# SPECIES DIVERSITY, DISTRIBUTION AND STATUS OF FISHES IN TINAU RIVER, NEPAL

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A Thesis submitted in partial fulfillment of the requirements for the Degree of Master of Science in Zoology with special paper Fish and Fisheries

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# DECLARATION

I hereby declare that the work presented in this thesis has been done by myself, and has not been submitted elsewhere for the award of any degree. All sources of information have been specifically acknowledged by reference to the author(s) or institution(s).

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## RECOMMENDATIONS

This is to recommend that the thesis entitled, **"Species Diversity, Distribution, and Status of fishes in Tinau River, Nepal"** has been carried out by **Mr. Bikram Rijal** for the partial fulfillment of the Degree of Master of Science in Zoology with special paper Fish and Fisheries. This is his original work and has been carried out under my supervision. To the best of my knowledge, this thesis work has not been submitted for any other degree in any institutions.

I recommend that the thesis be accepted for partial fulfillment of the requirements for the Degree of Master of Science in Zoology with special paper in Fish and Fisheries.

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## LETTER OF APPROVAL

On recommendation of supervisor Prof. Dr. Kumar Sapkota, this thesis submitted by Mr. Bikram Rijal entitled**, "Species Diversity, Distribution, and Status of Fishes in Tinau River, Nepal"** is approved for examination and submitted to the Tribhuvan University in partial fulfillment of the requirements for the Degree of Master of Science in Zoology with special paper Fish and Fisheries.

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## CERTIFICATE OF ACCEPTANCE

This thesis work submitted by Mr. Bikram Rijal entitled**, "Species Diversity, Distribution and Status of Fishes in Tinau River, Nepal"** has been accepted as a partial fulfillment for the requirements of the Degree of Master of Science in Zoology with special paper Fish and Fisheries.

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Bikram Rijal

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## List of Abbreviation

| | |
|---|---|
| CBS | Central Bureau of Statistics |
| CDR | Conservation Development and Rare Species |
| CE | Critically Endangered |
| DDT | Dichloro Diphenyl Trichloroethane |
| DOFD | Directorate of Fisheries Development |
| EIA | Environmental Impact Assessment |
| EN | Endangered |
| GNP | Gross National Product |
| MUTM | Modified Universal Transverse Mercator System |
| PRO | Pristine Rare Ornamental Species |
| R | Rare and Threatened Species |
| Spp. | Species |
| UN | Uncommon or Lower Risk/ List Concern |
| VU | Vulnerable |

# ABSTRACT

A study was conducted to assess the fish diversity, distribution, abundance and status of fishes in Tinau River. The Tinau River supports for the habitat of many fresh water fishes of many types like carps, barbs, minnows, catfishes, eels etc. The study was focused on the diversity pattern of fishes and data was collected through selecting the sampling site and the field was visited on 4 different seasons. The study revealed that total 26 fish species have been collected from the Tinau River, belonging to 4 orders, 9 families and 19 genera. The most commonly observed fish species during the study period were *Barillus bendelensis* and *Puntius sophore and Garra s*pp. Similarly, *Tor tor* and *Brachydenio rerio* were rare caught fishes. The physiochemical parameters were found to be related with the composition and distribution of the fished in Tinau River. Highest Shannon weiner diversity index was observed in station IV (1.14) and in the month of July (1.11). Similarly, the maximum richness was observed in station IV (6.63) and in the month of April (9.97). Evenness index was found to be higher in January (0.97) and in the station III (1.18). No significant difference in the diversity status was obtained during the investigation period rather it was a seasonal phenomenon in the composition of fish species.

# 1 INTRODUCTION

## 1.1 Background

Geographically, Nepal touches India at its Southern, Western and Eastern borders, while the Northern boundary is with China and has a fascinating cultural and biological diversity. It lies in South Asia between the east medians of 88° 4' to 88° 12'E and parallel of 26°12' to 30° 27' N latitude. Its territory which has an area of 54462 square miles (147,181 sq.km.) extends roughly 500 miles from east to west and 90 to 150 miles from north to south. In the south the altitude is about 50m above sea level, while at northern end the elevation goes up to the highest peak 8848m (Mt. Everest) of the world. It is a small land locked country which possesses 2.27% of the water resources in the world has great potential for hydropower generation (Rai 2008, Gubhaju 2012).It bears snow clad mountains, eternal glaciers, ice cold torrents, clear –water and lakes which contribute too much of its hydrosphere. These vast stretches of inland water support many and varied forms of freshwater life including fish.

## 1.2 Topography

Nepal has tremendous geographic diversity. It contains a series of most rugged and inaccessible hilly terrains in the world. Along a south-to-north transect, Nepal can be divided into three belts: Terai, Hill and Mountain Regions.

### 1.2.1 Terai region

The Terai region begins at the Indian border and forms the northern extension of the Gangetic plain and varies in width from less than 16 to more than 20 miles. It is situated at an altitude above 60m from the sea level. The important fishes found in this region are Rohu (*Labeo* spp.) Sidre (*Puntius* spp.) catfishes like *Heteropneusteus fossilis, Wallago attu, Clarias batrachus* (Shrestha 1981).

### 1.2.2 Hill region

Situated south of the Mountain Region, the Hill Region is mostly between 700 and 3,000 meters (2,000 and 10,000 ft) altitude. In the upper part of this region fishes like Snow Trouts (*Schizothoraichthys* spp.), sucker headed (*Garra* spp.), stone loaches (*Nemacheilus* spp.) and *Glyptothorax* spp. are found and in the lower part fishes like

Sahar (*Tor* spp.), Bhakur (*Catla catla*), Rohu (*Labeo* spp.), Faketa (*Barilius* spp.) Kabre (*Pseudochenesis sulacatus*) are found (Shrestha 1981).

### 1.2.3 Himalayan region

Mountain Region begins where high ridges begin substantially rising above 3,000 meters (10,000 ft.) into the subalpine and alpine zone which is mainly used for seasonal pasturage. A few tens kilometers further north the high Himalaya abruptly rise along the Main Central Thrust fault zone above the snow line at 5,000 to 5,500 meters (16,400 to 18,000 ft.). Some 90 of Nepal's peaks exceed 7,000 meters (23,000 ft.) and eight exceed 8,000 meters (26,247 ft.) including Mount Everest at 8,848 meters (29,029 ft.) and Kanchenjunga at 8,598 meters (28,209 ft.). Fishes are not recorded from this region.

## 1.3 Climate

The Tropical zone below 1,000 meters (3,300 ft.) experiences frost less than once per decade. It can be subdivided into lower tropical (below 300 meters or 1,000 ft.) with 18% of the nation's land area) and upper (18% of land area) tropical zones. The Siwalik Hills are mostly upper tropical. Tropical climate zones extend far up river valleys across the Middle Hills and even into the Mountain regions.

The Subtropical climate zone from 1,000 to 2,000 meters (3,300 to 6,600 ft.) occupies 22% of Nepal's land area and is the most prevalent climate of the Middle Hills above river valleys.

The Temperate climate zone from 2,000 to 3,000 meters (6,600 to 9,800 ft.) occupies 12% of Nepal's land area. It is encountered in higher parts of the Middle Hills and throughout much of the Mountain region. The Subalpine zone from 3,000 to 4,000 meters (9,800 to 13,100 ft.) occupies 9% of Nepal's land area, mainly in the Mountain and Himalayan regions. The Alpine zone from 4,000 to 5,000 meters (13,100 to 16,400 ft.) occupies 8% of the country's land area. Arid and semi-arid land in the rain shadow of high ranges has a Trans-Himalayan climate. Precipitation generally decreases from east to west with increasing distance from the Bay of Bengal, source of the summer monsoon.

## 1.4 Water resources of Nepal

Nepal is endowed with many forms of water resources scattered throughout the country. These water bodies are in the form of rivers and streams, lakes, reservoirs, ponds, swamps and paddy fields. Water surface area covers 0.1% of global water for Nepal. The water

surface coverage is 2.7% of total land area of the country. The aquatic ecosystem of mountainous Nepal offers excellent habitats for different indigenous and exotic fish species of high economic, environmental and academic value. Glaciers and the monsoon rain are among the several sources of water in this country. Nepal is ranked second richest country in water resources in the world possessing about 2.27% of the world water resources (CBS 2005). The inland water resources totaling 820077 (DOFD 2013/14) comprises of river system, lakes, reservoirs, marginal swamps, irrigated paddy fields and so on which are given in the **Table 1.**

**Table 1 Estimated Water Surface Area of Nepal**

| S.N | Resources | Estimated area (ha) | Coverage (%) | Potential for fisheries (area in ha) |
|---|---|---|---|---|
| 1 | Natural waters | 401500 | 49 | - |
| | Rivers | 395000 | 48.2 | - |
| | Lakes | 50000 | 0.61 | - |
| | Reservoirs | 1500 | 0.18 | 78000 |
| 2 | Village ponds | 7277 | 0.89 | 14000 |
| 3 | Marginal swamps, irrigated fields | 13,300 | 1.6 | - |
| 4 | Irrigated paddy fields | 398000 | 48.5 | - |
| | Total | 820077 | | |

Source: Directorate of Fisheries Development (DOFD, 2013/14)

## 1.5 River system of Nepal

Nepal has three categories of rivers. The largest systems - from east to west Koshi, Gandaki/Narayani, Karnali/Goghra and Mahakali- originate in multiple tributaries rising in or beyond the high Himalaya that maintain substantial flows from snowmelt through the hot, droughty spring before the summer monsoon. These tributaries cross the highest mountains in deep gorges, flow south through the Middle Hills, then join in candelabra-like configuration before crossing the Mahabharat Range and emerging onto the plains where they have deposited megafans exceeding 10,000 km2 (4,000 sq. m) area.

The Koshi is also called Sapta Koshi for its seven Himalayan tributaries in eastern Nepal: Indrawati, Sun Koshi, Tama Koshi, Dudh Koshi, Liku, Arun, and Tamur. The Arun rises in Tibet some 150 kilometers (100 m) beyond Nepal's northern border. A tributary of the Sun Koshi, Bhote Koshi also rises in Tibet and is followed by the Arniko Highway connecting Kathmandu and Lhasa.

The Gandaki/Narayani has seven Himalayan tributaries in the center of the country: Daraudi, Seti Gandaki, Madi, Kali, Marsyandi, Budhi, and Trisuli also called Sapta Gandaki. The Kali Gandaki rises on the edge of the Tibetan Plateau and flows through the semi-independent Kingdom of Mustang, then between the 8,000 meter Dhaulagiri and Annapurna ranges in the world's deepest valley. The Trisuli rises north of the international border inside Tibet. After the seven upper tributaries join, the river becomes the Narayani inside Nepal and is joined by the (East) Rapti from Chitwan Valley. Crossing into India, its name changes to Gandak.

The Karnali drains western Nepal, with the Bheri and Seti as major tributaries. The upper Bheri drains Dolpo, a remote valley beyond the Dhaulagiri Himalaya with traditional Tibetan cultural affinities. The upper Karnali rises inside Tibet near sacred Lake Manasarovar and Mount Kailash. The area around these features is the hydrographic nexus of South Asia since it holds the sources of the Indus and its major tributary the Sutlej, the Karnali—a Ganges tributary—and the Yarlung Tsangpo/Brahmaputra. It is the center of the universe according to traditional cosmography. The Mahakali or Kali along the Nepal-India border on the west joins the Karnali in India, where the river is known as Goghra or Ghaghara.

Second category rivers rise in the Middle Hills and Mahabharat Range, from east to west the Mechi, Kankai and Kamala south of the Kosi; the Bagmati that drains Kathmandu Valley between the Koshi and Gandaki systems, then the West Rapti and the Babai between the Gandaki and Karnali systems and also Tinau river and many other. Third Category Rivers rise in the outermost Siwalik foothills and are mostly seasonal. The river system of Nepal is given in the **Figure** 1.

