally considered as being physically, chemically and biologically a single system. Within the running surface water of any such system, however considerable difference can occur in water velocity, volume, depth and river bed materials. All of these parameters give river system a wide and diverse range of habitats for fishes. The factors of ecological significance which exhibit a progressive change in value along the length of rivers are current velocity, substratum, temperature, dissolved oxygen, hardness and organisms. The interaction between them creates favourable or unfavourable circumstances for the growth and development of the ichthyofauna.

5.1 Distribution of Fish Fauna in Tinau River

A total of 184 indigenous fish-species have been reported to exist in river systems and other natural and man-made water bodies of Nepal (Shrestha, 2001/ '03). Shrestha (2004), has reported eight fish species from the Tinau river belonging to the families Cyprinidae, Cobitidae and Amblycepidae, which are *Barilius bola*, *Danio devario*, *Garra annandalei*, *Grra gotyla*, *Tor putitora*, *Acanthocobitis botia*, *Schistura (Noemacheilus) rupicola* and *Amlyceps mangois*. Among them, *Amblyceps mangois*, *Grra gotyla*, *Garra annandalei* *Acanthocobitis botia*, *Schistura rupicola* were found, but *Bola* sps., *T. putitora* and *Danio devario* were not observed in the present study period.

According to local fishermen, *Bagarius yarelli* ('Gonch') which is reportedly largest fish of Nepal and *Tor* sps. were abundant in this river

before the construction of hydro dam. After the construction of dam, they are not reportedly found in upstream of hydro-dam (above station 'iii'), but these species were occasionally observed by local fishermen at the stations 'iv' and 'v' below the dam during the monsoon seasons of recent years. They also gave the information about the existence of *Schizothorax* sps. and *Schizothoraichthys* sps.

Most of the fish species in Tinau river fall under the family Cyprinidae, which consists 53.12% of total species composition. Of which, sub family Cyprininae comprises 8, Rasborinae 7 and Garrinae 2 species.

Family Balitoridae consists 6.25% by species composition. Similarly, 6.25% in each of Cobitidae, Bagridae and Mastacembilidae and other all constitute 5.62%.

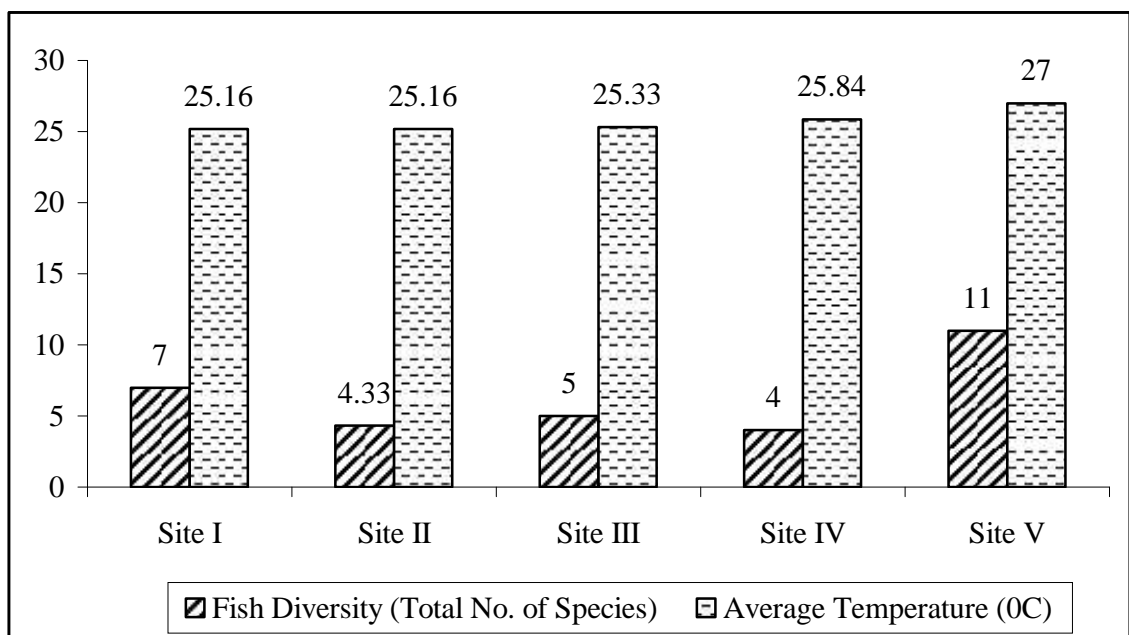
About 14.72% of the total catch composition was constituted by *Puntius conchoniis*, 9.06% by *Lepidocephalus guntea*, 8.61% by *Puntius sophore* and 7.93% by *Channa punctatus*. 11 species of fishes were collected from each of station i) and ii), 6 species from station iii) and iv). The largest number viz. 21 species of fishes were collected from station v). The present study revealed that the diversity of fish species decreases over the upstream in hilly region and increases over the downstream of Tinau river in Terai region. It might be due to increased temperature in lower region which increases the distribution of phytoplanktons, as a result dissolved oxygen gets increased.