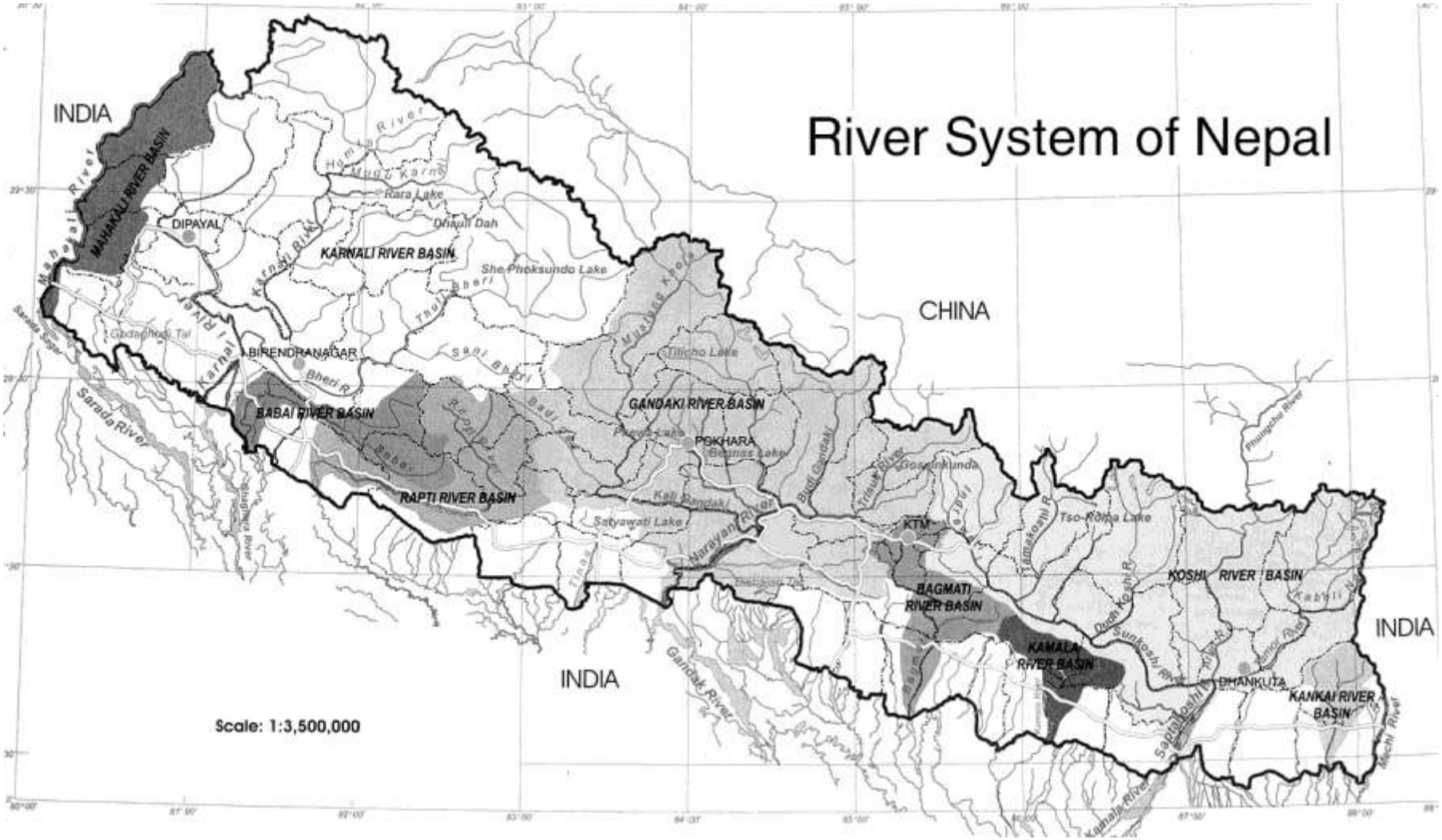


**Figure 1. River system of Nepal**

## 1.6 Current status of fishes of Nepal

The current status of fish shows there are 232 fish species in Nepal (Shrestha 2008). These 232 species belongs to 114 genera, 37 families and 11 orders. On the basis of taxonomic status, there are 2 endangered species(EN), 9 vulnerable species (VU), 23 rare and threatened species (R), 32 Data deficient Pristine Rare Ornamental species (PRO), 27 Conservation Dependent and Rare species(CDR), 53 uncommon or Lower Risk Least Concern species (UN), 71 Common species (C) and 15 Exotic species (*). No particular fish species is identified as Critically Endangered (CE) and extinct (EX) in Nepal yet. The conservation status of fishes in Nepal is given in the **Table 2.**

**Table 2. Tentative list of Conservation Status of Fishes of Nepal.**

| S.N. | Categories | Designated as | Number of Species |
|---|---|---|---|
| 1 | Common | C | 71 |
| 2 | Uncommon or lower risk / least concern | UN | 53 |
| 3 | Conservation Dependent and rare | CDR | 27 |
| 4 | Data deficient Pristine Rare ornamental | PRO | 32 |
| 5 | Critically Endangered | CE | 0 |
| 6 | Endangered | EN | 2 |
| 7 | Extinct | EX | 0 |
| 8 | Vulnerable | V | 9 |
| 9 | Rare or Near Threatened | R | 23 |
| | | | 217 |
| 10 | Exotic | | 15 |
| Total | | | 232 |

Source: Ichthyology of Nepal (Shrestha 2008)

## 1.7 Status of fisheries in Nepal

Fishing is traditional in Nepal but modern aquaculture techniques for the fish production edible Fishery constitutes around 3% of total AGDP of the nation and around 75000 people are engaged or participated in aquaculture and capture fisheries and the net production is 64,900 Mt. of which fish production from aquaculture is 43,400 and the fish production from capture fisheries is 21,500 Mt.(DOFD, 2013/14) The summary of fish production in Nepal is given in the

**Table** 3**.**

**Table 3. Summary of fish production in Nepal, 2013/14**

| S.N. | Particulars | Pond (Nos.) | Total Area (Ha.) | Fish production (Mt.) | Yield KG/Ha |
|---|---|---|---|---|---|
| 1 | Fish production from Aquaculture Practices | | | 43,400.00 | |
| a. | Pond fish culture | 34,400 | 8,600 | 37,427.00 | 4,352 |
| I | Mountain | 105 | 7 | 16.63 | 2,376 |
| II | Hill | 2,5l | 274 | 711.64 | 2,597 |
| III | Terai | 31,710 | 8,319 | 36,698.73 | 4,411 |
| c. | Paddycum fish culture(Ha) | | 100 | 45 | 450 |
| d. | Cage fish culture (m3) | | 70,000 | 350 | |
| e. | Enclosure fish culture | | 100 | 140 | 1400 |
| f. | Trout fish culture in Raceway (m2) | | 12,000 | 192 | |
| g. | Fish production in Public Sectors (Mt ton) | | | 26 | |
| 2 | Fish production from capture fisheries | | | 21,500.00 | |
| a. | Rivers | | 395,000 | 7,110.00 | 18 |
| b. | Lakes | | 5,000 | 850 | 170 |
| c. | Reservoirs | | 1,500 | 385 | 257 |
| d. | Marginal/swamps/Ghols etc | | 11,100 | 5,990.00 | 540 |
| e. | Low land irrigated paddy fields | | 398,000 | 7,165.00 | 18 |
| | Net Fish Production (Mt.) | | | 64,900.00 | |

Source: Directorate of Fisheries Development (DOFD, 2013/14)

## 1.8 Tinau River

The Tinau River is a perennial river. It originates from the Mahabharat range of Palpa district that is from Madiphant, about 20 km east of Tansen and flows to the south of Nepal. The Tinau River flows through the western part of Butwal city. 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 the sea level. It flows to southern direction joining many feeder streams along its way through a valley called Madiphat. About 5km south of Madiphat, it meets

two feeder streams at Charchare namely Dumre and Suke. 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. It joins with west Rapti River in India near Gorakhpur. The width of this river varies from place to place. 35 species of fish were reported from the Tinau River which includes 5 orders, 12 Families, 25 genera (Sharma and Shrestha 2001).

Nepal is rich in water resources and has great potentiality for electricity power generation The Hydropower of Tinau River is located at Dovan about 4 km away from Butwal, which was constructed for the production of hydroelectricity of 1000 kilowatt in 2022 B.S. by Butwal Power Company. It was hand overed to Nepal electricity authority in 2037 B.S. The power house is located near the siddhababa temple, which is approximately 1 km away from the dam. The Tinau River system is presented as **Figure 2.**

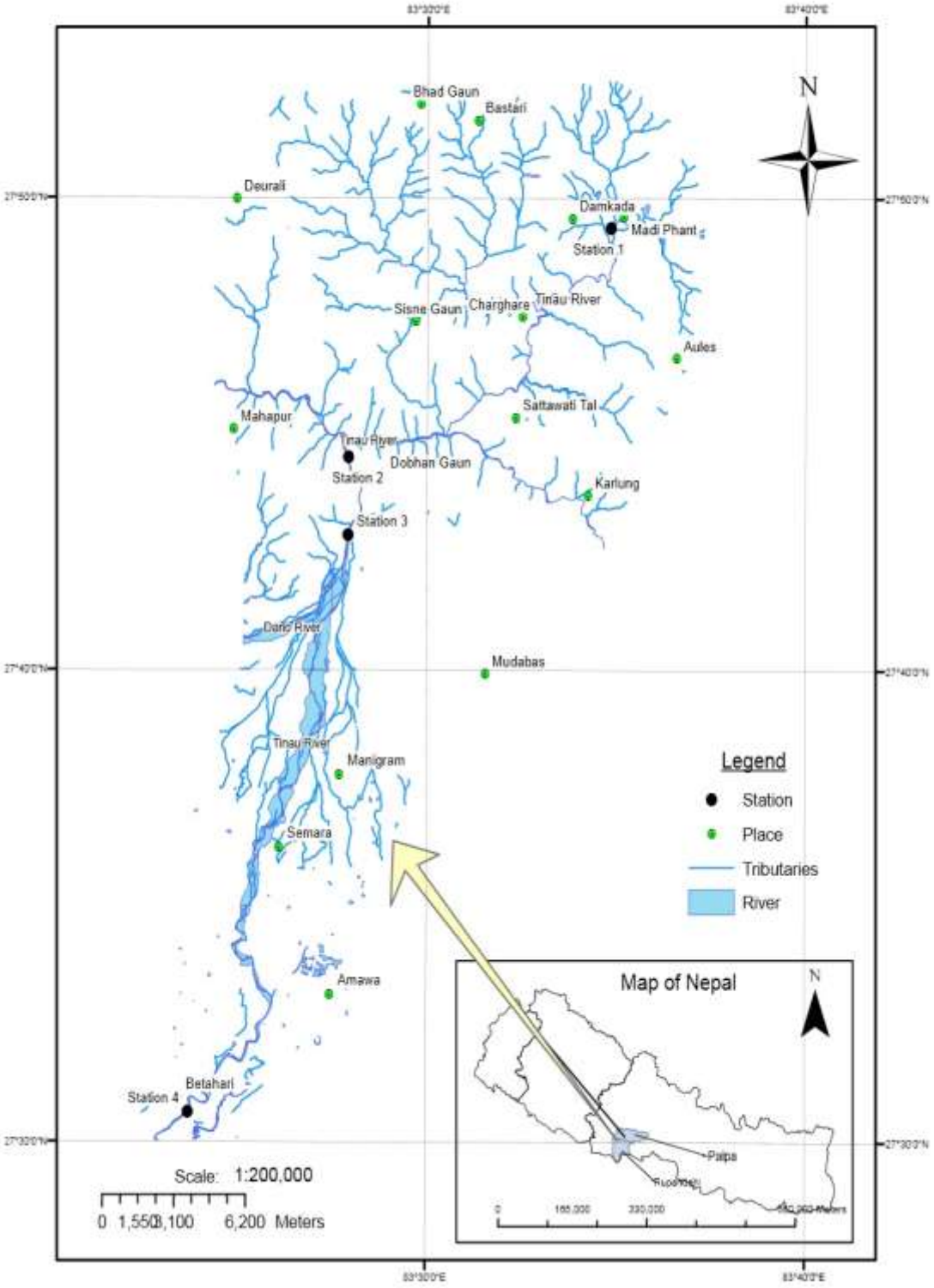


**Figure 2. Tinau River system**

## 1.9 Objectives

The Main objective of the study is to explore the diversity of fish in Tinau River.

The specific objectives are

- To investigate seasonal physio-chemical parameters.
- To estimate the Diversity status of fishes in Tinau River.

## 1.10 Justification of the study

Recently fishes in Tinau River have steeply declined due to pollution harmful fishing practices habitat modification, environmental degradation and barrier effects of dams and impact of other developmental activities. Dam installed in this River does not have fish ladders and they obstruct and prevent upstream and downstream movement of fish. Dam have also cut linkages between upstream and downstream which can have serious consequences for fish migration by creating barriers to species that breed in headwater streams. Although, the work has been carried out in the Tinau River but it is too old and there is no latest result on the diversity of fish in this particular river. There is much more modified artificial environment near the river which has obvious to cause serious problem to the aquatic flora and fauna. And the physio-chemical parameters are also certain to be changed in these recent years which are also the cause for the loss in fish diversity. Since this river contributes habitat for this many large fish species. So i have chosen this river system which may have served as a habitat for the different fish species.

## 1.11 Limitation of the study

This study is focused on fish diversity in the Tinau River that is in the range of about 40 km and covers limited site of 4 stations in different km. range gap. This study is also based on some interview with local fishermen who could not explain about the diseases, exact name of extinct fishes for the convenient in identification. Near the stations there were no laboratory and transport facility.