5.2 Effects of Physiochemical Parameters on Fishes

The physical quantities of the environment in many respects appear to be basically more important than the chemical ones in governing the

distribution of fishes (Hynes, 1970). It is well defined that all aquatic organisms including fishes have limited temperature tolerance. Temperature has importance on the physical and physiological activities of fishes, affecting growth rate and reproduction. The optimum temperature for warm water fishes ranges from 20 to 30⁰C, where as for cold-water fishes is 10 to 20⁰C (Boyd, 1980 cited in Matsya Palan Series-9). The temperature of Tinau river ranges from 15 - 29⁰C. This range of temperature is favourable for majority of fish species. The correlation of coefficient between water temperature and fish population of Tinau river is positive. This explains the increment of fish population with increase in water temperature up to a certain limit.

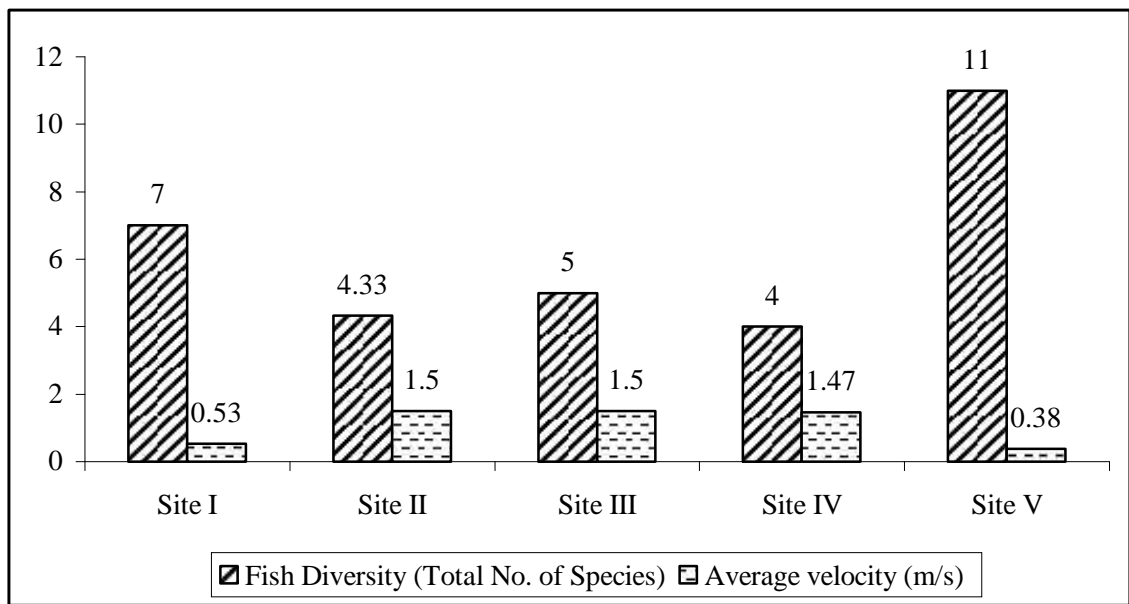
Figure 5: Bar Diagram Showing Relationship Between Water Temperature and Fish Diversity



The water velocity plays a major role in the determination of the habitat and abundance of flora and fauna in a river by grading the river bed materials and maintenance of high levels of dissolved oxygen (Whitton, 1975). In Tinau river, the velocity of water found having

positive correlation with dissolved oxygen, which explains the increment of dissolved oxygen with the increase of water velocity. But, the correlation coefficient was found negative (-0.69) between velocity of water and fish diversity.