# 2 LITERATURE REVIEW

Although no priority was given to the study of riverine fishery in the past years, but the history of exploration of fish fauna goes back to the eighteenth century. The first historical account starts from 1973 A.D by colonel kirkpatric followed by francis Buchanan (later Hamilton) at the beginning of 19$^{th}$ century. Hamilton (1822) was the first author to provide valuable references of the fishes of Nepal in his work entitled "An account of the fishes found in river Ganges and its branches" which provided the description of 269 species of fishes of Ganges and its tributaries. Hence Hamilton furnished the first authentic information concerning the description of Nepalese fishes. His study was primarily concerned with the fishes inhabiting in the Terai region of Nepal. Besides Hamilton, (Gunther 1861) reported some cold blooded vertebrates including fishes, collected by Hodgson in Nepal. Beavan (1872) described two imperfectly known species of cyprinid fishes from Punjab and had mentioned some of the fishes of Nepal. Day (1886) performed his classical work "fishes of India, Burma and Ceylon" in which he referred a number of fresh water fishes of Nepal. Boulenger (1907) reported a small collection of Nepalese fishes and he classified Teleostean fishes of the order Ostariophysi and 5 species of Nepalese fishes( Regan 1907) also reported a small collection of Nepalese fishes and he classified Teleostean fishes of the order Ostariophysi, and 5 species of Nepalese fishes. One of the outstanding contributions in this field is that of (Hora 1937). He obtained a collection of fishes from Nepal in 1923 through colonel, Bailey which includes 159 specimens of 22 species. Again Hora (1937) reported of a small collection of fishes from Nepal.

Menon (1949) described fishes from the Koshi Himalaya region, Nepal which counts of 11 families comprising 26 genera and 52 species. Taft (1955) conducted fish survey of Nepal and collected fishes from Kathmandu and adjoining area. His checklists include 94 species. Menon and Dutta (1961) described a new fish *psilorhynchus pseudochenesis* from Bhotekoshi during Indian choyo expedition to Nepal. De -witt(1960) studied fishes of Nepal and gave a checklist of 102 species of fishes belonging to 21 families without any description of their biology and ecology. Majupuria and Shrestha (1968) published a paper on "Fresh water fishes and fisheries of Nepal"

Shrestha (1978) studied the fish fauna of Nepal and reported118 fish species out of which she described two new species and one sub species (*Barillus Jalkapoorei* spp.nov.,*Lepidocephalichthys nepalensis* spp.nov. *and Pseudeutropius marius,batarensis* sub spp.nov ). Shrestha et al. (1979) have reported 82 fish species from downstream of the river Bagmati. Ferro and Badagami (1980) reported 22 fish species from lakes Begnas and Rupa in pokhara valley. Robert (1982) studied genera *Macrognathus* and *Wallago.* Jayaram (1981) reported 106 species under 61 genera, 21 families and 8 orders from Nepal of which one species *Myersglanis blythi* , this has been specified as being endemic in Nepal. The first compilation of the reported fish fauna for the central or Nepal Himalaya within the boundary of the kingdom of Nepal for the period 1793-1982 was prepared and it contained 171 fish species of which 164 were indigenous and 7 exotic ( Rajbansi, 1982). Terashima (1984) reported three new species endemic to Mahendra tal (lake Rara). Edds (1985) has further reported a list of 111 and 113 native fish species from the River Kaligandaki/ Narayani river and the waters of Royal Chitwan National Park , Chitwan respectively. Jha and Shrestha (1986) have studied fish fauna of the River Karnali and have reported 57 fish species under 38 genera, 19 families and 9 orders from the River Rapti and the River Narayani.

Shrestha (1990) has recorded 108 fish species from the River Koshi, 102 fish species from the Gandak, 74fish species from the Karnali, 82 fish species from River Narayani, 34 fish species from Trishuli and 69 fish from Mahakali. Shrestha (1990) has also stated that 130 species of fish occurs in the snow fed Rivers and mountain lakes of the Nepalese highlands. Talwar and Jhingram (1991) have reported 96 fish species representing 19 families and 5 orders from Nepal in their book "inland fisheries of india and adjacent countries". Shah et al. (1992) have explored the lower stream of the River Arun in eastern Nepal and have reported 46 fish species from there. Sapkota (1992) studied fishery ecology of swampland of koshi River. Shrestha (1994) reported fishes, fishing implements and methods of Nepal. She had described 66 genera and 129 species of fish reported so far by the author. Shrestha (1994) has reported a total of 188 fish species from Nepal, out of which 179 indigenous and 9 exotic. Subba (1995) have reported a new record on the occurrence of a hill stream fish *Olyra longicaudata* McClelland from a tributary of the River Trijuga, a tributary of the Koshi River, Saptari District, Eastern Nepal.

Shrestha (1996) studied the fishes of Kali Gandaki River and reported 57 species. Subba and Ghosh (1996) have reported a new record of the pigmy barb – *Puntius phutunio*

(Hamilton) from the Koshi TappuWildlife Reserve's lowland catchment area. Smith et al. (1996) have studied aquatic biodiversity in the Karnali and Narayani River basins of Nepal and have reported 141 species( including *Glyptothorax ribeiroi* synonymous to *laguvia ribeiroi*), of which 121and 134 fish species have been reported from the Karnali and Gandaki rivers, respectively. Shrestha (1997) made an Environment Impact Assessment Study of the Upper Karnali Hydropower Project and reported 48 fish species. Shrestha (1999) studied on 'Cold Water Fish and Fisheries in Nepal' and reported 59 indigenous and 2 exotic fish species. Shrestha (1999) studied on the Bheri –Babai Hydroelectric Project and reported 46 fish species out of which 21 fish species for the River Bheri and 19 fish species for the River Babai. Jayaram (1999) explains in his recent book "the fresh water fishes of the Indian Region", 108 fish species from Nepal. Nath and Day (2000) contributed fish and fisheries of north eastern India. Sharma and Shrestha (2001) have reported 35 species of fishes existing in the Tinau River.. Menon (2004) highlighted threatened fishes of India and their conservation. Rajbansi (2005) published a paper entitled "Review of Current Taxonomic Status and Diversity of Fishes of Nepal" based on the current work of the (Menon 1999). Similarly Shrestha (2005) conducted a study and reported 36 species of fishes in Dano River. Shrestha (2008) enumerate the fishes of Nepal and describe the 232 species of fish in his book titled with "fish diversity and potentiality of indigenous fishes for the future development of aquaculture". Bagra and Das (2010) conducted the study on fish diversity of River Siyom of Arunachal Pradesh, India and reported 44 species of fishes belonging to 9 families in which family Cyprinidae was found to be dominant followed by Balitoridae. Similarly, Srivastava(2013) conducted studied Fish Diversity and Conservation perspectives of Gandak River, India within the stretch of 10 km in Uttar Pradesh and reported 54 species of many commercially important fishes.

Mandal and Jha (2013) conducted a study on impacts of Damming on Ichthyo-faunal Diversity of Marshyangdi River in Lamjung District, Nepal and reported 26 species of fishes belonging to 5 orders, 6 families and 18 genera. Baro et al. (2014) also studied the status of ornamental fish diversity in Sonkosh River,Badoland Territorial council,Assam, India and recorded total 49 ornamental fish species belonging to 34 genera, 18 families and 6 orders. Cyprinidae family represented the maximum number of species.(Vijayasree and Radhakrishan 2014) studied fish diversity of Kuttanand River, Kerala state, India and revealed 62 freshwater species belonging to 17 families were found. Among cultivable fishes, order Cypriniformes were found to be dominant.

# 3 MATERIALS AND METHODS

For the present investigation the field work was conducted from October 2014 to July 2015 in every interval of two months. To achieve as the aims and objectives, the following methods and materials were carried out.

## 3.1 Study period

The field work was conducted for one year (October 2014 to July 2015) with four seasons. Two visits were performed for each station for fish collection.

## 3.2 Study area

The field study was conducted in the River Tinau which originates from the Mahabharat range of Palpa district about 20 km east of Tansen. The Tinau River lies in the western part of Butwal city. The Tinau River, originates from the Mahabharat range of Palpa district.

## 3.3 Selection of Sampling Stations

Before beginning the study work, survey techniques were followed for fixing the study sites. These sites were selected so that it could represent the faunal distribution for the Tinau River. Also these were selected on the basis of human settlement, altitude variation, dam sites, meeting of other tributaries, transportation facilities etc. The selected stations are as follows:

Station I = Dhamkada (Mariphant)
Station II = Dovan gaun
Station III= Butwal
Station IV= Bethari

Station I (Dhamkada)

Damkada (Mariphant) lies in the palpa district and it is 5-7 km from the Aaptari. It has an altitude of 675m from the sea level. The aerial distance of this station from sauraha chowk, Butwal is 16.77 km. The co-ordinate value of this station according to the Modified Universal Transverse Mercator System (MUTM) is 459177.406 E. and 3078581.751 N. This is the topmost station and it has less human encroachment. It passes between the large agricultural lands.

Station II (Dovan)

This station lies at an altitude of 280 m from the sea level. The aerial distance of this station from Butwal is 4.91 km. The co-ordinate value of this station according to the MUTM system is 450864.349 E. and 3070169.075 N. A hydroelectric dam is built near to this station. The main stream of Tinau river is mixed with other feeder stream here so it is called Dovan.

Station III (Butwal)

Butwal lies at an altitude of 190m from the sea level. The aerial distance from Sauraha Chowk to the station is 1.11 km. The co-ordinate value of this station according to the MUTM system is 447280.697 E, to 3065279.697 N. Butwal joins hilly region with the terai region. After river enters to the terai region it expands. The river bifurcates near the bridge of Mahendra highway as it bifurcates the river is given its name as Dano river and Tinau river. Before its bifurcation it is passed through an irrigation canal.

Station IV (Bethari)

Bethari is situated about 5 km away from the Bhairahawa. It is situated at an altitude of 104 m from the sea level. The aerial distance of this station from Sauraha chowk, Butwal is 23.27 km. The co-ordinate value of this station according to the MUTM system is 440292.89, E to 3044178.62 N. It is the industrial area and the river is mostly polluted.

## 3.4 Physical Analysis of Water

The existing meteorological conditions and the chemical compositions affect the physical properties of water in any aquatic ecosystem. Different physical properties of River Tinau were analyzed during the study period after (Trivedy and Goel 1986), (Adoni 1985) and (APHA 1976). The physical properties are as follows:

### 3.4.1 Water velocity

The river's velocity was measured by the simple method of timing a float with stopwatch. The float material was squeezed lemon which was tied with a rope and left in the river and the time to cross the point was calculated and this velocity was expressed in m/s.

### 3.4.2 Temperature

The standard mercury thermometer was used for recording the water temperature. The bulb of thermometer was dipped inside the surface of water and reading was taken.

### 3.4.3 Transparency

The transparency of the water was measured by Sechii disc method. The metallic plate of 20cm diameter with four alternatively black and white quadrants on the upper surface and a hook at the middle to tie a rope was used. This disc was dipped in the water and the depth was noted at which it just disappeared. Then conversely, it was raised gradually to note the depth at which reappeared and the calculation was done using following formula.

$$Transparency\ (cm) = \frac{Just\ Disappearance + Just\ Reappearance}{2}$$

### 3.4.4 Turbidity

Turbidity of the water is inversely proportional to the transparency. Hence, the turbidity of the river water was calculated by using transparency value into the following equation.

$$Turbidity\ (x) = \frac{1000}{1.568Y - 1.2752}$$

Where, X = turbidity

Y = transparency

## 3.5 Chemical Analysis of Water

Water sample was collected from every stations of Tinau River. The chemical parameters were analyzed after (APHA 1976), (Adoni 1985) and (Trivedy and Goel 1986).

### 3.5.1 Hydrogen Ion Concentration

A pH meter was used to record the hydrogen ion concentration of water during the study period at every station of the Tinau River.

### 3.5.2 Dissolved Oxygen

The dissolved oxygen of water was calculated using Winkler's method. The sample of water from every station was collected in a BOD bottle without bubbling. Two milliliters of Manganese sulphate and similar quantity of alkaline- iodide- azide solution were added and shaken. Brown precipitation was obtained which was again dissolved by adding 2ml

of conc. Sulphuric acid. Then this solution was titrated against standard Sodium thiosulphate solution (0.025N) and the calculation was carried out using formula

$$\text{D.O. (mg/l)} = \frac{ml \times normality\ of\ titrant \times 8 \times 1000}{V_2\{(V_1 - V)/V_1\}}$$

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

$V_1$= Volume of BOD bottle

$V_2$= Volume of the part of the content titrated.