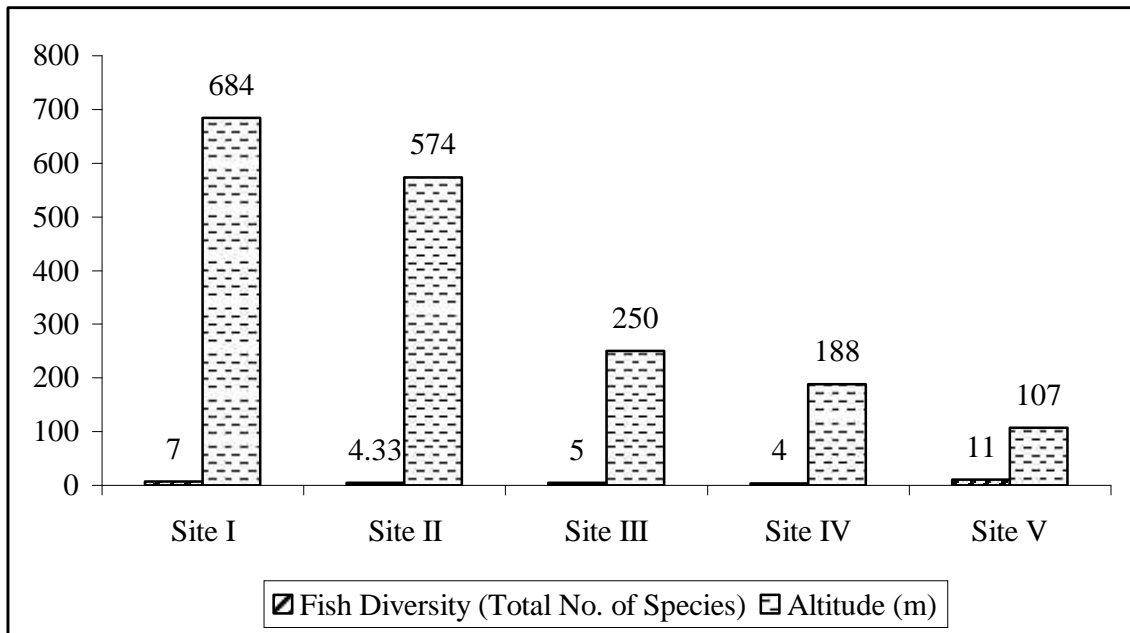
Figure 6: Bar Diagram Showing Relationship Between Water Velocity and Fish Diversity.



The water velocity is mainly regulated by the slope gradient of the river bed which is highest at the station iii), where torrential hill stream fishes like *Garra gotyla*, *Garra annandaeli* etc were reported.

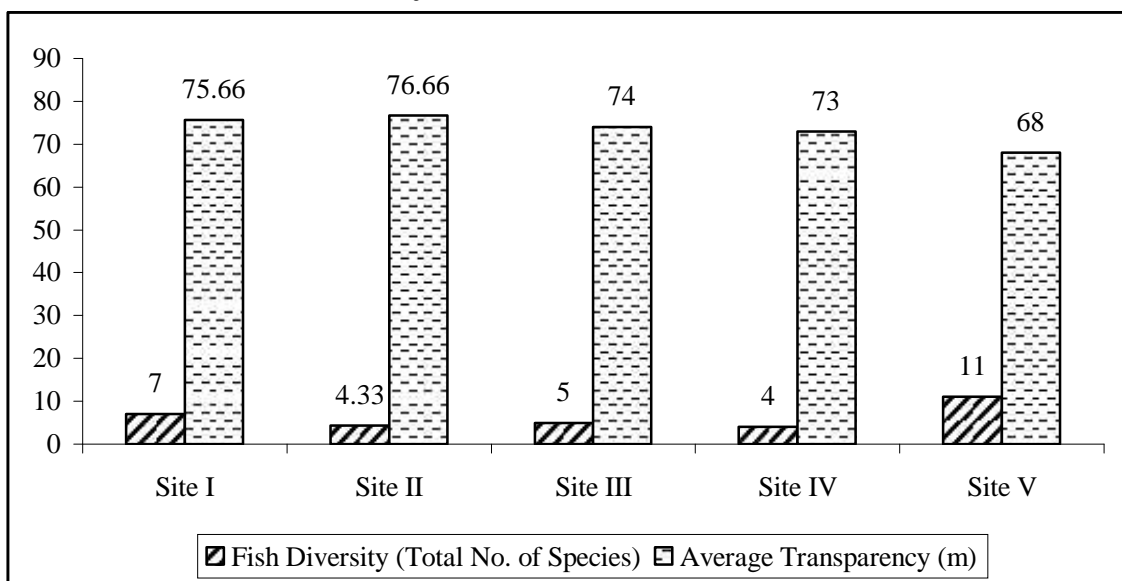
The current velocity of water in Tinau river was not found uniform. Stations ii), iii) and iv) found having higher velocities in comparison to the stations iv) and v). This is due to slope gradient of river bed, which is higher at the stations ii), iii) and iv) than stations i) and v). In the present investigation, low velocities in stations i) and v) may be due to the maximum flatness as well as minimum slope gradient of the river bed.

Figure 7: Bar Diagram Showing Relationship Between Free CO₂ and Fish Diversity



The slope gradient is maintained by the altitudinal variations in river bed and the altitude has negative correlation with composition of fish fauna in the Tinau river i.e. composition of fish fauna increases with the decrease of altitudinal range and the correlation coefficient between them was found negative (-0.29).

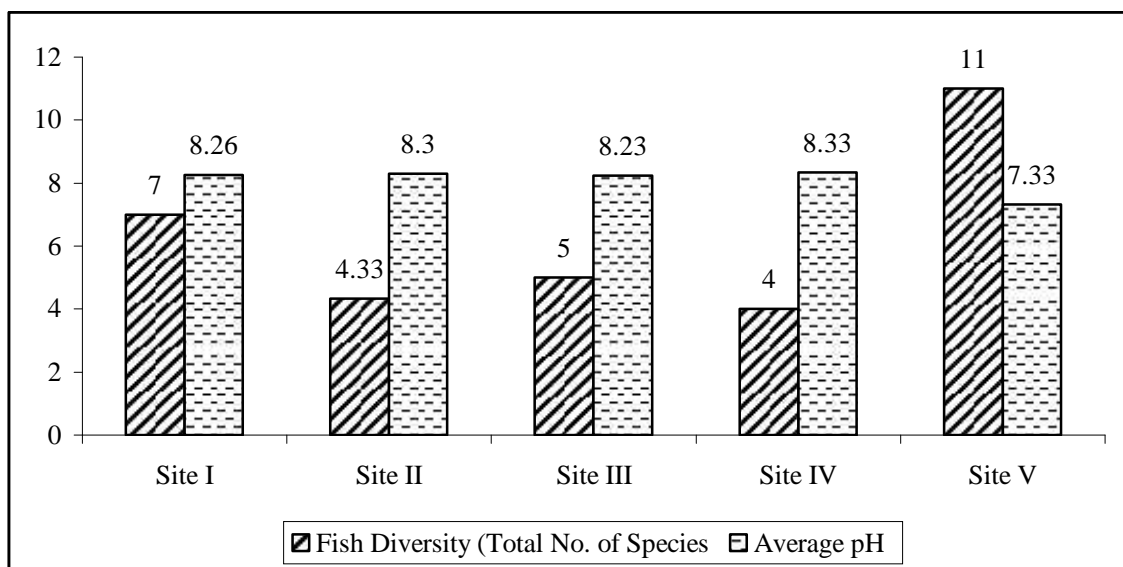
Figure 8: Bar Diagram Showing Relationship Between Transparency of water and Fish Diversity



Transparency that directly or indirectly determines the productivity of the river by controlling the penetration of solar radiation, seems to be one of the major physical parameters. During the present investigation period, the river water remained highly transparent throughout the year except in monsoon. This temporary decrease in transparency value in monsoon was caused by the rainfall and flood. The transparency shows negative correlation (-0.59) with the species diversity of fishes in Tinau river. This might be due to productivity of water mass in Terai region due to decrease in water current.

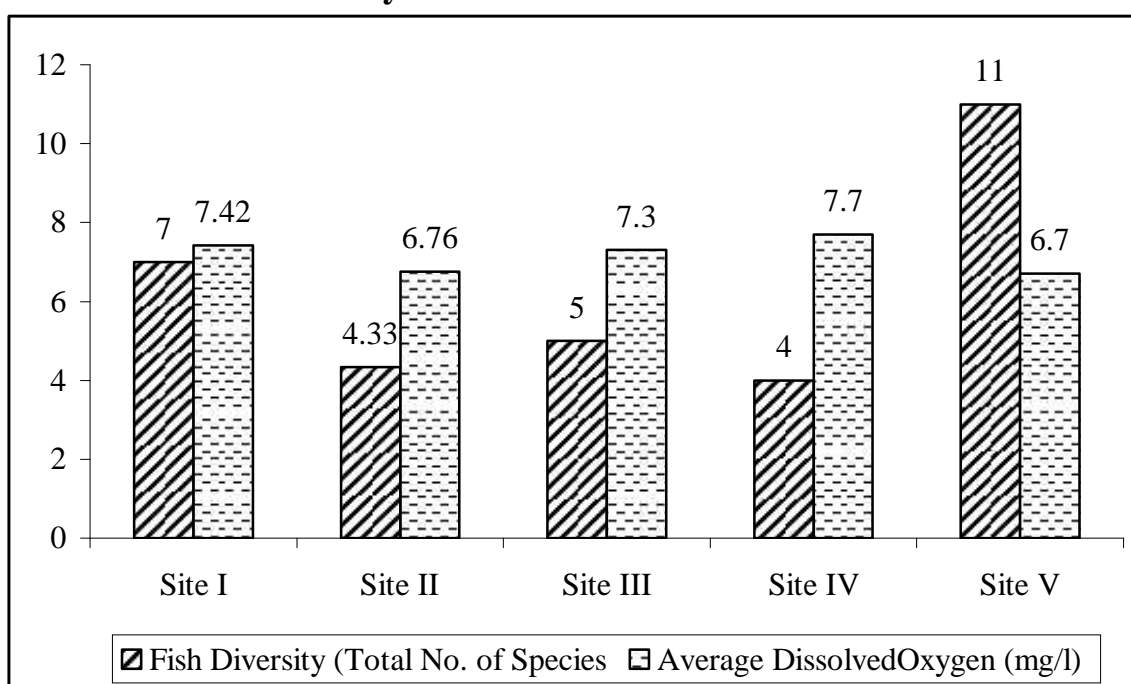
According to Jhingran (1975), the turbidity of natural water system may be due to the suspended inorganic substances, such as silt and clay or due to planktonic organisms. In the present study, turbidity was found maximum in the month of August at all five sampling stations. It was mainly due to mixing of sand and clay particles resulting from soil erosion and rainfall during monsoon.