### 3.5.3 Free Carbondioxide

To determine the free CO2, 50 ml of sample water was taken and few drops of phenolphthalein indicator were added. Thus obtained colourless solution indicated the availabiltity of carbondioxide. Now this solution was titrated against standard alkali titrant (Sodium hydroxide 0.02272 N) to the slight pink end point. Free carbondioxide in the water sample was calculated using formula

$$Free\ CO2 = \frac{(ml * N) of\ NaOH * 1000 * 44}{V}$$

Where, V = Volume of water sample taken (ml)

## 3.6 Statistical Analysis of Ichthyofauna

For the statistical analysis (coefficient of correlation) between some important physiochemical parameters of water they are temperatures, pH, D.O etc. with fish density was calculated using Karl-Pearson's method (Gupta 1988)

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

$$\text{Probable error (P.E.)} = \frac{1 - r^2}{\sqrt{N}} 0.6745$$

## 3.7 Diversity Status

### 3.7.1 Species diversity index

The diversity of species was calculated by using Shannon-Weiner diversity index (Shannon and Weaver, 1949)

Shannon Weiner diversity index is designated as H', which is calculated as:

$H' = -\Sigma (ni /N) \log (ni/N)$

Or, if $Pi= ni/N$

$H' = -\Sigma Pi \log_e Pi$

Where,

ni = Importance values for each species is the number of individuals in each species, the abundance of each species.

N = Total Importance value, the total number of individual observed.

Pi= ni/ N = Relative abundance of each species, calculated as the proportion of individuals of a given species to the total number of individuals in the community.

### 3.7.2 Species richness index

The species richness is calculated by using Margalef Species richness (Margalef's 1968).

Margalef richness index is designated as d, which is calculated as:

Margalef species richness (d) = S-1/ log N

Where, S= Number of species

N = Number of individuals

### 3.7.3 Evenness index

To calculate whether species are distributed evenly across seasons and across landscapes elements, evenness index was determined by the following equation (Pieleu 1966).

$E= H'/ \log S$

Where,

H' = Shannon-Wiener's diversity index.

S= Species richness is the number of species and is the simply a count of the number of different species in a given area

# 4 RESULTS

During the study period following parameters were analyzed and the results are given below.

## 4.1 Physical Parameters of Water

### 4.1.1 Water velocity

The velocity of river water is one the affecting factors for determining the distribution pattern and forms of fish species. During the study period, the velocity of river Tinau ranged minimum from 0.15 m/s at station IV in the month of April to maximum of 2 at station II in the month of July. The variation in velocity of River water in different station is given in the **Figure 3**.

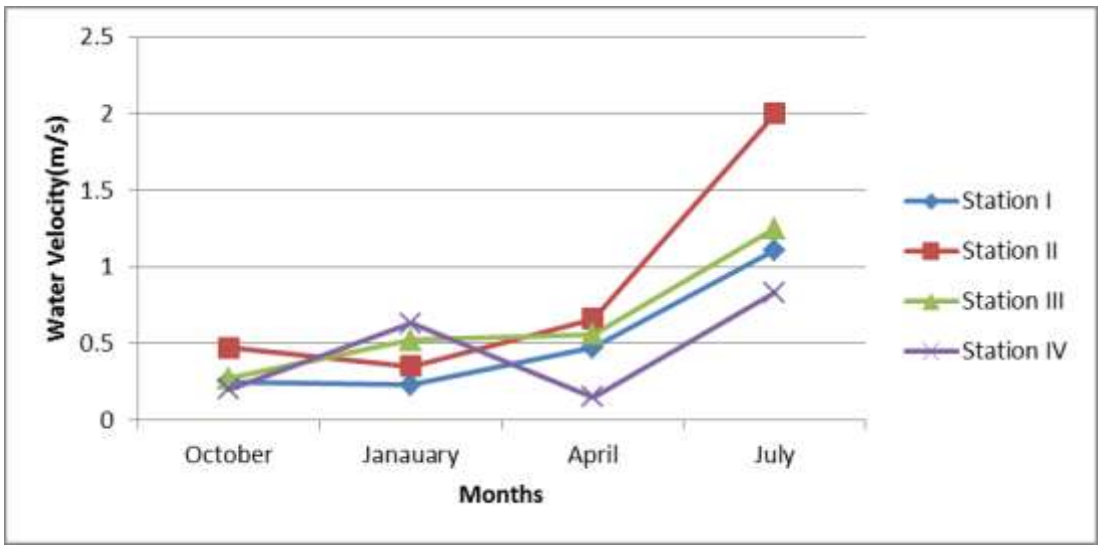


**Figure 3 Variations in water velocity (m/s) at different station in different seasons.**

### 4.1.2 Temperature

Temperature plays a key role in the species distribution of both planktons and fish species in the river water. The water temperature was recorded to be lowest at station I which was 18℃ and higher was at the station III and IV which was 30℃. The variation in temperature at different station during the study period is presented in the **Figure 4.**

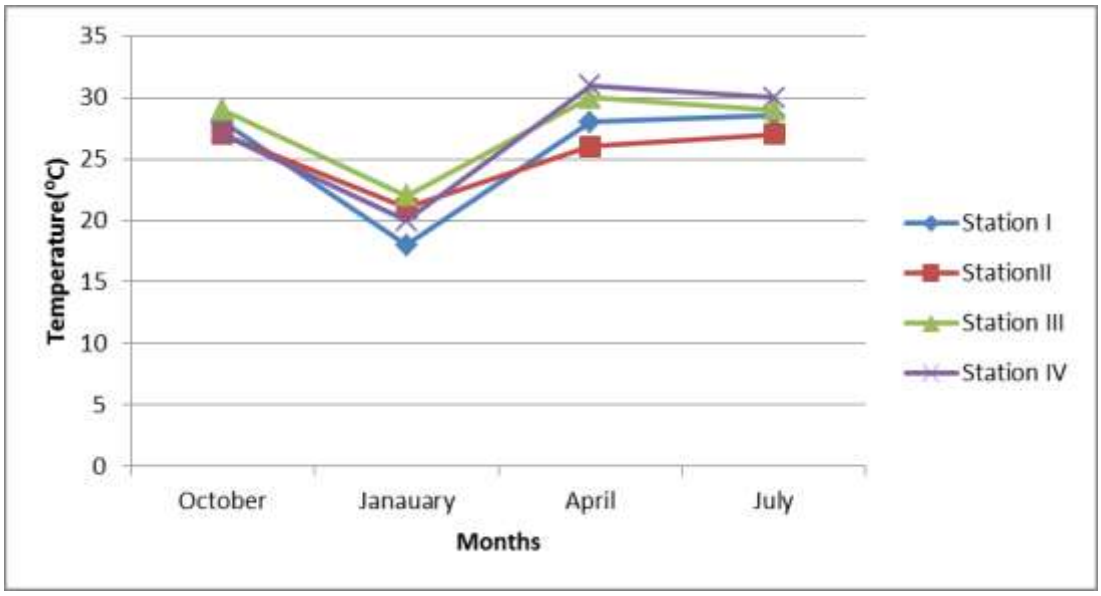


**Figure 4 variations in temperature (˚C ) at different stations in different seasons.**

### 4.1.3 Transparency

The Transparency of the river water except during the month of July was high in all months. The transparency remained only 3cm at station IV in July while it showed to 72cm in the month of January at station II. The level of transparency at different stations in different months is given in the **Figure 5.**

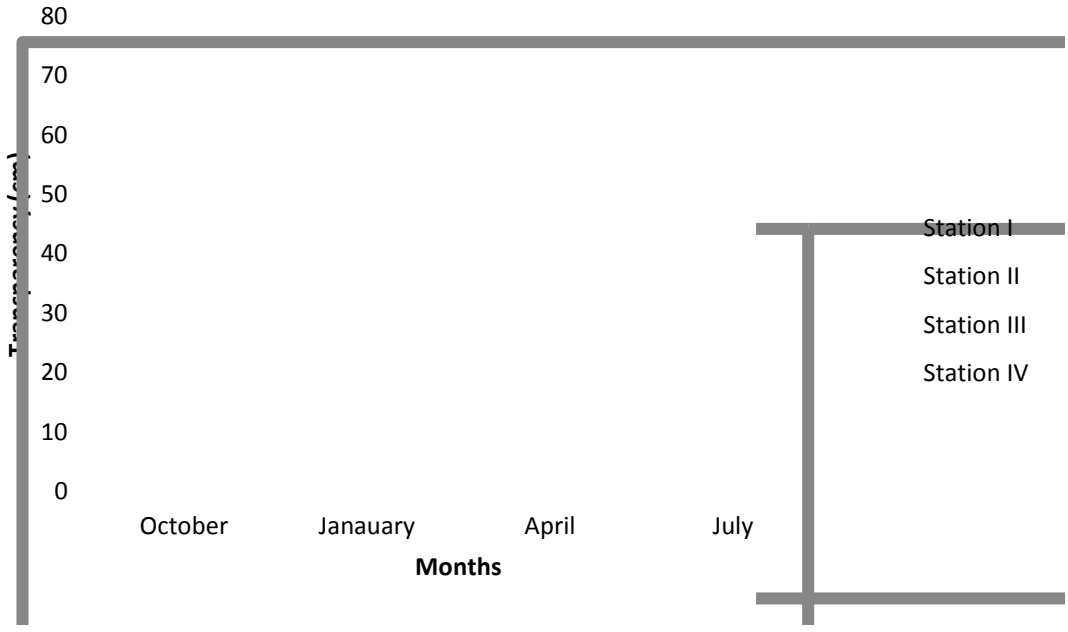


**Figure 5 Variations in transparency (cm) at different stations in different seasons**

### 4.1.4 Turbidity

The turbidity of water is linked with the transparency of the water surface. Its level was higher at station IV which reached 292.39 mg/l whereas it remained at 8.95 mg/l at station II during the investigation period. The variations in the turbidity in the Tinau River at different stations in different month are illustrated in the **Figure 6.**

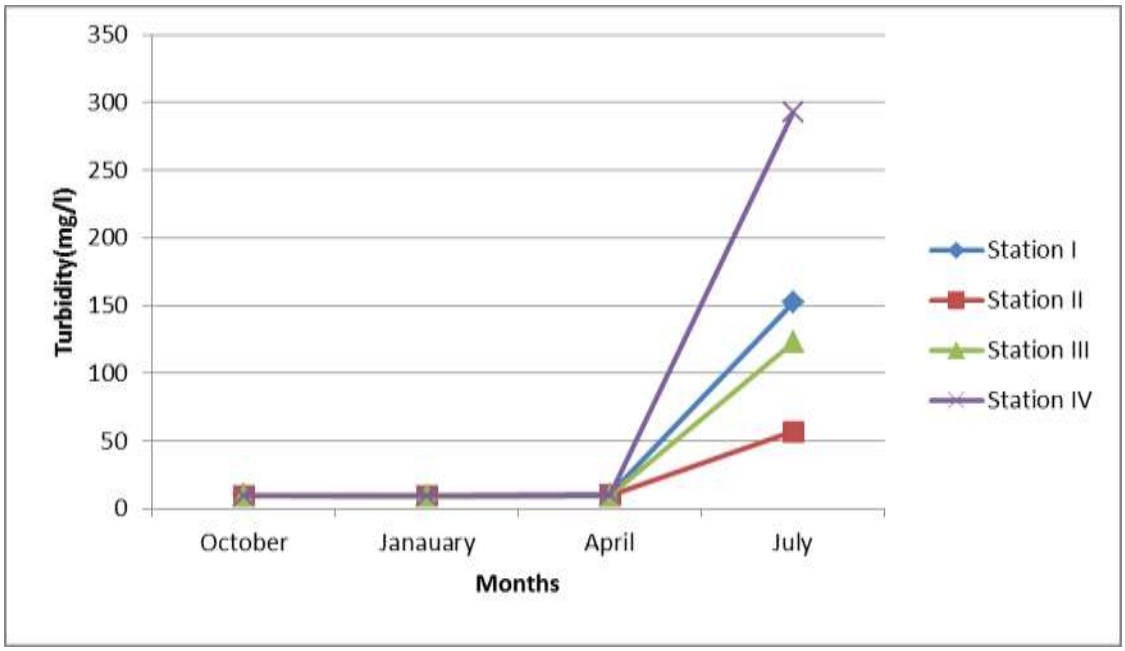


**Figure 6 Variations in turbidity (mg/l) at different station in different seasons.**

## 4.2 Chemical Parameters of Water

### 4.2.1 Hydrogen ion concentration

The pH of Tinau river remained slight basic almost all year around in all stations. The hydrogen concentration value remained 7.8 at station I during the month of October while its value reached upto 8.6 at station III during the month of April. The variation for the pH value at different stations in different months is given on the **Figure 7.**