Figure 9: Bar Diagram Showing Relationship Between pH of Water and Fish Diversity



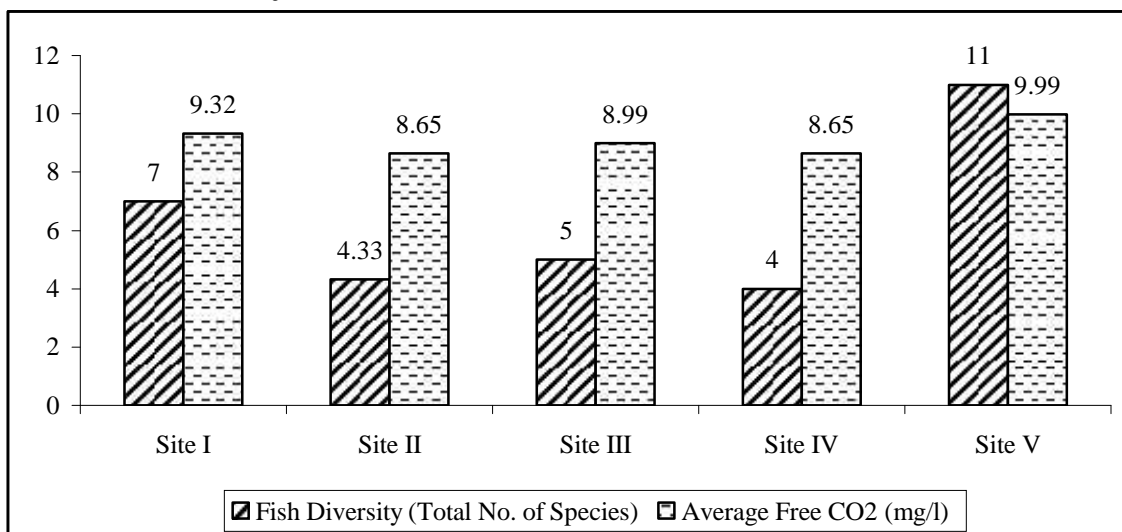
In the Tinau river, the pH value was found fluctuated with a narrow range of 0.2. The average value was 8.3. Under most natural conditions, variation in pH value has little effect on fishes, which can tolerate the normal pH range. There was found slightly positive correlation (0.37) between the pH value of riverine water and fish species composition (diversity) in Tinau river.

Figure 10: Bar Diagram Showing Relationship Between DO of Water and Fish Diversity



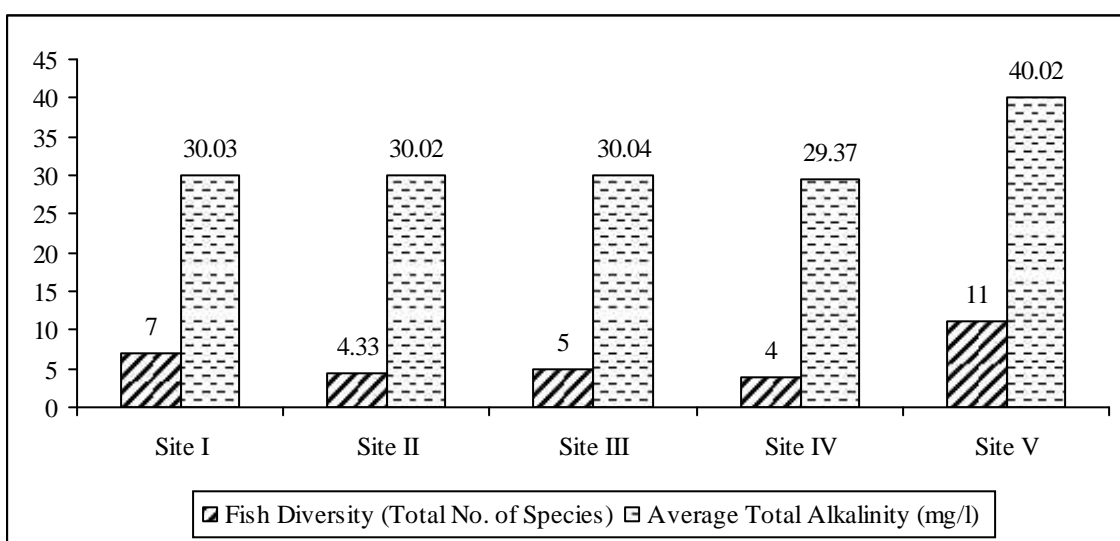
The concentration of dissolved oxygen (DO) is the most important chemical quality, which affects the distribution of fishes. According to APHA (1976), the dissolved oxygen concentration above 5mg/l is suitable for the support of diverse biota. The dissolved oxygen of Tinau river during the study period was found in the range of 4.49 mg/l to 8.92 mg/l, hence it may be considered good for fish habitat. The dissolved oxygen of Tinau river shows the positive correlation (0.38) with the diversity of fishes i.e. fish diversity increases with the increase of dissolved oxygen in this river.