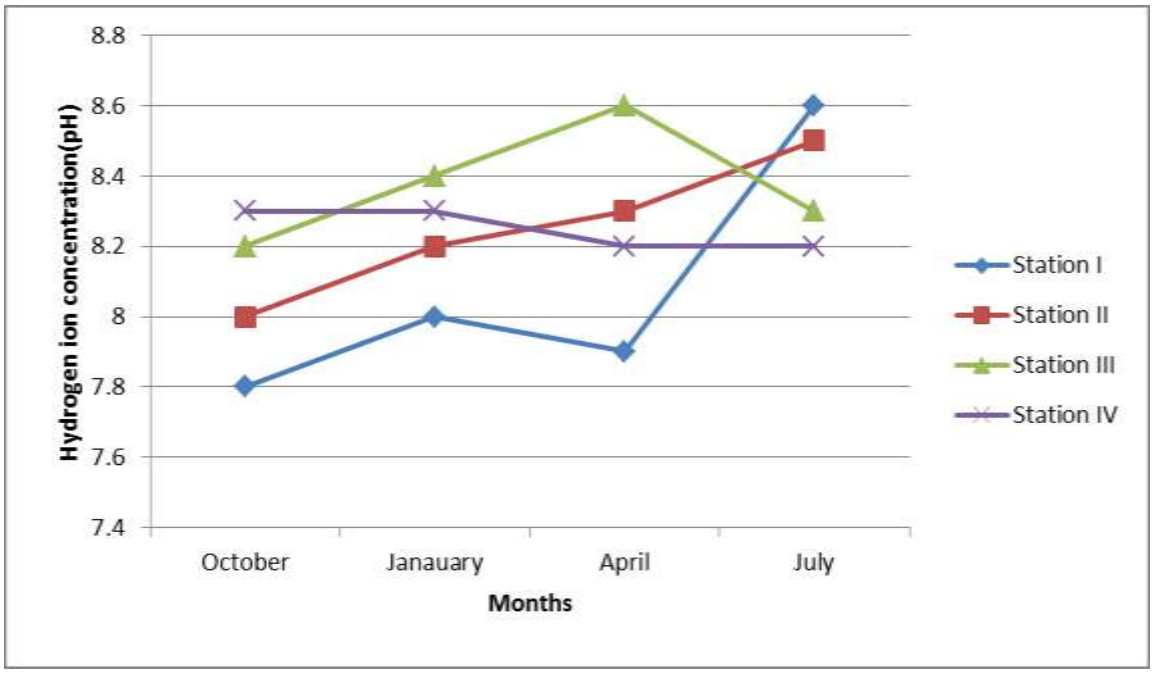


**Figure 7 Variations in $P^H$ value at different stations in different seasons.**

### 4.2.2 Dissolved Oxygen (D.O.)

The maximum dissolved oxygen in the river water was calculated to be 8.10 at station I and IV in the month of October and July respectively while it was lowest in the month of April at station IV which remained at 6.08. The concentration of dissolved oxygen in different stations at different month is depicted in **figure 8**.

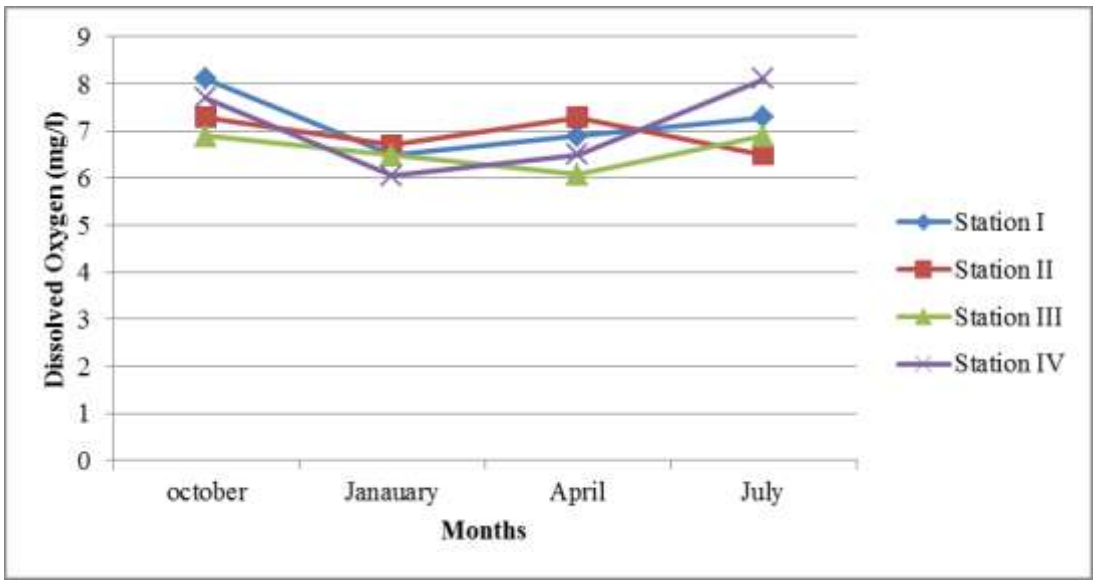


**Figure 8. Variation in Dissolved Oxygen (mg/l) at different stations in different months.**

### 4.2.3 Free Carbondioxide

The value of free carbon dioxide in the river water varied from 4.3 mg/l at station II in the month of April while its value remained at 13.3 mg/l at Station III in the month of January. Presence of free Co2 in the River Tinau during study period is presented in **Figure 9**.


**Figure 9 Variation in free carbon dioxide (mg/l) at different stations in different seasons.**

## 4.3 Fish Diversity of Tinau River

Fish diversity refers to the variety of fish species; depending on context and scale, it could refer to alleles or genotypes within fish population to species of life forms within a fish community and to species or life forms across aqua regimes (Burton et al. 1992). The Tinau river supports for the habitat of many fresh water fishes of many types like carps, barbs, minnows, catfishes, eels etc. 26 fish species are reported from the Tinau river, during the study period belonging to 4 orders, 9 families and 19 genera.

### 4.3.1 Systematic Position of Ichthyofauna from Tinau River

The identified fish of Tinau River are classified after (Jayaram 1999) and (Shrestha 2008).

I. Order: - Cypriniformes

Division- Cyprini

Sub order- Cyprinidae

Family-Cyprinidae

Sub family- cyprinae

Genus- *Cirrhinus* (Oken) Cuiver

*Cirrhinus reba* (Hmilton- Buchanan)

Genus- *Labeo* Cuvier

*Labeo calbasu*

Genus- *Neolissochilus* Rainboth

*Neolissochilus hexagonolepis* (McClelland)

Genus- *Puntius* Hamilton

*Puntius sophore*

*Puntius ticto*

Genus- *Tor* Gray

Tor tor (Hamilton- Buchanan)

Sub family- Cultrinae

Genus- *Salmostoma* (*oxygaster*) Vanhasse

*Salmostoma acinaces*

*Salmostoma bacaila*

Sub family- Rasborinae(Danioninae)

Genus- *Barilius* Hamilton

*Barilius barila* (Hamilton- Buchanan)

*Barilius bendelisis* (Hamilton- Buchanan)

Genus- *Brachydanio* Weber and de Beaufort

*Brachydanio rerio* (Hamilton- Buchanan)

Sub family- Garrinae

Genus- *Garra* Hamilton

*Garra gotyla gotyla* (Gray)

*Garra annandalei* (Hora)

Family- Cobitidae

Sub family- Nemacheilinae

Genus- *schistura* McCelland

*Schistura rupecola*

Sub family- Cobitinae

Genus- *lepidocephalus guntea* Bleker

*Lepidocephalus guntea* (Hamilton- Buchanan)

Sub family- Botinae

Genus- *Botia* Gray

*Botia lohachata* (Chaudhuri)

II) Order- Siluriformes

Division- Siluri

Sub-order Siluridae

Family- Bagridae

Genus- *Mystus* Scopoli

*Mystus bleekeri* (Day)

*Mystus vittatus*(Bloch)

Family- Siluridae

Genus *Wallago* Bleeker

*Wallago attu* (Schneider)

Family- Sisoridae

Genus- *Glyptothorax* Blyth

*Glyptothorax telchitta* ( McCellend)

Family- Claridae

Genus- *Clarias* Scolopi

*Clarias batrachus*

Family- Heteropneustidae

Genus- *Heteropneustes* Muller

*Heteropneustes fossilis* (Bloch)

III) Order- Synbranchiformes

Sub order- Mastacembeloidei

Family- Mastacembelidae

Genus- *Macrognathus* Lacepede

*Macrognathus pacalus* (Hamilton- Buchanan)

*Mastacembelus armatus* (Lacepede)

IV) Perciformes

Sub order- Channoidei

Family- Channidae

Genus- *Channa* Gronovius

*Channa orientalis* (Bloch and Schneider)

*Channa punctatus* (Bloch)

The distribution, abundance and frequency of fish species in Tinau River varied according to the stations and other parameters affecting them. Their distribution, abundance and frequency are given in the **Table 4** and **Table 5**.

**Table 4 Distribution of fish species found at different stations.**

| S.N. | Family | Scientific Name | Local Name | No. of individual in Stations<br>I II III IV |
|---|---|---|---|---|
| 1 | | *Barilius barila* | Fageta | 10 12 - |
| 2 | | *B.bendelisis* | Fageta | 23 28 48 - |
| 3 | | *Brachydenio rerio* | | 4 - - - |
| 4 | | *Cirrhinus reba* | Naini | 16 |
| 6 | | *G.gotyla* | Budhuna | 12 54 - |
| 7 | | *Oxygaster bacaila* | Chalwa | 6 |
| 8 | | *Puntius ticto* | Sidhre | 2 6 3 - |
| 9 | | *Puntius sophore* | Sidhre | 22 12 5 22 |
| 10 | | *Labeo calbasu* | Rohu | 6 |
| 11 | | *Neolissocheilus hexagonolepis* | Katle | 10 - - - |
| 12 | Cyprinidae | *Tor tor* | Sahar | 7 - - |
| | | | | |
| 13 | | *Salmostoma acinaes* | | 8 |
| 14 | | *Botia loha chata* | Baghi | 3 - - 7 |
| 15 | Cobitidae | *Lepidocephalus guntea* | | 6 |
| 16 | | *Schistura rupecula* | Gadela | 6 9 - |
| 17 | Bagridae | *Mystus vittatus* | Tengri | 12 |
| 18 | | *Mystus bleekeri* | Tengri | 10 |
| 19 | Siluridae | *Wallago attu* | Buhari | 8 |
| 20 | Heteropne-ustidae | *Heteropneustes fossilis* | Singhi | 8 - - - |
| 22 | Channidae | *Channa orientalis* | Bhoti/hile | 10 7 5 - |
| 23 | | *Channa punctatus* | Bhoti/hile | 20 - 7 15 |
| 24 | Claridae | *Clarias batrachus* | Mungri | 4 |
| 25 | Sisoridae | *Glyptothorax telchitta* | Kabhre | |
| 25 | Mastacem-belidea | *Mastacembelus armatus* | Chuche bam | 4 - - - |
| 26.. | | *Macrognathus pancalus* | Gainchi | 3 |
| | Total | | | 96 100 151 129 |

**Table 5 Abundance and frequency of fish collected in Tinau River.**

| S.N. | Family | Scientific Name | Abundance | Total number of fish | Frequency(%) |
|---|---|---|---|---|---|
| 1 | | *Barilius barila* | Common | 22 | 4.62 |
| 2 | | *B.bendelisis* | - | 99 | 20.79 |
| 3 | | *Brachydenio rerio* | Rare | 4 | 0.84 |
| 4 | | *Cirrhinus reba* | Common | 16 | 3.36 |
| 5 | | *Garra annanedalei* | Few | 11 | 2.31 |
| 6 | | *G.gotyla* | Common | 66 | 13.86 |
| 7 | | *Oxygaster bacaila* | Few | 6 | 1.26 |
| 8 | | *Puntius ticto* | Common | 11 | 2.31 |
| 9 | | *Puntius sophore* | Common | 61 | 12.81 |
| 10 | | *Labeo calbasu* | Few | 6 | 1.26 |
| 11 | | *Neolissocheilus hexagonolepis* | Few | 10 | 2.1 |
| 12 | Cyprinidae | *Tor tor* | Rare | 7 | 1.47 |
| 13 | | *Salmostoma acinaes* | | 8 | 1.68 |
| 14 | | *Botia loha chata* | Rare | 10 | 2.1 |
| 15 | | *Lepidocephalus guntea* | Few | 6 | 1.26 |
| 16 | Cobitidae | *Schistura rupecula* | _ | 15 | 3.15 |
| 17 | | *Mystus vittatus* | Occasional | 12 | 2.52 |
| 18 | Bagridae | *Mystus bleekeri* | Occasional | 10 | 2.1 |
| 19 | Siluridae | *Wallago attu* | _ | 8 | 1.68 |
| 20 | Heteropneustidae | *Heteropneustes fossilis* | Rare | 8 | 1.68 |
| 21 | | *Channa orientalis* | common | 22 | 4.62 |
| 22 | Channidae | *Channa punctatus* | Rare | 42 | 8.82 |
| 23 | Claridae | *Clarias batrachus* | Occasional | 4 | 0.84 |
| 24 | Sisoridae | *Glyptothorax telchitta* | Common | 5 | 1.05 |
| 25 | | *Mastacembelus armatus* | Occasional | 4 | 0.84 |
| 26.. | Mastacembelidae | *Macrognathus pancalus* | Occasional | 3 | 0.63 |
| | | Total | | 476 | |

**Order wise distribution of fish in Tinau River:**

The result revealed that Cypriniformes (75.21%) is most prevalence followed by Siluriformes (9.8%), Synbranchiformes (1.47) and Perciformes (13.02%) which is illustrated in **Figure11**.

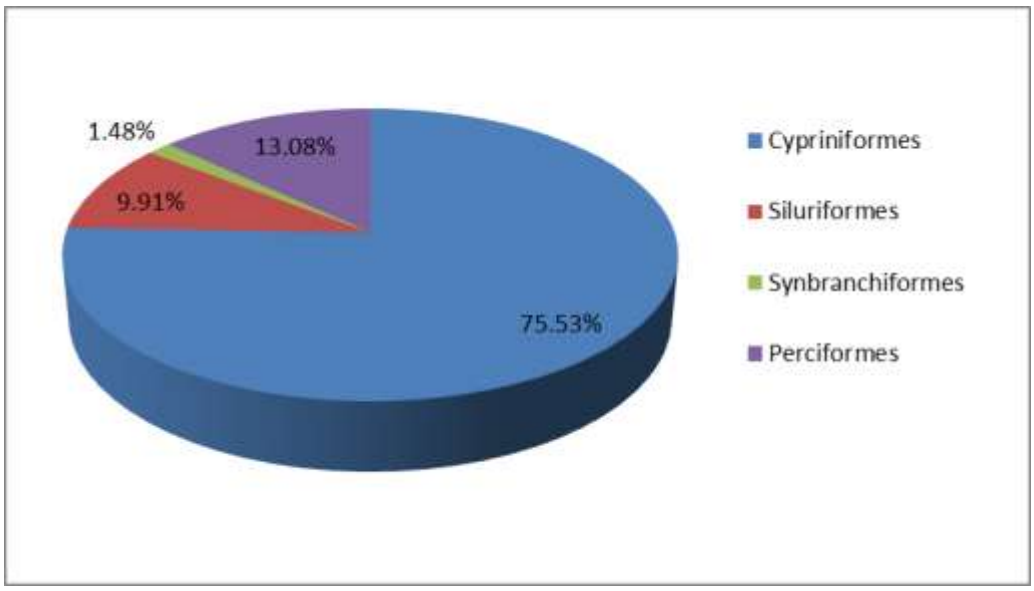


**Figure 10 Orderwise fish distribution in Tinau River.**

**Family wise distribution of fishes in Tinau River:**

The study revealed that the most abundant fish species is of Cyprinidae family which is (68.69%) followed by Channidae (13.44%), Cobitidae (6.51%), Bagridae (4.62%), Siluridae (1.68%), Heteropneustidae (1.68%), Mastacembelidae ( 1.47%), Sisoridae (1.65%) and Clariidae (0.84%) which is shown in Figure11**.**

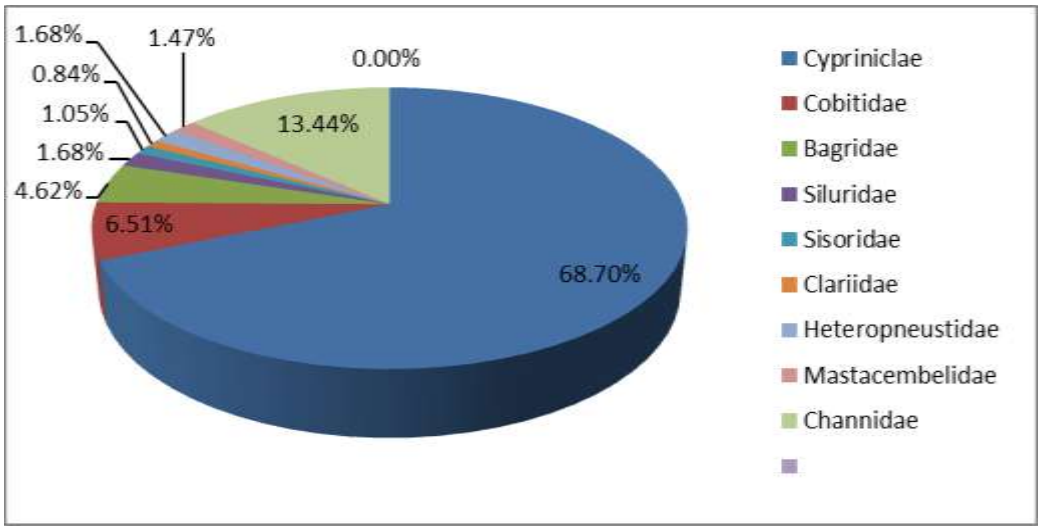


**Figure11 Family wise fish distribution in Tinau river.**

**Number of fish caught during study period**

During the study period all together 476 number of fish were caught. 22 were *Barilius barila*, 99 *B. bendelisis*, 4 were *Brachydenio rerio*, 16 were *Cirrhinus reba*, 11 were *Garra annanedalei* 66 were *G. gotyla*, 6 were *Oxygaster bacaila*, 11 were *Puntius ticto*, 61 were *Puntius sophore*, 6 were *Labeo calbasu*, 10 were Neolissocheilus hexagonolepis, 7were *Tor tor*, 8were *Salmostoma acinaes*, 10 were *Botia loha chata*, 6 *Lepidocephalus guntea*, 15were *Schistura rupecula*, 12 were *Mystus vittatus*, 10 were *Mystus bleekeri*, 8 were*Wallago attu*, 8 were *Heteropneustes fossilis*, 22 were*Channa orientalis*, 42were *Channa punctatus*, 4 were *Clarias batrachus*, 5 were *Glyptothorax telchitta*, 4 were *Mastacembelus armatus* and 3were *Macrognathus pancalus* which is presented on **Figure 13.**

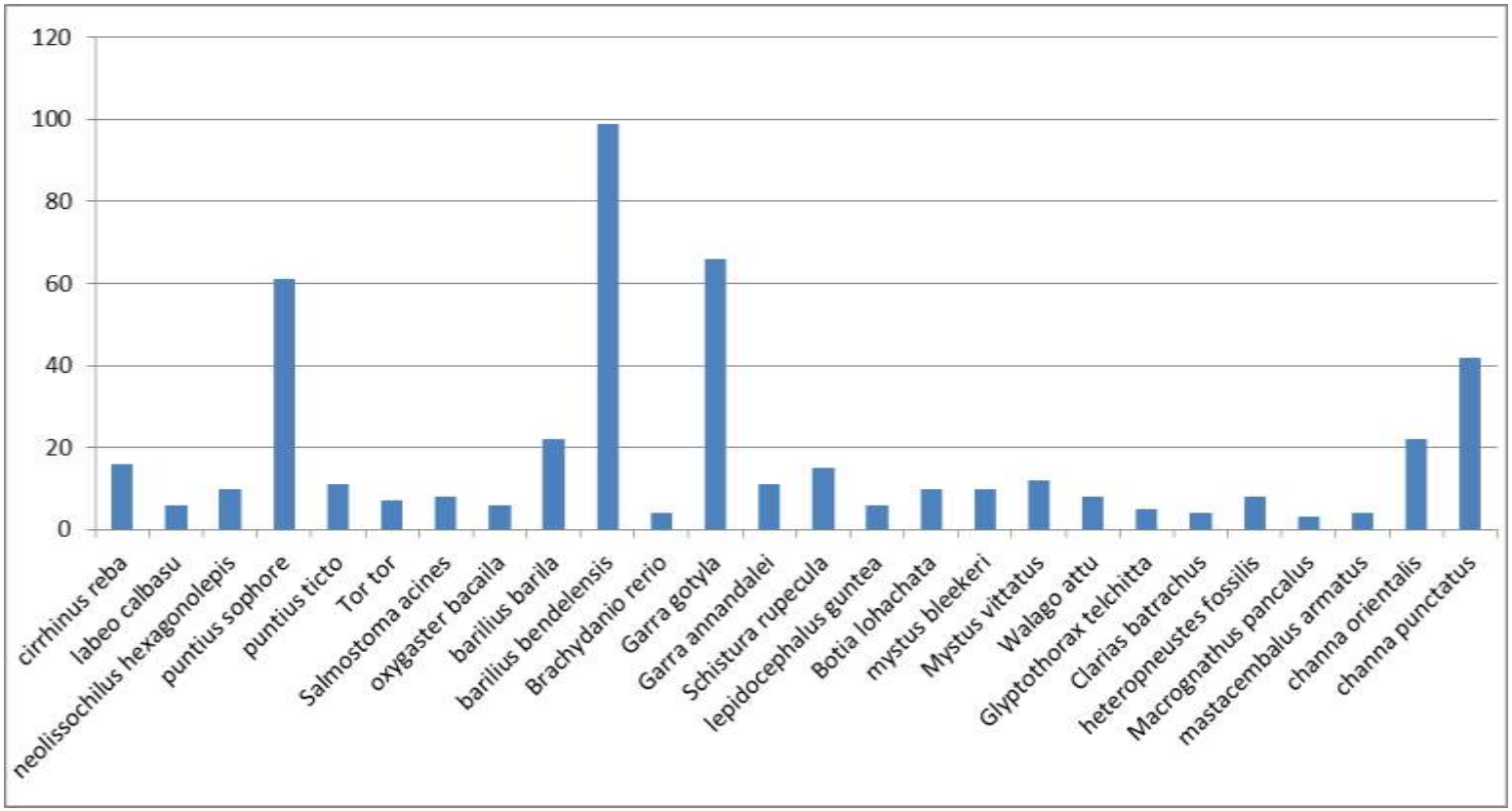


**Figure 12 Number of fish species caught during study period**

### 4.3.2 Correlation between the physiochemical parameter and number of fish collected

The coefficient of correlation was implied for analyzing statistically between various physiochemical parameters with the number of fish collected from each station using Karl Pearson's correlation coefficient method. Also probable error for each correlation coefficient was calculated for each station. The correlation coefficient between physical parameters such as water velocity, temperature and turbidity is positive in all stations. In contrast, the correlation coefficient between transparency of the water and the fish is negative. The relationship between the chemical parameters and the number of fish collected and the number of fish collected is positive similarly the chemical parameters of water showed positive as well as negative correlation with the number of fish composition at different stations. The correlation coefficient between various physiochemical parameters and the number of fish collected in each station and the probable error is given in the **Table 6.**

**Table 6 Correlation Coefficient between the water quality parameters and number of fish collected**

| S.N | Variants | Station I | | Station II | | Station III | | Station IV | |
|---|---|---|---|---|---|---|---|---|---|
| | | R | P.E(r) | R | P.E (r) | R | P.E(r) | R | P.E (r) |
| 1 | Correlation between water velocity and no. of fish caught. | 0.94 | 0.03 | 0.88 | 0.07 | 0.94 | 0.03 | 0.71 | 0.16 |
| 2 | Correlation between temperature and the no of fish caught | 0.74 | 0.15 | 0.8 | 0.12 | 0.35 | 0.29 | 0.41 | 0.28 |
| 3 | Correlation between transparency and the no. of fish caught | -0.89 | 0.07 | -0.85 | 0.09 | -0.99 | 0.006 | 0.98 | 0.01 |
| 4 | Correlation between turbidity and the no. of fish caught | 0.85 | 0.09 | 0.81 | 0.11 | 0.99 | 0.006 | 0.99 | 0.006 |
| 5 | Correlation between PH and the no. of fish caught. | 0.77 | 0.13 | 0.69 | 0.17 | -0.25 | 0.31 | -0.5 | 0.24 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 6 | Correlation between D.O and the no. of fish caught. | 0.2 | 0.32 | -0.2 | 0.32 | 0.48 | 0.25 | 0.78 | 0.13 |
| 7 | Correlation between CO2 and the no. of fish caught. | 0.36 | 0.29 | -0.15 | 0.32 | -0.17 | 0.32 | 0.81 | 0.11 |

### 4.3.3 Diversity status

The value of Shannon Wiener diversity index (H0) and Margaleafrichness (M) were calculated according to month and stations. Highest Shanon-weiner diversity index was found in station IV(1.14) and the lowest was found in station I(0.80) similarly. Higher Shannon diversity index values were found in July (1.11) where low during October (0.70). No significant difference was found in the mean Shannon diversity index among the stations and months.The maximum margalef richness value was observed 6.63 at station IV where minimum value was observed 3.67 at station III. Higher margalef richness value was found 9.97 during April where lower value 5.26 observed during Janauary. Similar to Shannon diversity index no significant difference was observed in mean margalef richness value among the stations and months. Evenness index was found to be highest at station III(1.18) and the lowest was found in the stationI(0.83). Highest evenness value was found 0.97 in Janauary and lowest value observed 0.63 in April. No significant difference was found in evenness value among the months and stations. The value of Shannon-weiner diversity, Margalef richness and the evenness in different station and in different seasons are presented in the **Figure 13**.

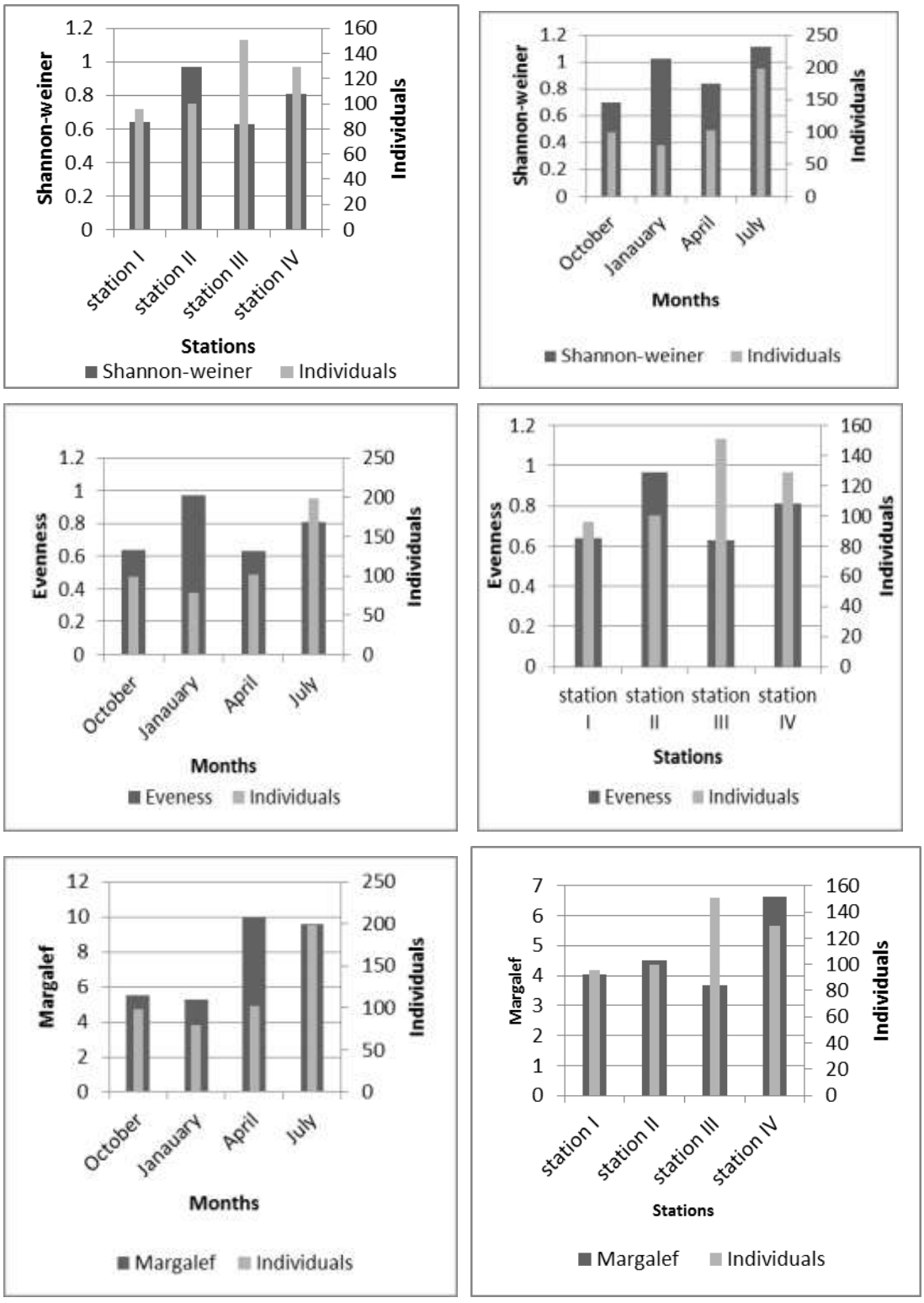


**Figure 13. Different fisheries diversity status at Tinau River.**

## 4.4 Fishing implements and fishing methods used in Tinau River

There are different methods used for catching fishes in Tinau River. On the basis of fishing practice the fishing methods can be categorized as;

a) Conventional fishing method

b) Non- conventional fishing method

a*)* Conventional fishing method

In this type of fishing method, traditional practices are implied. The traditional methods of catching fishes in Tinau River are;

i) Nets

Nets are far most widely used fishing gear in Tinau River. The nets are of different sizes and types and are implied in accordance with the season and the river condition. These nets are made up of nylon. Different types of nets used for fishing in Tinau River during the investigation period are;

ii) Gill net

Gill net is locally called as "Mahajaal". This net is rectangular and tied across the water and is fixed horizontally overnight. Next morning the fishes are collected. More than two persons are required to operate this net. It was found that childrens in their holidays enjoying with this Mahajaal at station I. Generally this type of net is used in the month of little flood in the Tinau river of plain and mid- hill.

iii) Cast net

It is round in shape and is locally called as "Jaal". The net is usually operated by a single person. It was found to be used in plain water of station I, III and IV. While throwing this net over a fish, it spread like an umbrella. The perimeters being weighted by sinkers it prevents the escape of fish from the net. Generally the occasional as well as professional fishermen were seen to use this type of net in Tinau River.

iv) Ghorlang

This net consists of a long wooden handle fixed with a circular wooden rim. A conical net is fixed on the wooden rim. Although it can be used in the fat moving water, it is mostly

preferred in the slow moving water. It can be operated by a single person. Mostly fishing community from Station IV and II were seen using this type of fishing equipment in Tinau River.

v) Chanki

Although this type of fishing method is mostly used in ponds of terai, during the study period it was seen being used in the slow moving water at station IV. It was made of two bamboo flanks crossed each other and tied fast at the midpoint. A square nylon net was loosely tied at four ends of bamboo flanks. Fisherman used it by dipping net in water and lifting it up. Mostly it was used for catching small fishes and prawn.

vi) Hook and line

Fishing with a rod and line is locally known as "balchii hanne". The local balchi is made from the rim of umbrella. The hook is baited with the food preferred by fish and dip in the water. The fish in its attempt to grab the bait is hooked at its barb from which it cannot free itself. Nowadays the motor hook and line is used for catching fish which is efficient than the homemade. It was seen during the study period that mostly children enjoy this type of implements. It was seen using in all stations.

vii) Fishing with a bow and arrow ( Tir hanne):

Fishing with bow and arrow is seldom used by small children. Shooting the fish with bow and arrow requires clear water and an appropriate allowance for refraction of light in order to hit rightly on the fish as seen in water. During the investigation period it was seen to be used in station II only.

b) Non – conventional fishing methods*:*

The nontraditional and recently developed fishing method is known as Non- conventional fishing practice. The different types of recent methods used for catching the fishes in Tinau River are Electro fishing, poisoning. Though these methods are banned in the Tinau River, it was heard using this method at certain hours of day like at night or at early morning. And during the study period it was seen that using some unique type of net that was given with electricity.

viii) Electro fishing:

In this method electricity is applied for catching fishes from small shallow river. Though it is illegal nowadays but people still are using this sort of method in Tinau river. It kills not only the desired fish but also other small species of fishes are also killed. It also affects other organisms inhabiting the water. In electrical fishing an electric field is produced in water between the two electrodes, anode and cathode. The electric current applied may be A.C, D.C or I.C.

During the investigation period it was not seen using this type of method though it was heard to be using this type of method still.

ix) Use of poisons:

Use of poisons is another type of non-conventional fishing method used in Tinau river. It is locally called as "Bikh halne".Plants like Khirro (*Sapium insigne*), ketuke(*Agave americane*), Mahuwa(*Madhuca indica*), Sihudi(*Euphorbia valyelane*), Pire sanewar(*Polygunum hydropiper)* etc. are used as plant poison. Also some chemicals such as DDT (Dichloro diphenyl Trichloroethane), Malathion are also used for fishing. These poisons either directly kills the fish or it paralyze them which makes fishing efficient. Fishes are either collected using hand or using nets.

### 4.5 Effect of Dam and Irrigation canal on fishery in Tinau River

The different developmental activities have led to obstruction on the normal behavior and activities of the fish fauna in the Tinau river. Among the varied activities the construction of dam and the irrigation canal is the serious causative factors for affecting the abundance and distribution of fish populations in the Tinau River.

#### 4.5.1 Effect of hydropower dam

Dams constitute a major threat to global freshwater species diversity (Vŏrŏsmarty et.al 2010) ;they lead to loss of native species but also to invasion by exotic species, partly because exotic species are likely to establish in modified or degraded freshwater.( Poff et. al 2007). Dams remove turbulent river sections and create tranquil water bodies, thus affecting for example, flow and temperature regimes, sediment transport and species communities. The shift from lotic to lentic environments after dam construction often favors generalist over specialist species, and it alters assemblages of taxonomic groups

and puts endemic species at particular risk of extinction which leads to biotic homogenization (Rahel 2000, Poff et al. 2007).

Dams retain sediments which limits the downstream substrate available for critical life-stage habitats such as nesting and refuge for many species (Černỳ et al. 2003). Dams inhibit organism migration, alter and fragment habitats, and reduce resources transport throughout rivers thus affecting species distributions among aquatic trophic levels and terrestrial ecosystems (Pringle et al. 2000). For resident or Potamodromous fish competition for spawning sites and food can increase as dam disconnect isolate and reduce the number and size of habitats (Cambray et al. 1997). Genetic pools of resident populations may also decrease with the isolation created by dams (Nielsen et al. 1997). Sometimes this isolation may prove beneficial for native biota by blocking the entry of massive species (Mclaughlin et al 2007) or of pollutants, parasites or diseases into the habitat.

Dam of Tinau River has obstructed the migratory and current loving fishes. The dam was constructed in 2022 B.S without Environmental Impact Assessment (EIA). Hence the effect on the faunal distribution and diversity before and after the construction of dam cannot be recognized. The migratory fishes both long distance and short distance migrants are affected by the construction of dam in Tinau River according to the elder fisherman. According to these aged fishermen there is considerable reduction in the size and weight of the fisherman. A lot of migratory fishes such as Raja bam (*Anguilla bengalensis)* , Jalkapur *(clupisoma garua)* and many other fish species have declined in the upper region and there is also increase in the number of sidra *(Puntius* spp.) Fageta (*Barilius* spp.) , Buduna *(Garra* spp.). Similarly according to the downstream fisherman there is also considerable reduction in the catch of native upstream fishes which they consider due to the construction of dam in Tinau River. There is no fish ladder in the dam hence it is difficult for migration of fish species.

### 4.5.2 Impact of Irrigation Canal

During the investigation period, it was found that irrigation dam had caused adverse impact on the diversity and distribution of the fish species in Tinau River by altering the ecology of the river. It has changed the upper part of the canal into a small reservoir, where there is a heavy deposition of mud and organic matters due to which there is massive growth of vegetation. It was also found that the effect of this canal had comparatively less impact on the upper region of the canal system than on the lower

region of the system. It was observed that the water in the canal was totally diverted into the canal system except in the rainy season. In the dry seasons several pockets of water bodies were seen which harbors a few species of fish which becomes easier to be caught by human as well as to the predatory birds. Migratory fishes are affected by this agricultural process.

## 4.6 Socio-economic Status of Fisherman in Tinau River

The socio-economic condition of fisherman depending on the fish community of Tinau River was investigated through the Questionnaires, and through the informal interviews. Despite most of the fishing communities were the people living near the river, the people living farther also rely on the fishing activities for their livelihood. During the investigation period, it was known that the people engaged totally on the fishing are called as "Jalari". In general fishing communities in the Tinau River can be distinguished into three types

### 4.6.1 Full time fisherman

The fisherman in this type are called as "Jalari" or "Majhi". They were from Mukhiya or "Yadav" caste group. Full time fishermen were seen only in the station III and IV during the study period. These old fisherman were fishing in the Tinau river for a long time. Most of the catches were sold to the market by this people According to these fishermen; the average catch was 2-3 kg fish per day depending upon the season and the level of water in the river. They sell this catch in the market for 200-250 per kg.

### 4.6.2 Part time fisherman

Most of the fishermen in this river fall under this category. They belong to Magar, Tharu, Dhimal etc. caste group. During the investigation period, at all station except in station IV these types of fishermen were found. They had a farmland in which they spend their most of the time and during the leisure period they would catch the fish. They consume almost all the catch and they rarely sell them to the nearby market.

### 4.6.3 Occasional fisherman

These types of fishermen can be said as recreational fishermen. Mostly young children and adults too in their off period were seen fishing. Students in their holidays were seen using hook and line and adults using nets for fishing. During the investigation period

these type of fisherman were mostly seen in the Station I and III. They consume almost all the catch and when asked they said they do not sell them.

Almost, in all season fishing activities were seen to occur in the Tinau River except during heavy flood at the Tinau River. Although women were not seen fishing but they were engaged in preservation of the fish such as drying and at station I and IV they were seen selling the fishes in the market. Economically the fisherman relying on the fishes of this river were not so poor. They do not have the marketing problems. Although fisherman from Station IV were landless to be engaged in farming but their catch was almost sufficient for meeting their family needs.

Although the older people were illiterate they were seen aware of their children education. They were sending their children at schools without any discrimination. Most of the fishermen in the Station IV were seen living in a joint family. Most of the family members ranged from 8-10, were recorded during the study period.

# 5 DISCUSSION

The current study reveals that 26 fish species existing in Tinau River belonging to 4 orders, 9 families and 19 genera. The study was done to determine the diversity of fish species with references to seasonal variation at different stations. Similarly Sharma and Shrestha (2001) and Shrestha (2005) reported 35 and 36 species of fish in the Tinau river and Dano river respectively. Out of all species collected cyprinids constitute the major one. It ranked at higher with (68.70%) followed by Channidae (13.44%). Recently (Negi and Negi 2010) reported Cyprinidae as the most dominant group during the study of the fish assemblage structure in the streams of Kumaon Himalayas of Uttarkhand state of India. The order Cypriniformes remained dominant constituting (75.53%) followed by Perciformes (13.08%) and then Siluriformes (9.91%) and lastly Synbranchiformes which was only 1.48% during the study period. (Mandal and Jha 2013) also reported cypriniformes constituting major ones in the Marshyangdi River in Lamjung district of Nepal. Shrestha (1981) has recorded 8 species of fish from the Tinau River which are *Amblyceps mangois, Barilius bola, Danio devario, Garra* spp. of which only *Garra gotyla* and *Garra annandalei* were recorded during the entire study period.

The most commonly found fish during the investigation period were *Barilius bendelensis, Puntius sophore,* and *Garra gotyla* during the study period. The rare fish collected were *Tor tor* and *Brachydenio rerio*. Similarly Sharma and Shrestha (2001) and Shrestha, (2005) also reported Tor tor as a rare fish collected.

Water colour of the river Tinau was observed to be clear all year around except during monsoon (July) which influences the turbidity and transparency of river water. Water velocity plays important role in determination of habitat and abundance of flora and fauna in a river by grading the riverbed and material and maintenance of high level of dissolved oxygen (Whiton 1975). Velocity of the Tinau River was higher during the rainy season (July) and lower during other seasons. The velocity of water ranged from 0.15m/s at station IV in the month of April and was maximum at station II in July, it is due to its relation with the slope gradient of river bed . The growth , reproduction and other biological activities of fish are controlled by temperature . During the study period temperature was recorded to be lower at station I and higher at station III and IV which were 18℃ and 30 ℃ respectively. Temperature of the river water showed positive correlation with the distribution of fish species. Similarly, Sharma and Shrestha (2001) found temperature being positively correlated with the number of fish collected. Turbidity

in the natural water restricts the penetration of light thereby reducing the photosynthetic activity hence, acts as a limiting factor for productivity. The level of turbidity was found higher at the station IV which suspended as 292.39mg/l and lower as 8.95mg/l. According to Swingle (1967) pH 6.5-9 is suitable for fish and pH more than 9.5 is unsuitable because free co2 is not available in this situation. The value of Hydrogen ion concentration in the river Tinau was observed to be higher at station III and I which was 8.6 and lower at station I which was 7.8 in the month of October. The pH of the river Tinau showed positive correlation with the number of fish collected. Dissolved oxygen above 5 mg/lt is suitable for the support of diverse biota (APHA 1976). During the investigation period it never lowered than 6.08mg/ lt. It means that river Tinau had favorable D.O concentration for the fish diversity. It was observed to be higher at station I and IV and lower at station III in the month of April, during the study period. Free Co2 more than 20 ppm may be harmful to fishes and even lower concentrations may be equally harmful when Co2 concentrations are less than 3-5 ppm (Lagler 1972). Free Co2 was found higher at the station IV in the month of January and lower was found in station II in the month of April during the study period. Sharma and Shrestha (2001) reported about 83% of fisherman of this River was totally illiterate but quite different result was obtained during the investigation period. Although few old fisherman were found to be totally illiterate most of them now had gone to school it was found that more than 60% fisherman had reached to school. They were found conscious for their children education. Although Shrestha (2005) stated marketing problems of fish in Dano River but it was found that the fishermen do not have marketing problems in all station during the study period.

The concept of the ‘‘species diversity’’ involves two components: the number of species or richness and the distribution of individuals among species. However, the formal treatment of the concept and its measurement is complex (Williamson 1973). A biodiversity index tries to characterize the diversity of a sample or community by a single number (Magurran 1988). Shannon–Wiener diversity index considers the richness and proportion of each species while Evenness represents the relative number of individuals in the samples. The biodiversity index values obtained from current investigation is not so very high according to Shannon-Weaver biodiversity index values and they do not exactly depict the differences occurring among the stations either. The reason for showing lower species biodiversity is that fishing gears used have high selectivity effect (Keskin and U¨ nsal 1998). The equipment effect of the fishing gear and methods used in this study was

ignored. Highest Shannon diversity index was found in station IV and July month where lowest was observed at station I and during October. The main causes of the differences occurring in the biodiversity indexes are atmospheric air currents and environmental conditions (Keskin and U¨ nsal, 1998), and seasonal fish migrations (Ryer and Orth 1987). The evenness index had the lowest value in April and the highest value in January, where the highest and lowest poled Evenness recorded in station III and station I respectively. The maximum margalef richness value was observed at station IV where minimum value was observed at station III and in case of month higher richness value was found during April where lower value observed during Janauary. During the study period in the value of Shannon (H), Evenness (e) and Mergalef (d) diversity no significant difference was observed. Therefore, it may be considered that the seasonal difference in species diversity is a common phenomenon in the studied area.

# 6 CONCLUSION AND RECOMMENDATIONS

## 6.1 Conclusion

The Tinau River supports for the habitat of many fresh water fish of many types like carps, barbs, minnows, catfishes, eels. The diversity of fish species in Tinau River was observed with references to the seasonal variation. A total of 26 fish species have been collected from this particular river, belonging to 4 orders, 9 families and 19 genera. Most commonly observed fish during the study period are *Garra* spp. and *Puntius* spp. While the rare caught fishes were *Tor tor* and *Brachydenio rerio.* Cyprinidae family remained dominant throughout the study period. It has seemed that physiochemical parameters being related with the composition and distribution of the fishes in the Tinau River.Highest Shannon weiner diversity index was observed in station IV (1.14) and in the month of July(1.11). Similarly, the maximum richness was observed in station IV(6.63) and in the month of April (9.97). Evenness index was found to be higher in January (0.97) and in the station III(1.18). No significant difference in the diversity status was obtained during the investigation period rather it was a seasonal phenomenon in the composition of fish species

## 6.2 Recommendations

- It is recommend that development of fish ladder especially for the population of migratory fishes such as *Tor tor*, *Neolissochilus hexagonolepis* and *Anguilla bengalensis* should be made for the easy passage.
- Since the natural fish stocks may deplete rapidly due to over fishing and aquatic pollutions, it would be better to make efforts for conservation of habitats and fish species by educating local communities.
- Further studies on native fish populations, their catch and socio-economics of fisher communities depending on fishing can give foresight to develop strategies to sustain and develop the capture fisheries in this river.
- Poisoning of water bodies and other destructive fishing practices should be controlled and should be punish according to the law.
- Breeding season of the fishes should be recognized and the strict laws should be implemented against fishing activities in these vary seasons.
- The information flow on fish diversity is scanty limited in the country. In such a gap of knowledge on fish diversity, it is advisable to have government plan,school syllabus, so the knowledge on fish taxonomy and conservation could be prioritised.

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# APPENDICES

## Appendix-I Data for the physio-chemical parameters of water

Table 1: water velocity (m/s) in different stations

| Months | Stations | | | |
|---|---|---|---|---|
| | Station I | Station II | Station III | Station IV |
| October | 0.25 | 0.47 | 0.27 | 0.2 |
| January | 0.23 | 0.35 | 0.52 | 0.63 |
| April | 0.47 | 0.66 | 0.56 | 0.15 |
| July | 1.11 | 2 | 1.25 | 0.83 |

Table 2: Temperature ($^0$ C) in different stations

| Months | Stations | | | |
|---|---|---|---|---|
| | station I | Station II | Station III | Station IV |
| October | 28 | 27 | 29 | 27 |
| January | 18 | 21 | 22 | 20 |
| April | 28 | 26 | 30 | 31 |
| July | 28.5 | 27 | 29 | 30 |

Table 3: Transparency (cm) in different stations

| Months | Stations | | | |
|---|---|---|---|---|
| | Station I | Station II | Station III | Station IV |
| October | 66 | 68 | 70 | 69 |
| Janauary | 69 | 72 | 71 | 68 |
| April | 63 | 65 | 69 | 64 |
| July | 5 | 12 | 6 | 3 |

Table 4: Turbidity( mg/L) in different stations

| Months | Stations | | | |
|---|---|---|---|---|
| | Station I | Station II | Station III | Station IV |
| October | 9.78 | 9.49 | 9.21 | 9.35 |
| January | 9.35 | 8.95 | 9.08 | 9.49 |
| April | 10.25 | 9.93 | 9.35 | 10.09 |
| July | 152.32 | 57 | 122.95 | 292.39 |

Table 5: PH in different stations

| Months | Stations | | | |
|---|---|---|---|---|
| | Station I | Station II | Station III | Station IV |
| October | 7.8 | 8 | 8.2 | 8.3 |
| January | 8 | 8.2 | 8.4 | 8.3 |
| April | 7.9 | 8.3 | 8.6 | 8.2 |
| July | 8.6 | 8.5 | 8.3 | 8.2 |

Table 6: D.O (mg/l) in different stations

| Months | Stations | | | |
|---|---|---|---|---|
| | Station I | Station II | Station III | Station IV |
| October | 8.1 | 7.29 | 6.89 | 7.7 |
| January | 6.5 | 6.7 | 6.48 | 6.05 |
| April | 6.89 | 7.29 | 6.08 | 6.49 |
| July | 7.29 | 6.49 | 6.89 | 8.1 |

Table 7: Free co2(mg/l) in different stations

| Months | Stations | | | |
|---|---|---|---|---|
| | Station I | Station II | Station III | Station IV |
| October | 6.7 | 5.3 | 9.4 | 8.8 |
| January | 8.2 | 10.6 | 13.3 | 14.2 |
| April | 5.4 | 4.3 | 6.8 | 8.6 |
| July | 9.8 | 9.6 | 9.4 | 11.3 |

Table 8: Total number of fish collected in different stations in different Months

| Months | Stations | | | |
|---|---|---|---|---|
| | Station I | Station II | Station III | Station IV |
| October | 22 | 23 | 28 | 26 |
| January | 19 | 15 | 25 | 20 |
| April | 25 | 27 | 30 | 20 |
| July | 30 | 35 | 70 | 63 |
| Total | 96 | 100 | 151 | 129 |

Table 9: Order wise fish species composition in Tinau River

| Order | Species composition (%) | no. of fish species |
|---|---|---|
| Cypriniformes | 75.21 | 16 |
| Siluriformes | 9.87 | 6 |
| Synbranchiformes | 1.47 | 2 |
| Perciformes | 13.02 | 2 |

Table 10: Family wise fish species composition in Tinau River

| Family | species composition(%) | Total number of fish |
|---|---|---|
| Cyprinidae | 68.69 | 327 |
| Cobitidae | 6.51 | 31 |
| Bagridae | 4.62 | 22 |
| Siluridae | 1.68 | 8 |
| Sisoridae | 1.05 | 5 |
| Clariidae | 0.84 | 4 |
| Heteropneustidae | 1.68 | 8 |
| Mastacembelidae | 1.47 | 7 |
| Channidae | 13.44 | 64 |

Table 11: Diversity status in different stations

| | Stations | | | |
|---|---|---|---|---|
| | Station I | Station II | Station III | Station IV |
| Shannon-weiner | 0.8 | 0.91 | 1.13 | 1.14 |
| Margalef Richness | 4.03 | 4.5 | 3.67 | 6.63 |
| Evenness | 0.83 | 0.91 | 1.18 | 0.96 |

Table 12: Diversity status in different months

| | Stations | | | |
|---|---|---|---|---|
| | October | January | April | July |
| Shannon-weiner | 0.7 | 1.02 | 0.84 | 1.11 |
| Margalef Richness | 5.51 | 5.26 | 9.95 | 9.57 |
| Evenness | 0.64 | 0.97 | 0.63 | 0.81 |

## Appendix-II Representative photographs

*Barilius barilla*

*Botia lohachatta*

*Brachydenio rerio*

*Neolissocheilus hexagonolepis*

*channa orientalis*

*Garra gotyla*

*Heteropneusteus fossilis*

*Glyptothorax telchitta*

*lepidocephalus guntia*

*Macrognathus panclus*

*mastacembalus armatus*

*Mystus vittiatus*


*Tor tor*

*Schistura rupecula*

*puntius sophore*

*Oxygaster bacaila*

*Salmostoma acinaes*

*B. bendelisis*

*Puntius ticto*

*Labeo calbasu*

*Cirrhinus reba*

Fishing implements used by fisherman in Tinau River

A child using hook and line

part time fisherman at Dhamkada

Occassional fisherman near Dovan

fisherman near Dovan

Tinau River(Bethari)

Irrigation canal in Butwal

Tinau River(Dhamkada)

Lab work (CDZ)