Figure 11: Bar Diagram Showing Relationship Between Free CO₂ and Fish Diversity



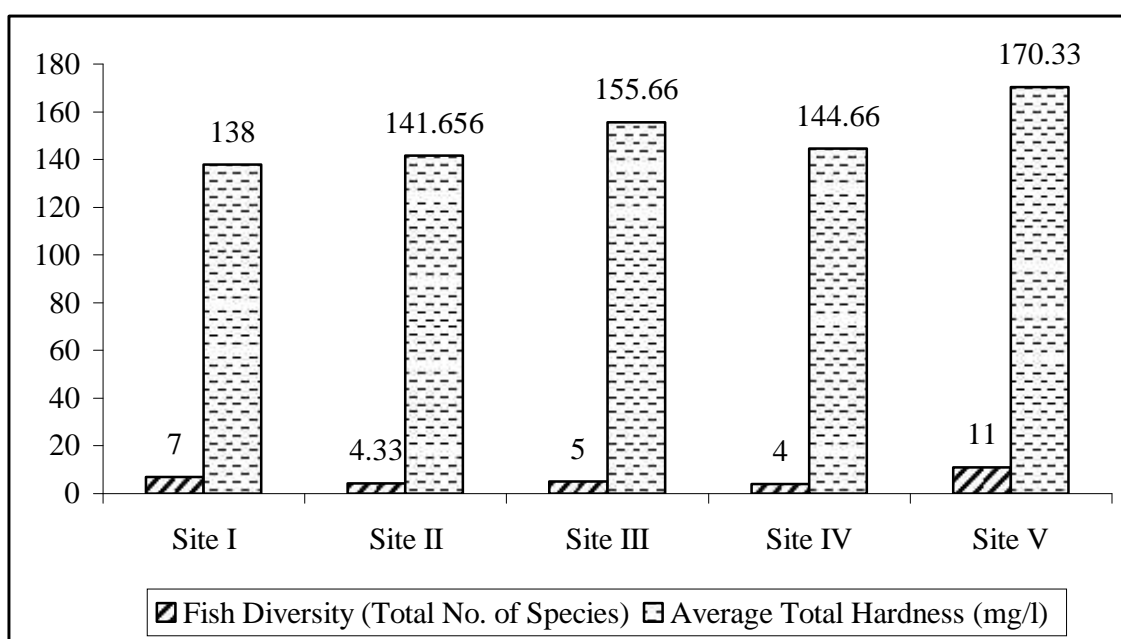
During the present study period, total alkalinity of water sample was recorded 50.05 mg/l as maximum at sampling station v) during the month of December and 26.02 at sampling station iv) during the month of March. Jhingran (1975), suggested about the fluctuation in total alkalinity of natural water bodies, stating that the hill streams, sandy and rocky areas, flooded rivers in the rainy season usually have low total alkalinity.

Figure 12: Bar diagram Showing Relationship Between Total Alkalinity and Fish Diversity



Sum of the concentration of alkaline earth metals cations (eg. Ca^{++} , Mg^{++}) form the total hardness in natural waters. Lind (1974, cited in Karna, 1993) reported that hardness more than 100 mg/l of $CaCO_3$ is common in Nepal. During the present study, the total hardness ranged in between 102-202 mg/l, which is favourable for riverine fishes.

Figure 13: Bar Diagram Showing Relationship Between Total Hardness and Fish Diversity.



The free Carbon dioxide of water in Tinau river was recorded in between 7.99-10.00 mg/l with an average of 9.05 mg/l. Most of the CO_2 in water comes from the decomposition of organic matters and respiration of organisms which help in the formation of bicarbonates and carbonates and checked the fluctuation of pH. Variation of free CO_2 value in Tinau river showed negative correlation with abundance of fishes (-0.16), which explains the negative effect of free CO_2 in water.

Few planktons could be reported from Tinau. Among which, *Spirogyra* sps. was abundant as the phytoplankton and *Cyclops*, *Daphnia*

sps. and *Cypris* sps. as the zooplanktons. These were main foods of the fishes in this river.

5.3 Socioeconomic Status of Fishercommunity in Tinau

Fishermen of Tinau river are poor and are dominated by the people of higher caste. About 70 percent are illiterate. They are locally known as 'Majhi' and 'Mallah'. About 23 percent of fishermen are full timer and professional. They are not found aware of school education and family planning systems, so have huge sized families. This might be one of the potential causes of their poverty. Very few among them are part time fishermen have agricultural land, which is also in sufficient for their livelihood.

5.1.3 Effect of Hydro-Dam

After construction of hydro-dam in Tinau river, it has under gone many changes, which in turn affected the distribution pattern of fish fauna. During present study period, the fishes reported from just upstream of dam in station iii) are *Barilius barna*, *B. bendelisis*, *Lepidocephalus guntea*, *Garra gotyla*, *G. annandali*, *Acanthocobitis botia*, *Schistura beavani*, *Puntius conchoni*, *Puntius ticto*. While fish fauna reported from down stream of dam (station iv) are *Puntius sophore*, *Puntius conchoni*, *Barilius bendelisis*, *Barilius barila* and *Lepidocephalus guntea*. The migratory fishes (both local and long migrants) were found affected due to dam construction. Present study also revealed that good sized fish species like *Tor* sps., *Bagarius* sps., *Labeo* sps., *Cirrhinus* sps. etc have been replaced by small sized fishes like *Puntius* sps., *Lepidocephalus* sps. *Barilius* sps. etc, which has severe negative impact on riverine fisheries.

CHAPTER - VI

SUMMARY

The present study entitled "Study on Fish Diversity and Fishery Resources of the Tinau river" was conducted for a period of about 8 months, from July 2002 to March 2007 to cover different four seasons. This study has dealt with the fish fauna, fish abundance, some physio-chemical parameters of the riverine water and their relation with fish species diversity and abundance of fishes. Study was focused on socio-economic status of fisher community, management consideration of river and the fishing appliances and methods used in this river and its tributaries.

The present investigation is divided into eight chapters. The first chapter deals with the introduction providing general information about water resources and status of fish and fisheries in Nepal along with the description of study area. The justification of the study, limitation of the study and objectives of the study have been also given in the same chapter under the plan of study. A review of literature is given in chapter two.

Chapter three deals with the details of the methodology used to meet aims and objectives of the present investigation. The primary data were based on the direct field observation, interviews with fishermen and local people. The secondary information were collected from different reports, journals, research papers, magazines and books. Five different sampling stations were selected for the collection of water samples and fish species. For the analysis of water quality, physico-chemical as well as biological parameters were analyzed.

The fourth chapter deals with the observation / result. The physico-chemical as well as biological parameters seem to be an ideal environment for fishes in Tinau river. The water of Tinau river was found saturated with sufficient amount of dissolved oxygen and total hardness.

A total of 32 species of fish-fauna were collected from different sampling stations of Tinau river which belong to 4 orders, 11 families, 24 genera. Among the total collection, 17 species were related to the family cypriniformes. Fishes were not found uniformly distributed in Tinau river. The physicochemical parameters of riverine water were also found varied as moving from upstream in the hilly region to down stream in the Terai region. The distribution pattern of ichthyofauna were found directly or indirectly influenced by these parameters.

Among the species collected, *Barilius* sps., *Channa* sps., *Schistura* sps., *Puntius* sps. and *Lepodocephalus* sps. were found most common. *Puntius ticto*, *Brachydanio rerio* and *Neolissocheilus hexagonolepis* were found as the rare species. Among the ten species recommended for legal protection by NRDP, three species namely *Neolissocheilus hexagonolepis*, *Chagunius chagunio* and *Brachydanio rerio* have been reported in this river during the present investigation period.

Due to construction of dam, declination of good sized fishes like *Bagarius* sps., *Tor* sps., *Labeo* sps. occurred. *Bagarius yarelli*, which is used to visit the upper reaches of Tinau river are now totally disappeared from upstream of dam site. Similarly, the number of upstream migrants have been reduced considerable in downstream. While those fishes, which are totally inhabiting in down stream in Terai region are not affected and have got good hydrobiological conditions such as *Puntius* sps., *Barilius* sps. etc. in the absence of their predatory large sized migratory

fishes. As a result, abundance of large sized migratory fishes have been replaced by small sized fishes.

The present study shows the poor socio-economic status of fishermen in Tinau river. Lack of productive agricultural land, illiteracy and large family size are main causes for their poverty.

The fishermen of this river were found using both types of fishing practices i.e. conventional and non conventional. The popular fishing practice is netting by using different types of nets namely cast-net, 'Bhureli jal' etc. 'Balchhihane' is another popular type of fishing method. Electro fishing and poisonings were also reported during the present study period. The statistical analysis for the coefficient of co-relation between different physico-chemical parameters with species diversity of fishes was performed.

Hence, the preset study provides baseline information regarding the fishes and fishery resources of Tinau river. It is helpful for the development, management and conservation of the riverine fisheries of Tinan river. Such information will be helpful to take steps for the restoration of biodiversity and to enhance the livelihood of local people residing the vicinity of Tinau river.

CHAPTER - VII

CONCLUSIONS AND RECOMMENDATIONS

7.1 Conclusions

Following conclusions can be drawn from the results obtained of the present study .

-) Tinau river is rich in fish diversity. Altogether, 32 fish species (under 4 orders, 11 families and 24 genera) were collected during the present study period.
-) *Puntius conchoni*, *P. sopore*, *Channa punctatus* and *Lepidocephalus guntea* were found dominant fish species.
-) Construction of hydro-dam in the river found affecting the fish diversity of Tinau river. Due to lack of any fish migration provision like fish ladder in this dam, large sized migratory fishes were found blocked to move up and down stream.
-) The socio-economic conditions of fishermen living in the vicinity of Tinau river found poor. The fishermen were found hardly able to meet their livelihood needs based on fishery activities and found adopting other accessory professions like agriculture and wage labour etc.

7.2 Recommendations

The initiation towards conservation and management in the Tinau river has not been taken seriously. The fishermen and local villagers must be made aware of the importance of riverine ecology and riverine fishery. Due to lack of awareness towards the riverine fishery. The fish

population is being declining and many other fish species are either in rare condition or at the verge of extinction.

The improvement of fisheries in natural water resources offer a great opportunity for self employment and income generation among the poor people living in the vicinity of river. For successful management of riverne ecology and conservation of existing fish fauna, the following recommendations can be made.

a) Ban of Harmful fishing Implements

The fine meshed net like cast net. which catches fish juveniles must banned, as such implement reduces the survival rate of fish species.

Fish poisoning in diverted channel or stagnant water bodies like pools and crevices of rocks by applying either plant poisons or chemical poisons was frequently observed in Tinau river during the present study period. Such poisoning method affects all fishes along with other aquatic lives indiscriminately.

Dynamiting has been also recorded in sampling station. iii) Dovan during monsoon season. This is also a destructive fishing method. Sometime fishes are killed by applying electric shock. Hence all these indiscriminate, harmful and unconventional fishing methods must be prohibited in the governmental level. Not only legal prohibition, there must be the provision of regular supervision also.

b) Implementation of Act

Aquatic Life Conservation Act (2017 B.S.) and its ammenmends must be implemented strictly.

c) Closed Fishing Season

Different kinds of fishes breed in different seasons. If the females with thousand of eggs in their ovaries are caught, large quantity of eggs are being perished.

For the protection of fish stocks, the closed seasons are quite effective measure. The basic of such areas should allow fish freedom to complete spawning cycle without being hindered. For this, the times of spawning of various fish species should be known in order to establish closed fishing season.

e) Improvement of Habitats

The most important factor towards the conservation of fishes is the improvement of their habitats. Most of the fishes deposit their eggs in fine and clear oxygenated water over the gravel bottom. Due to soil erosion and silt deposition, eggs are destroyed. To protect the fish seeds and fries from the siltation, there must be an improved up land spawning ground and its vegetation. This will prevent bank erosion and protect the river bed from getting over silted.

The water pollution affects all kinds of living organisms. The Tinau river seems to be polluted mostly due to discharge of domestic wastes. Industrial wastes were also found heavily discharged into it mostly in Butwal area. Chemical fertilizers and pesticides are mixed into the water flowing through the agricultural lands. So, it is necessary to make the villagers aware of the impacts of pesticides and discourage them to use pesticides in their form.

A suitable provision must be made and implemented strictly by Butwal municipality to control the discharge of industrial and domestic wastes in to the river.

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APPENDIX-1

A List of Questionnaire Used in Interview with Fisherman of the Tinau River.

1. Name: 2. Caste:

3. Age: 4. Sex.....

5. District: V.D.C.:

6. How many members are in your family?

Ans.: Male Female Children

7. Who earns money in your family for daily life'?

Ans.:

8. From how many years you are been involved in this occupation ?

Ans:

9. Is it your full time or part time work?

Ans.:

10. Literate Illiterate

11. Do you have your own land? If yes, how much? Yes No

Ans.: Yes No

12. What is your income per month by fishing?

Ans:

13. What do you do besides catching fish?

Ans.:

14. How many members are included in fishing?

Ans.:

15. How many days do you spend in fish catching in this river within a week?

Ans.:

16. Which implement do you use mostly in fishing?

Ans.:

17. How many types and sizes of fishes do you catch?

Ans.:

18. Which fish species do you capture mostly?

Ans.:

19. In your opinion, how many species are there in the river?

Ans.:

20. Which season is best for fishing?

Ans.:

21. Is the population of fish declining from this river? If yes, causes of declination.

Ans.:

22. Is there any fish disappeared from this river?

Ans.:

23. Does fisherman use poison in this river? If yes, what type of poison you are using for fishing?

Ans.:

24. How many fishermen come to fishing at this site & From where do they come from?

Ans.:

25. What is the selling rate of the fish?

Ans.:

26. Is there any fish market in this area? Where?

Ans.:

27. Do you prepared fishing implement yourself or buy from market?

Ans.:

28. Any suggestion would you like to give for the improvement of fishery of Tinau river?

Ans.: