CHAPTER - I

1.0 Introduction

1.1 Topography, Geography and Climate

The Himalayan country of Nepal is situated on the southern slope of the Central Himalaya with the formidable range of world renowned snow capped mountains. Nepal is bounded on the north by Tibet region of China and on the south, east and west by India. Nepal is roughly rectangular and elongated in shape having about 885 km. in length (east-west) and 193 km. in breadth (north-south). The altitude of Nepal ranges from 70 m. above sea level in Terai region (south) to 8848 m., the highest peak of the world, Mount Everest in the North. Nepal is situated on the Northern hemisphere in between 26°22' to 30°27' north latitudes and 80°4' to 88°12' east longitude with the total area of 1,47,181 sq .km. According to altitudinal variation, there are three distinct geographical regions in Nepal viz. the Himalayan Region, the sub Himalayan Region and lower plain of Terai Region. The Himalayan Region contributes about 15% (22,077 sq. km.) of the total area of Nepal (Amatya and Shrestha, 1967). The sub Himalayan region or mountainous region is about 68% and the Terai region contributes about 25% of the total area of Nepal. Nepal has extremely contrast climatic and altitudinal variations. The climate of Nepal is greatly influenced by altitudinal variation. Due to the altitudinal effect, the temperature distribution in Nepal is not uniform - warmer low lands like Terai, inner-Terai and mid lands and cooler midhills and the Himalayan region.In general, temperature increases from March to July and decreases from October to January (Pandey, 1987).

1.2 Water Resources

The total area of inland water bodies like river systems, lakes, reservoirs, village ponds, wetlands and irrigated rice fields is 818,500 ha. in Nepal (FDD, 1998). Various inland water resources existing in the country provide a great

scope for the expansion of fisheries. The natural water resources comprise approximately 48.8% of the total water area of Nepal (Table 1) (FDD, 1998).

Table –1 : Water Resources of Nepal

S.N.	Resource Details	Estimated Area (ha).	Coverage %	Potential areas
1.0	Natural water systems			
1.1	Rivers	395,000	48	-
1.2	Lakes	5000	0.6	-
1.3	Reservoirs	1,500	0.2	78,000
2.0	Village ponds	6,5000	0.8	14,000
3.0	Marginal swamps around irrigated fields	12,500	1.4	-
4.0	Irrigated rice field	398,000	49.0	
		818,5000	100.0	92,000

Source: Fisheries Development Division (FDD), 1998.

1.2.1 Rivers

The rivers are the major constituents of water resources in regard to coverage (Table 1). There are more than 6,000 rivers in Nepal with a total length of 45,000 km. There are three major rivers systems and each river system has seven main tributaries. They are i) Sapta Koshi in the east ii) Sapta Gandaki in the mid region and iii) The Sapta Karnali in the west. Besides these, Kankai, Kamala, Mechi, Babai, Rapti, Tinau, Mahakali rivers are also equally important rivers. All these river systems constitute the 48% of the total water area of Nepal which drains into the Ganges system in India. The combined run off from all rivers of Nepal contributes 40% of the annual flow of the Ganges river and 71% of the dry season flow (Abbas, 1982; cited in Shreshta, 1992).

Hydrologically, the rivers of Nepal can be divided into i) Purely rain fed rivers and ii) Snow plus rain fed. The rivers of shorter lengths are seasonal and dry up from time to time. But the snow fed rivers, the melting of the snow of the Himalayas in dry season maintains certain water flow. The rivers of Nepal loose their speed as they reach the southern plain or Terai region and deposit silt in the fertile flood plains.

1.2.2 Lakes

There are several lakes scattered all over the country. The estimated area of lake is about 5,000 ha that is 0.6% of the total existing water areas. The lakes can be categorized into 3 types on the basis of their origin viz. 1) glacial, ii) oxbow and iii) tectonic. There are 17 major glacial lakes in the northern Himalayan region which are located above 4000 m. altitude. Tectonic lakes occur in the hill region. The most of the lakes of Nepal are tectonic origin which when drained out were replaced by flat basins. The Kathmandu valley, Banepa, Panchkhal, Mariphant (Palpa), Dang, Surkhet, valleys are the good examples of such basins. Oxbow lakes are mainly confined to the southern part of the country.

1.2.3 Reservoirs

There are few reservoirs with a total area of 1500 ha. comprising 0.2% of the total existing water area of Nepal. These reservoirs are mainly constructed for hydroelectric and irrigation purposes. Among the existing reservoirs, the Indrasarobar reservoir, Kulekhani is newly impounded reservoir for producing hydroelectric power by damming Kulekhani river in the mid hill region of Nepal. Other existing reservoirs are Trisuli (16 ha.), Marsyangdi (62 ha.), Panauti, Sunkoshi for irrigation & generating hydroelectric power. The estimated 78,000 ha reservoirs will be added for hydropower generation and irrigation from Gandaki basin (45, 000 ha.), Bagmati river (9,000 ha.) and Karnali river (24,000 ha.) (FDD, 1993). It is estimated that 50,00,000 ha of water surface will be available for fish production; out of which approximately 100,000 hectares would be from lakes, reservoirs and village ponds (Pant, 1995)

1.3 Fish Resources

The Himalayan country, Nepal occupies a large part of the central Himalaya which supports the varying array of water bodies supporting biologically

diverse fish fauna. According to Shrestha (1998), there are one hundred and eighty five fish species belonging to 79 genera, 31 families and 11 orders. None of the fishes of Nepal are listed for protection under the category of IUCN and cites. However realizing the present status of fishes, some fishes are identified for protection. 25 species of fishes are categorized as threatened (vulnerable, endangered and rare species) comprising 18.2% of total number. Ninety species comprising 48.3% have commonly/occasionally recorded status and 62 species (33.3%) kept in insufficiently known status (Table 2) (Shrestha, 1995).

Table– 2 : Status of fish species in Nepal

Status	Categories	No. of species
Common/ occasional		90
Insufficiently Known	K	62
Vulnerable	V	9
Endangered	E	1
Rare	R	24

Source: Shrestha, 1998

The vulnerable species include *Neolissochilus hexagonolepis*, *Chagunius chagunio, Tor putitora, Danio rerio, Schizothorax plagiostomus, Schizothorax richardsonii, Schiothoraichthys progastus, Psilorhynchus pseudoecheinus, Anguilla bengalensis*. *Tor tor it* is kept in endangered status. These ten species of fishes were recommended for legal protection (Shrestha, 1995).

1.4 Status of fisheries in Nepal

Fisheries is a small but potentially important sector of agriculture in Nepal. At present fisheries contribute about 1.7% of the agricultural gross domestic product (Pradhan and Shrestha, 1997). Although the present relative economic importance of fisheries appears to be rather low, the potential for increasing its economic contribution in the future through aquaculture is very high. Fish culture has a short history in Nepal while capture fishery in rivers, lakes,

reservoirs, wetlands and flood plains had been practiced since time immemorial. Significant increase in the amount of fish production can be achieved through the development and management of culture fisheries.

1.5 Aquaculture

Fish is consumed by non-vegetarian consumers of all ethnic groups as one of the food items in Nepal. .The demand is very high but production supply is low on the ratio of demand. The present demand is mostly fulfilled by domestic products and imported from neighboring countries (Joshi and Tiwari, 1998). According to Joshi and Tiwari (1998) the fish supply situation in Nepal indicated that the fish consumption had been increasing from the level of 0.35 kg to 1.1 kg per capita per annum between 1985/86 and 1997/98 but it is still less in comparison to global consumption rate.

Aquaculture production was estimated to be about 750 metric tones in 1981/1982 and the aquaculture production continued to increase with remarkable pace to reach 4939 metric tones in 1986/87. This increase in fish production clearly showed an increase of over 6 times within five years during first Aquaculture Development Project Phase. The trend of fish production was continued to increase thereafter and the fish production reached 8,364 metric tones in 1992/93 during the second Aquaculture production. After the termination of aquaculture development project and production reached 14,000 metric tones in 1999/2000 (DOFD, 2001). **1.6 Study area**

The study area is located in the transitional zone between the Chitwan National Park and inner-Terai agricultural land of Makawanpur and Chitwan district. It falls on central Terai region of Nepal. The main study area is located between Manahari and Meghuli at a 55 km distance. The study area covers various settlements located along the roads including important areas of tourism such as Manahari, Sauraha and Kasara. The settlement includes ethnic community involved in fishing activities from time immemorial. It originates near Bhimphedi (1307m) of Makawanpur district and flows through Bhaise. The Samari Khola from Sukaura meets Rapti at Suparitar and Karra Khola

meets it at Hetaunda. From Hetaunda, the Rapti river flows along the side of Mahendra Highway. Chakari Khola from Padampokhari and Makari Khola from Gaganpani meet Rapti River at Bastipur. The river, then becomes wide and flows in a deep incised gorge. Due to a fault zone and river turns to south entering Terai. At Handi Khola, Rapti joins with Chaura Khola, Tungra Khola and Bagau Khola. Manahari Khola from Namatar and Chuling Khola from Sarikhet Palase join together and meet Rapti river at Manahari of Makawanpur and enters Chitwan district. It flows along the northern face of Chitwan National Park till it combines with Narayani river at Khoriamohan. Budhi Rapti from Siddhi, Kair Khola from Saktikhor VDC, Kageri Khola.join at Bagmara finally meet Rapti at Bachhauli. Jagatpur located at west Chitwan, the Kerung Khola joins Rapti and Rehu Khola from Madi meets Rapti River inside Chitwan National Park (CNP). The river now flows south westward, parallel to the CNP and meets Narayani River at Khoria Mohan.

The Rapti river flows from inner terai to Southward along the bank supported by different vegetation like (*Shorea robusta*), Sissoo (*Dalbargia sisso*), Simal (*Bombax seiba*), Khair (*Acacia catechu*), Chilaune (*Schhima wallichi*), Katush (*Castanopsis indica*), Palash tree known as the flame of the forest and silk cotton tree with spectacular crimson flowers visible from a distance. In the shore of river, different types of grasses including the elephant grass (*Saccharum* sps.) renowned for its immense height (8 m) and short grasses (*Imperata* sps.) which is used for roof thatching and making mats, rope and paper by local people.

The study area provides a good habitat for wild life. One horned rhinoceros (*Rhinoceros unicornis*), Gaur (*Bos gaurus*), Royal Bengal tiger (*Panthera tigris*), wild elephant (*Elephas maximus*), Four horned antelope (*Tetraceros quadricornis*), pangolin, jungle cat (*felis chaus*), Deer (*Axis axis*) etc are recorded from study sites. There animal are protected by CNP; where they shelter and come to the river for drinking and bathing in summer. The birds like Bengal florican, lesser florican, giant hornbill, black stork, white stork etc. are also found around the river. River has provided the habitat for Gharial

(*Gavialis gangeticus*), golden monitor lizard (*Varanus flavescens*), Python (*Python molurus*) etc.

The study area is composed of plains with mild water current. River is flat and wide with heavy flood during rainy season. The bank of the river can be divided into different regions: i) boulder, gravels and pebbles, rubble, cobbles and sand, ii) sand and iii) sand and mud with the growth of grasses. Most part of the bank consists of agricultural lands remained covered by water during the flood.

During the study period, the river was shallow with clean water in winter so that the bottom of the river is covered with a layer of algae making it slippery. Many good sized pools are noted in Rapti, Hetaunda at the confluence of Rapti and Narayani. Near Meghauli, the pools had higher depth with reduced water velocity, silt, less suspended particles as materials settle down at the bottom.

It has a range of climatic seasons offering a unique experience. From October to February, average temperatures 25^{o}C offering an enjoyable climate. From March to June, temperatures can reach as high as 43^{o}C. The hot humid days in late January, local villagers cut thatch grasses to meet their needs; which monsoon season lasts from late June. In September, river becomes heavily flooded and roads are impassable. In late January, local people are permitted to cut thatch materials for roofing. The clean surrounding offers a better view of wildlife to visitors. Between September-November and February-April, migratory birds join the residential birds and create spectacular bird watching opportunities.

1.7 Justification of Study

The Rapti River is inhabited by large number of aquatic animals - different fish species, important reptiles like Tortoises and Gharials. Rapti River has contributed lot in the livelihood of fishermen living along this river using traditional fishing gears mainly for subsistence production and generating

some economic benefits. In spite of the presence of Chitwan National Park, natural habitat of Rapti River is deteriorating day by day and fish population had also declined due to number of factors such as fish poachers, heavy flooding and erosion

It is very important to study limnological and socioeconomics for the conservation and management to enhance the production capacity of the river. The present study in Rapti River is done to identify existing fish fauna, physicochemical and biological parameters of water, socio-economic condition of local fishermen. The base line information of the present study will be helpful in the management aspects for the conservation, protection and formulation of plan and policy for the better management of rivers.

1.7.1 Study sites and sampling stations

For the present work, study sites were selected from Manahari VDC of Makawanpur district to Jagatpur VDC of Chitwan district. To study the fish biodiversity, study area was divided into three sampling stations located at Manohari, Sauraha and Jagatpur. The stations were selected on the basis of population difference, natural habitat of the river like low sandbank adjacent to deep pool and small sand bank with vegetation above riffle. Fishes were collected by fisherman from different water surface of the river

Station 1 - Manahari

The sampling station I lies at Manahari of Manahari VDC, Makawanpur district. It is very popular for fish market. The station lies close to the confluence of Chuling Khola and Manahari Khola and both joining Rapti river. (Mahendra high way lies in north side of the station I; whereas CNP is in south).The river is wider with higher water velocity i.e. 1.3-1.9 m/sec. The

substratum is composed of stones, pebbles and rocks. The water in the river is clear. The vegetation around the area is Khair, *(Acacia catechu),* Sisso *(Dalbergia Sisso),* Sal *(Shorea robusta)* etc.

Station II (Sauraha)

The sampling station II had been established in Sauraha of Bachhauli V.D.C. It is very important site from the point of view of tourism. Many tourists visit to enjoy interesting sites of wildlife. The interview with the visitor at Sauraha provides fascinating information on wildlife and conservation programs. The elephant breeding center at Sauraha gives information on domesticated elephant. Elephant safari provides an opportunity to get a closer view of the endangered one horned rhinoceros. It is 25 km down stream from the station I. The river bed is composed of mostly sand, small stones and peebles.

Station III (Jagatpur)

The sampling station III lies at Jagatpur, situated in Jagatpur VDC, Chitwan district. The station is 20 km southward from Narayangarh, the main city of Chitwan. Here, the river has a low sandbank close to deep pool. The river become more wider and deeper in comparison to other stations. There is a thick forest of sal, sisso and simal on both sides of the river; one can see one horned rhinoceros easily. Sometimes, Rhinoceros and tiger invade village and destroy crops and domestic animals. There is Rapti bridge near this station. Kasara, the headquarters of CNP lies one km distance from the Sampling station. Near Kasara, visitors can see Bikram Baba, a Hindu religious site of archival value. A short walk from the Kasara, the Gharial Breeding centre is present which is also home to the marsh mugger *(Crocodylus palustris),* Gharial (*Gavialis gangeticus*) and number of turtles.

1.8 Objectives of the Study

The main aim and objective of the present work is to:

- analyse the physicochemical and biological parameters of Rapti river.
- study the existing ichthyofauna and frequency occurrence of some economically important fish species.
- study socio-economics and demographic parameters of fishermen.

CHAPTER-II

2.0 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 AD by colonel Kirkpatric followed by Francis Buchanan (Later Hamilton) at the beginning of 19th century. Hamilton was the first author to provide valuable references of the fishes of Nepal (1822) in his work entitled "An account of the fishes found in the river Ganges and its branches" which provided the description of 269 species of fishes of the 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 Panjab and had mentioned some of the fishes of Nepal. *Day* (1878-1889) 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 fish. *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.

Hora (1920-1939) published many papers regarding his fish collection and the collection was included 158 specimens of which 22 species are from Nepal. He gave an excellent account of the *Mahseer* (*Tor putitora,* Hamilton) in the series of journal of Bombay Natural History Society and indicated the distribution of the species all along the Himalayas. Hora (1940) reported the Nepalese "Katle" Neolis*socheilus hexagonolepis* (Mc Cleland).

Menon (1949) collected fishes from the lower stretches of Koshi river and produced a check list of the fishes of Koshi. His collection was included 11 families comprising 26 genera and 52 species. Further in 1954 and 1956 he

described the fish fauna from the Koshi drainage of ten eastern Himalayas and discussed zoo-geographical significant of their distribution. In 1962, he gave a distributional list of all known species of fishes from the defined drainage system in the Himalayas and recorded 69 species from Koshi drainage.

Menon and Dutta (1961) described a new fish *Psilorhynchus pseudocheneis* from Bhotekoshi during the Indian Choyu expedition to Nepal. Swan (1954) collected a number of fishes during California Himalayan expedition to Makalu. Taft (1955) conducted a fish survey of Nepal and prepared a check list of 94 species of fishes representing 13 families from Kathmandu, Trisuli, Simara and Biratnager. David (1959) gave some account of fish seed collection centers from Koshi and suggested as probable breeding ground of major carps of India. 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 (1981, 1992), Rajbanshi (1982) worked on the bibliography of fish and fisheries of Nepal and had listed 330 references. Ferro and Swar (1978) made study on biological and limnological condition of lakes and water in Pokhara Valley with reference to the existing fish population and their feeding habits.

Majupuria (1969) introduced a paper on 'Socioeconomic condition of fisherman of Kathmandu Valley'. Shrestha (1970) studied 'Taxonomy of fishes of Nepal'.

Bhatta and Shrestha (1973) gave an account of 27 species of fish from the Mahakali river.

Masuda and Karki (1980) provided a checklist of fish fauna of the Trisuli river and they have reported 6 families, 16 genera and 28 species of fishes. Shrestha

(1980) studied the fishing gears and methods used in Narayani river. He had reported 103 species of fishes from Narayani bridge fishing with lift net.

Shrestha (1990) reported 74 species from Karnali river, 108 species from Trisuli, 102 species form Narayani, and 69 species from Mahakali river in his book "Resource ecology of the Himalayan water". He also described about the swamp land ecology and fish management and conservation in this book.

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. Biodiversity profiles project (1995) described the status of fish species in Nepal based on Shrestha (1995) who enumerated the fishes Nepal. According to her enumeration, there are one hundred and eighty five indigenous fish species found in Nepal.

A large number of contributions have cited about fishery and on the ecology and fish behaviors. In spite of large number of studies as mentioned above, still much more study have to be done, such as on the management and conservation, ecology and behavior of fishes existing in the hill streams and their relationship with the physical, chemical and biological parameters.

Altogether 59 species of fishes were reported from Rapti river. The present study entitled "Study on the Fish and Fishery Resources of Rapti River" is carried out to contribute further knowledge about the fish fauna, their biological distribution, rate of productivity and socio-economic status of fisherman of Rapti River.

CHAPTER -III

3.0 MATERIALS AND METHODS

For the present study the field work was conducted from January 2005 to September 2005.

3.1 Sources of data collection

The data was collected from direct field observations, photographs, sampling and interviews with fisherman of the study area. Monthly visits were conducted to study the water quality parameters, biology, fishing method, socioeconomics of fisherman in Rapti river. Altogether eight observations have been recorded during investigation period.

3.1.1 Data collection techniques and analysis

To meet the objectives of the current study three stations were fixed with different considerations such as the characteristics of the river, tributaries joining the mainstream, human activities and dam or bridge sites. Each station was visited monthly starting from February 2005 to September 2005 covering winter, summer & rainy season.

3.2 Physicochemical parameters

All the physical parameters like water color, temperature, water velocity was studied in present study. Similarly, chemical parameters like dissolved oxygen, PH and CO_2 were analyzed in the laboratory.

3.2.1 Physical parameters

3.2.1.1Water Colour

The colour of water was determined by taking water sample of river in a beaker which was placed on a white filter paper and the colour was recorded.

3.2.1.2 Temperature

The air temperature was recorded by using a standard mercury thermometer; and for water temperature, thermometer was dipped directly into water for two minutes while the air temperature was recorded by holding the thermometer in the air avoiding the direct sunlight, the result was expressed in degree celsius. The readings were noted down in the record sheet.

3.2.1.3 Water velocity

The velocity of river water was measured monthly during the study period. Water velocity of running water was measured with the help of float method. First of all certain distance was measured with the help of measuring tape. The starting and end points were marked. Then a cork was released at the starting point and the time taken by it to reach the end point was recorded, in the record sheet; expressed in m/s.

3.2.1.4 Depth

The depth of water was measured by immersing graduated rod in river until it touches the bottom and the point which was just inside the water was noted. It was repeated at different place to take average depth.

3.3 Chemical parameters

Water samples were collected monthly from different three stations of Rapti river; directly from the surface water in a polythene bottles. Chemical analysis was done using the standard methods of APHA (1976) and Adoni (1984).

3.3.1 Hydrogen ion concentration

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 station in Rapti River.

3.3.2 Dissolved oxygen (DO)

Modified Wrinkler's method was used to determine the dissolved oxygen. Water sample was collected in a BOD bottle (300ml) without bubbles. Then 2ml of manganese sulphate and 2 ml of alkaline iodide azide solution were

added and shaken well. Brown precipitate collected at the bottom, was dissolved by adding 2 ml. of concentrated sulphuric acid. Then the solution was titrated against standard sodium thiosulphate solution (0.025 N) and the calculation was done by using the following formula:

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

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**.**

3.3.3 Free carbondioxide

To determine free CO_2, 50 ml of sample water was taken in a conical flask and two drops of phenolphthalein was added as indicator. The colorless solution indicated the presence of free CO_2. The solution was titrated against standard alkali titrant (sodium hydroxide) to the slight pink end point.

$$\text{Free } CO_2 \text{ (mg/l)} = \frac{ml \mid normality\ of\ NaOH \mid 44 \mid 100}{ml\ of\ sample\ used}$$

3.3.4 Total Hardness

Total hardness of the water was measured by EDTA titrimetric method. 50 ml of sample water was taken in a conical flask. 2 ml of ammonia buffer solution and 200mg of Eriochrome Black T indicator was added to the sample solution till wine red colour appeared. This solution was titrated against standard EDTA solution (0.01N) until a clear blue colour appeared. The total hardness of water was calculated by using following formula.

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

3.3.5 Total Alkalinity

The presence of carbonates, bicarbonates and hydroxide ions denote the alkaline properties of water. It is the quantitative capacity to neutralize strong acid. 0.5 ml of methyl red bromo- cresol green indicator was added to the 50 ml of sample water in a conical flask. Then it was titrated against standard sulphuric acid solution up to the end point. Calculation for total alkalinity was done by applying the following formula.

Total alkalinity (mg/l) as $CaCO_3$ =

3.4 Biotic parameters

The samples were studied at the laboratory using methods described by Adoni (1984), Edmondson (1959), Needam and Needham (1962), Masuda and Pradhan (1988).

3.4.1 Planktons

Planktons are the free floating and drifting microscopic organisms having neutral buoyance capacity. The planktons of plant origin are named phytoplankton while of animal origin are called zooplankton. They are important components of water system and include aquatic bacteria, algae and microscopic forms of crustaceans. They are also indicator of water quality in aquatic ecosystem.

Phytoplankton and Zooplankton samples were collected from the surface water of river by sing plankton net (30 No. Bolting Silk cloth), once in a month from each station. Planktons (both phyto and zooplankton) were preserved in 5% format in solution in separate bottles. The qualitative analysis was done by placing a drop of concentrated sample on a glass silk covered with a cover slip. The sample was analyzed under the compound microscope. Both types of planktons up to genus level were identified after Edmondsen (1959), Masuda and Pradhan (1988), and Adoni (1985).

3.4.2 Collection of fishes and Identification

The fishes were collected monthly from all stations with the help of local fishermen using local implements like cast net, Paso, Rod, and line. Fishes were also collected from the local market at Manahari, Tandi etc. All the collected fishes were preserved in 10% formaldehyde. The preserved specimens were identified after Shrestha (1981), Shrivastava (1968) and Jayaram (1981) in the Central Department of Zoology. Ecological behavior of fish was recorded by interview with local fisherman. The collected fish samples were identified.

3.5 Statistical Analysis

The statistical analysis (Coefficient of Correlation) between some important physicochemical parameters of water viz, temperature, PH, D.O with fish density was calculated using Karl-Pearson's method (Gupta, 1988).

3.6 Limitation of the Study

It was micro level study to collect basic general information about Rapti River. During the study period, a regular sampling of fishes was carried out from the different stations but there were some difficulties in sampling fishes during rainy season due to heavy flood and difficulty to find fisherman as they were busy in paddy plantation.

CHAPTER -V

5.0 OBSERVATIONS AND RESULTS

5.1 Physical parameters of water

5.1.1 Temperature: The air temperature ranged from 18^{o}C-38.5^{o}C. The air temperature was recorded to be the lowest 18^{oC} in January at station I. The highest temperature recorded 38.5^{o}c in June at station III (Table 3).

Table–3 : Air temperature in different month at different stations (2005)

Months (2005)	Station I	Station II	Station III
January	18.0	18.5	19.0
February	22.0	23.0	23.5
March	25.0	27.0	27.0
April	30.0	32.0	31.5
May	33.0	34.0	34.8
June	37.0	38.0	38.5
July	34.0	35.0	35.0
August	33.0	33.5	34.0
September	29.5	30.0	30.5

The water temperature of the Rapti River ranged from 15^{o}C to 33^{o}C. The lowest temperature was recorded 15^{o}C at station I and the highest temperature recorded 33^{o}C at June in station III (Table 4).

Table – 4: Water temperature in different months at different stations (2005)

Months (2005)	Station I	Station II	Station III
January	15.0	15.5	17.0
February	15.0	19.0	19.0
March	22.5	22.5	23.5
April	26.5	27.5	27
May	29.5	30.	30.5
June	33.0	33.5	33.5
July	30.	30.0	31.0
August	29.0	29.5	29.5
September	28.0	28.5	28.0

5.1.2 Velocity

The highest velocity was recorded from station I in July i.e.1.9 m/s. Similarly the lowest velocity was recorded is 1.0 m/s from station III in January (Table 5).

Table–5 : Velocity of the Rapti River in different months at different stations.

S.N	Months (2005)	Station I	Station II	Station III
1	January	1.1	1.1	1.0
2	February	1.3	1.2	1.1
3	March	1.3	1.2	1.2
4	April	1.4	1.3	1.3
5	May	1.6	1.5	1.4
6	June	1.7	1.6	1.6
7	July	1.9	1.8	1.8
8	August	1.8	1.8	1.7
9	September	1.5	1.5	1.6

5.1.3 Depth

The depth of the Rapti river ranged from 24 cm to 154cm. The maximum depth was recorded at station III in July i.e. 154cm and the minimum depth 24 cm at station III in January (Table 6).

Table–6 : Variation of depth (cm) in Rapti River in different months at different stations

S.N	Months (2005)	Station I	Station II	Station III
1	January	25	25	24
2	February	26	25	31
3	March	26	29	36
4	April	35	34	45
5	May	45	50	56
6	June	120	152	154
7	July	124	126	154
8	August	122	122	130
9	September	65	74	78

5.1.4 Water Colour

The water colour of the Rapti river was found to be clear, but in the rainy season (June-August) the water was found muddy.

5.2 Chemical parameters of Water

5.2.1 Hydrogen ion concentration (pH)

The pH of water was almost neutral to slightly alkaline with the highest pH 8.6 at station III in September and the lowest was 6.9 at stations I and III in April and May respectively (Table 7).

Table –7 : pH value of water in different month at different stations

S.N	Months (2005)	Station I	Station II	Station III
1	January	7.1	7.1	7.0
2	February	7.0	7.1	7.1
3	March	7.2	7.2	7.1
4	April	6.9	7.5	7.4
5	May	7.6	7.1	6.9
6	June	8.0	7.5	7.8
7	July	8.2	8.0	8.1
8	August	8.1	8.5	8.4
9	September	8.0	8.5	8.6

5.2.2 Dissolved oxygen (DO)

The maximum value of dissolved oxygen was recorded 9.6 mg/l at station I in January and the minimum value 6.1 mg/l in May at stations II and III (Table 8).

Table –8 : Dissolved Oxygen variations at different stations in different months

S.N	Months (2005)	Station I	Station II	Station III
1	January	9.6	9.5	9.3
2	February	9.5	9.2	9.2
3	March	9.1	9.0	8.9
4	April	7.6	7.4	7.2
5	May	6.2	6.1	6.1
6	June	6.4	6.2	6.3
7	July	7.0	6.9	6.9
8	August	8.1	8.1	7.8
9	September	9.0	8.9	8.7

5.2.3 Carbondioxide:

The maximum CO_2 was 29.5 mg/l recorded at stations II and III in May and the minimum 10 mg/l in January at station I (Table 9).

Table– 9: Free carbon dioxide at different months in different stations

S.N	Months (2005)	Station I	Station II	Station III
1	January	10.0	13.0	14
2	February	18.0	22.5	23.4
3	March	20.0	23.4	24.1
4	April	26.0	26.9	27.8
5	May	29.2	29.5	29.5
6	June	25.5	26.1	26.7
7	July	19.0	22.2	22.0
8	August	15.0	16.1	16.6
9	September	11.0	11.0	11.2

5.2.4 Total Hardness

The maximum total hardness was 205 mg/l recorded in January at station I. The lowest total hardness recorded was 124 mg/l at station III in August (Table 10).

Table–10: Variation of total hardness at different months in different stations.

S.N	Months (2005)	Station I	Station II	Station III
1	January	205	180	195
2	February	185	182	182
3	March	179	176	178
4	April	171	173	172
5	May	162	162.9	162.9
6	June	150	152	151
7	July	145	144	146
8	August	132	124	130
9	September	126	129	125

5.2.5 Total Alkalinity

The minimum and maximum alkalinity recorded were 150 mg/l from station I in July and 175 mg/l from station III in February (Table 11).

Table –11: Variation of alkalinity in different months at different stations

S.N	Months (2005)	Station I	Station II	Station III
1	January	152	155	165
2	February	172	172	175
3	March	160	165	164
4	April	162	162.5	163
5	May	157	157.5	157.5
6	June	153	153.9	153.5
7	July	152.0	152.0	152.5
8	August	158	159.5	159.0
9	September	155.5	156.0	156

5.3 Biotic parameters

5.3.1 Plankton

5.3.1.1 Phytoplankton

Phytoplankton includes chlorophyll bearing organisms which are responsible for the photosynthesis. They are the primary producers in the river ecosystem. During present study, altogether 4 different phyla of phytoplankton with 8 genera were recorded (Table 12).

Table –12 : Phytoplankton at different stations in Rapti River

S.N	Phylum	Genus	Station I	Station II	Station III
1	Chlorophyta	*Clostrodium*	-	+	+
2	Cyanophyta	*Oscillatoria*	+	+	+
		Nostoc	+	-	+
3	Euglenophyta	*Spirogyra*	+	+	+
		Microspora	+	-	+
4	Chrysophyta	*Synendra*	-	+	+
		Navicula	+	+	-
		Fragillaria	-	+	-

Index: + Present, - absent

5.3.1.2 Zooplankton

During present study, only few Rotifers, Copepods and Cladocera such as *Cyclops*, *Daphnia* and *Monostyla*, were recorded in all stations.

5.4 Fishes

5.4.1 Species Diversity

The Rapti river provides a habitat for different species of fresh water fishes viz. major carps, cat fishes, barbs, loaches, eel live fishes etc. During present study, 59 fish species were recorded from the Rapti River. These fishes belong to 7 orders, 19 families, 38 genera and 59 species.

5.4.2 Systematic Position of Fishes

The collected fishes were identified after Shrestha (1981) and Jayaram (1981).

1. **Order – Osteoglossiformes**

    Family – Notopteridae

    Genus - *Notopterus* Lacepede

    Species- *N. notopterus* (Pallas)

2. **Order – Cypriniformes**

    Family – Cyprinidae

    Sub family – Rasborinae

    Genus – *Barilius* (Hamilton-Buhanan)

    Species – *B. barila* (Hamillon-Buchanan)

    B. barna (Hamillon-Buchanan)

    B. bendelisis (Hamillon-Buchanan)

    B. tileo (Hamillon-Buchanan)

    B. vagra (Hamillon-Buchanan)

    Genus – *Esomus* Swainson

    Species – *E. danricus* ((Hamillon-Buchanan)

Genus – *Rasbora* Blecker

Species – *R. daniconius* (Hamillon-Buchanan)

Sub Family-Cultrinae

Genus – *Chela* Hamilton-Buchanan

Species – *C. laubuca* (Hamilton-Buchanan)

Genus –*Salmostoma* Swainson

Species –S. *bacaila* (Hamilton-Buchanan)

Sub family – Cyprininae

Genus – *Neolissocheilus* Rainboth

Species – *N. hexagonolepis* (Mc-Clelland)

Genus – *Catla* Valenciennes

Species – *C. catla* (Hamillon-Buchanan)

Genus– *Cirrhinus* Cuvier

Species – C. mrigala

Genus – *Labeo* Cuvier

Species – *L. angra* (Hamilton-Buchanan)

- *L. boga* (Hamilton-Buchanan)
- *L. dero* (Hamilton-Buchanan)
- *L. gonius* (Hamilton-Buchanan)
- *L. rohita* (Hamilton-Buchanan)

Genus – *Puntius* Hamilton - Buchanan

- *P. chola* (Hamilton-Buchanan)
- *P. conchonius* (Hamilton-Buchanan)

- *P. sarana* (Hamilton-Buchanan)
- *P. sophore* (Hamilton-Buchanan)
- *P. ticto* (Hamilton-Buchanan)

Genus – *Tor* Gray

Species – *T. tor* (Hamilton-Buchanan)

Sub family – Garrinae

Genus – *Garra* Hamilton-Buchanan

Species - *G. annandalei* (Hora)

- *G. gotyla* (Gray)

Family – Cobitidae

Sub family – Botinae

Genus – *Botia* Gray

Species – *B. lohachata* (Chaudhuri)

Subfamily – Cobitinae

Genus – *Lepidocephalus* Bleeker

Species- *L. guntea* (Hamilton-Buchanan)

Family-Balitoridae

Sub family – Nemacheilinae

Genus – *Nemacheilus* Bleeker

Species – *N.corica* (Hamilton-Buchanan)

- Genus-Schistura Mc Cleland
- Species-s. botia (Hamilton Buchanan)

-s.rupecola(Mc Cleland)

3.0 **Order Siluriformes**

Family Bagridae

Sub family - Ritinae

Genus – *Rita* Bleeker

Species – *R. rita* (Hamilton-Buchanan)

Sub family - Bagrinae

Genus – *Mystus* Scopoli

Species – *M. bleekeri* (Day)

- *M. cavasius* (Hamilton-Buchanan)
- *M. tengra* (Hamilton-Buchanan)
- *M. vitatus* (Bloch)

Family Siluridae

Genus – *Ompok* Lacepede

Species – *O. bimaculatus* (Bloch)

Genus – *Wallago* Bleeker

Species- *W. attu* (Bloch and Schneider)

Family Sisoridae

Genus – *Gagata* Bleeker

Species – *G. cenia* (Hamilton-Buchanan)

Genus – *Bagarius* Bleeker

Species– *B. yarelli* (Hamilton- Buchanan)

Genus – *Sisor* Hamilton-Buchanan

Species – *S. rhabdophorus* (Hamilton-Buchanan)

Family – Heteropneustidae

Genus – *Heteropneustus* Muller

Species – *H. fossilis* (Bloch)

Family – Claridae

Genus – *Clarias* Scopoli

Species – *C. batrachus* (Linnaeus)

4.0 **Order – Anguilliformes**

Family – Anguillidae

Genus – *Anguilla* Schrank

Species- *A. bengalensis* (Gray and Hardwicker)

5.0 **Order- Beloniformes**

Family- Belonidae

Genus – *Xenentodon* Regan

Species – *X. cancilla* (Hamilton- Buchanan)

60 **Order – Perciformes**

Family Channidae

Genus – *Channa* Scopoli

Species – *C. barca* (Hamilton - Buchanan)

- *C. marulius* (Hamilton - Buchanan)
- *C. punctatus* (Bloch)
- *C. striatus* (Bloch)

Family – Belontidae

Sub-Family-Trichogasterinae

Genus – *Colisa* Cuvier

Species – *C. fasciatus* (Bloch and Schneider)

Family – Chandidae

Genus – *Chanda* Hamilton-Buchanan

Species – *C. nama* (Hamilton-Buchanan)

Genus-Paraambassis Bleeker

Species – *P. ranga* (Hamilton-Buchanan)

Family – Nandidae

Sub Family-Nandinae

Genus – *Nandus* Valenciennes

Species – *N. nandus* (Hamilton-Buchanan)

Family – Anabantidae

Genus – *Anabas* Cuvier

Species - *A. testudineus* (Bloch)

Family – Gobiidae

Sub Family-Gobiinae

Genus – *Glossogobius* Gill

Species – *G.giuris* (Hamilton-Buchanan)

7.0 **Order – Synbranchiformes**

Family – Mastacembelidae

Sub Family-Mastacembelinae

Genus – *Macrognathus* Lacepede

Species – *M. aral* (Bloch)

– *M. puncalus* (Hamilton-Buchanan)

Genus – *Mastacembelus* Scopoli

Species – *M. armatus* (Lecepede)

Family-Synbranchidae

Genus-Monopterus Lacepede

Species-M.cuchia(Hamilton Buchanan)

5.4.3 Important fishes with ecological behavior

The fishes recorded in present study can be categorized as game fishes and food fishes. All the fish species found in Rapti River are edible and consumed by local inhabitants. The most popular fishes are *Tor tor, Bagarius yerelli Neolissocheilus hexagonolepis, Labeo rohita, Wallago attu, Mystus tengra, Clarias batrachus, Barilius bendelesis* etc.

***Labeo* spp.** Cuvier

The five species of *Labeo* were found in three different stations of Rapti river. One of the species was *Labeo angra*, which is locally called 'Thaind' and very tasty. Others species of *Labeo* were *L. bata. L. boga, L. dero, L. gonius* and *L. rohita*. They have cylindrical and elongated body with small and pointed head. Mouth is terminal and small with fringed lower lips. *Labeo sps*. are column

feeder and feeds on phytoplankton and decaying debris of aquatic plants. These fishes generally breed in the month of June and July and breeding ground comprises gravel beds. Optimum temperature for this fish is 25-30^{oC}. It attains maximum wt. of 1.5-2kg.

***Barilius* spp.** Hamilton

Altogether five species of this genus were recorded from the Rapti River. All the five species were found in almost all the stations. It is commonly known as 'Faketa'. The size of the captured ranged from 5-10cm. These fishes have 9-10 vertical bands on the body. Mouth is anterior often oblique with deep cleft. Generally they inhabit in the low depth but the adult occurs in rapids as well as pools of streams. It feeds upon insects, earthworms, algae like *Spirogyra*, *Oscillatoria* etc. *Barilius* spp. is surface feeder.

***Channa* spp.** Scopoli

Channa spp. is commonly known as 'Hile Bhoti". Four species of *Channa* were found in the Rapti River. The C. striatus (Saur) was not recorded from station I i.e. Manahari. The size recorded was 7cm – 12 cm. Body is long, head depressed and covered with scales. There species are also called 'Snake head" These are carnivores and active predators, feed on crustaceans, insects, larvae, mollusk, smaller fishes and tadpoles.

***Puntius* spp.** Hamilton-Buchanan

It is locally know as 'Sidre' or 'Pothi'. Five species of *Puntius* were found in all the stations. *P. chola* which is locally known as 'Sidre'. It has black blotch on caudal peduncle and at the base of dorsal fin. Its size ranges from 6.0-7.5cm. *P. conchonius* is also known as 'Sidre'. It has black spot on tail and at the tip of the dorsal fin. It's size ranges form 5.0-8cm. *P. Sarana* is locally called 'Pothi'. Body colour is silvery on side and belly dark, back without any black patch. Size ranges from 8cm –15 cm. *P. Sophore* is locally called 'Chandre Pothi'. It has one black blotch on caudal peduncle, another on dorsal fin base. Barbell is absent and size ranges from 7–10 cm. *P. Ticto* called

‘Darai Pothi’. Two black blotches are present one on anterior side of the body and another on caudal peduncle. It has broken lateral line and without barbles, size ranged from 4.5 – 7cm. These fishes are generally sold dried by the local fishermen. According to local fishermen, the breeding season of these fishes is June-July and breeding ground consists of pebbles and gravel beds. They feed insect larvae and nymphs, green algal and diatoms.

Neolissocheilus hexagonolepis (MC Clelland)

It is locally called as ‘Katle’. It is an important game fish. Body colour is golden yellow above lateral line, but olive green on dorsal side. It was found in all stations, Manahari, Sauraha and Jagatpur. The fishes captured from Rapti River ranged from 8.0-29cm. Its breeding season is in August to September.

Tor tor (Hamilton-Buchanan)

It is locally known as ‘Sahar’ and it is an important food and game fish. The captured fish is golden in colour. This fish was recorded from all three stations. The fish captured from Rapti River was ranged from 15 cm. – 40 cm. This fish generally inhabits in the rapid and deep pool. It shows local migratory behavior in June-July towards upstream for breeding. While the breeding season for this fish lies between August and September. It is omnivorous in habit. It feeds upon filamentous algae like *Spirogyra*, *Oscillatoria*, earthworm, insects (flies) and small crabs etc.

Clarias batrachus, Linnaeus

Clarias batrachus is commonly known as ‘Magur’ or ‘Mungri’. It is distinguished by the presence of four pairs of long barbels. Body is elongated and compressed laterally behind dorsal fin origin. This fish is found in all three stations of Rapti River. It is omnivorous and feeds on decaying algae, small crustaceans, insects, larvae, earthworm etc. It is bottom feeder. Captured species ranged from 5.0-12 cm. The breeding season lies in between April to June.

5.4.4 Distribution and frequency occurrence of fishes in the Rapti River

The total species of 59 different fish species were recorded from the Rapti River in the present study. All these fish species are not equally distributed in all stations of the river. The distribution pattern of fish species in the Rapti River is related to the climatical and altitudinal variation. The large numbers of fish species found in Terai were recorded in Rapti River. Among all the three stations, largest number of fish species was recorded from station I and least number of fish species from station II. Among the total fish species, family Cyprinidae constitutes the largest group consisting 25 species. The family Cobitidae constitutes 2 species. The most common fish species distributed in all the sampling stations were *Barilius spp, Labeo spp, Puntius sp, Channa spp, Nemacheilus spp* etc. Apart from this, *Clarias batrachus, Neolissocheilus hexagonolepis, Tor tor, Anabus testudineus, Heteropneustis fossilis* were also quite common. *Mystus tengra* had the highest frequency occurrence of 3.07% and *Anguilla bengalensis* had the lowest frequency occurrence of 0.48%. Other most important game fish were *Bagarius yarelli* and *Tor tor* with the frequency of 0.76% and 1.73 respectively (Table 13).

Table–13: Distribution and frequency occurrence of fishes at three different stations of Rapti River.

S. N.	Family	Scientific Name	Total fish caught	Frequency (%)	Sampling stations		
1.	Cyprinidae	*Barilius barila*	25	2.40	+	+	-
		Barilius barna	16	1.53	+	+	+
		Barilius bendelesis	15	1.44	+	+	+
		Barilius tileo	15	1.44	+	+	+
		Barilius vagra	24	2.30	+	+	+
		Catla catla	24	2.30	+	-	+
		Chela laubuca	12	1.15	-	+	+
		Cirrihinus mrigala	20	1.90	+	+	+
		Esomus dandricus	20	1.92	+	-	+
		Garra annandalei	16	1.53	+	+	+

		Garra gotyla	26	2.5	+	+	+
		Labeo angra	20	1.9	+	+	-
		Labeo boga	19	1.82	+	+	+
		Labeo dero	18	1.73	+	+	-
		Labeo gonius	21	2.02	+	+	+
		Labeo rohita	28	2.69	+	+	+
		Neolissocheilus hexagonolepis	18	1.73	+	+	+
		Salmostoma bacaila	15	1.44	+	+	+
		Puntius chola	14	1.34	+	+	+
		Puntius conchonius	22	2.11	+	+	+
		Puntius sarana	24	2.3	+	+	+
		Puntius sophore	21	2.02	+	+	+
		Puntius ticto	19	1.82	+	+	+
		Rasbora daniconius	10	0.9	-	+	+
		Tor tor	16	1.53	+	+	+
2	Cobitidae	*Botia lohachata*	15	1.44	-	+	-
		Lepidocephalus guntea	14	1.34	+	-	+
	Balitoridae	*Nemacheilus corica*	29	2.79	+	-	+
		Schistura botia	25	2.40	+	+	+
		Schistura rupicola	17	1.63	+	+	+
4	Bagridae	*Mystus bleekeri*	18	1.73	+	+	-
		Mystus cavasius	11	1.05	+	+	+
		Mystus tengra	32	3.07	+	+	+
		Mystus vitatus	21	1.92	-	+	+
		Rita rita	14	1.34	-	+	+
5	Siluridae	*Ompok bimaculatus*	12	1.15	-	+	+
		Wallago attu	18	1.73	+	+	+
6	Sisoridae	*Bagarius yarelli*	28	0.76	+	-	+
		Gagata	11	1.05	-	+	+
		Sisor rhabdophorus	10	0.96	-	-	+
7	Heteropneustidae	*Heteropneustus fossilis*	25	2.40	+	+	+
8	Claridae	*Clarias batrachus*	13	1.25	+	+	+

9.	Anguillidae	*Anguilla bengalensis*	5	0.48	+	+	+
10	Belonidae	*Xenentodon cancilla*	8	0.76	+	+	+
11	Notopteridae	*Notopterus notopterus*	10	0.96	+	+	-
12	Channidae	*Channa barca*	9	0.86	+	+	+
		Channa marulius	13	1.25	+	-	+
		Channa punctatus	15	1.44	+	+	+
		Channa striatus	16	1.53	-	+	+
13	Channdidae	*Chanda nama*	6	0.57	+	+	+
		Paraambasis ranga	9	0.86	-	-	+
14	Nandidae	*Nandus nandus*	12	1.15	-	+	+
15	Anabantidae	*Anabas testudineus*	22	2.11	+	+	+
16	Belontidae	*Colisa fasciatus*	21	2.02	+	+	+
17	Gobitidae	*Glossogobius giuris*	25	2.5	+	+	+
18	Mastacembelidae	*Macrognathus aral*	19	1.82	+	+	+
		Macrognathus puncalus	20	1.92	+	+	+
		Mastacembelus armatus	15	1.44	+	+	+

5.4.5 Fish composition and total catch in Rapti River

During the investigating period, the family wise fish species composition was observed. According to which 42.37 percent of reported species fall under the family *Cyprinidae*, 8.47 percent under the family Bagrida*e*,. Similarly family *Sisoridae* shows 5.08 percent species composition; 6.77 percent under *Channidae* family, 5.08 percent under *Mastacembelidae*, 3.38 percent under *Siluridae,3.38% of Cobitidae* and 20.33% under other families (Table 14).

Table –14 : Family-wise Fish Species Composition in Rapti River

S.N.	Family	No. of Species	Species Composition
1	Cyprinidae	25	42.37
2	Bagridae	5	8.47
3	Channidae	4	6.77

4	Sisoridae	3	5.08
5	Balitoridae	3	5.08
6	Mastacembelidae	3	5.08
7	Siluridae	2	3.38
8	Cobitidae	2	3.38
9.	Others	12	20.33

In terms of number of fishes of total catch belonging to families, *Cyprinidae* was the highest comprising 478 number and 46.27% followed by *Bagridae* (96 and 9.29%), Channidae (53 and 5.13%), *Mastacembelidae* (54 and 5.22%), *Siluridae* (30 and 2.90%), *Sisoridae* (29 and 2.80%) and others comprising 173 number and 16.84% (Table 15).

Table–15 : Total catch (in number) and fish composition (%) of different families in Rapti River

S.N.	Family	Total catch no. of fishes.	Fish composition %
1	Cyprinidae	478	46.27
2	Cobitidae	29	2.80
3	Bagridae	96	9.29
4	Channidae	53	5.13
5	Mastacembelidae	54	5.22
6	Siluridae	30	2.90
7	Sisoridae	49	4.74
8	Others	173	16.84

5.5 Aquatic Predators of Rapti River

Many aquatic predatory birds like kingfishers, (*Ceryle rudis*, *Petargopsis capensis)*, cranes, turtles (*Aspideretes gangeticus*), gharial (*Gavialis gangeticus*) were recorded.

5.6 Socio-Economic Condition of Fishermen of Rapti River

The socio-economic condition of fisherman was studied in the vicinity and peripheral areas of Rapti river. The numbers of houses engaged in fishing were varied in different stations. In Manahari (I) station, more than 140 houses were engaged in fishing; whereas 60 houses in Sauraha (II) station and 150 houses in Jagatpur (III) station. Generally, all the communities were recorded

involved in fishing; but the main communities involved in fishing were Bote, Majhi, Tharu, Darai, and Magar and sometime Pahadi, Kshetri people involved in fishing as occasional fishermen. These fishermen used different implements or gears for fishing depending upon the seasons.

Depending upon the time spending in fishing, the fishermen of Rapti River could be classified into three categories. i) occasional fishermen ii) part time fisherman and iii) fulltime fishermen.

i) **Occasional fishermen:** Occasional fishermen were those who engaged in fishing activities when their agricultural or other types of basic work load became low. These people did fishing when they had leisure from other work. Generally occasional fishing is carried in summer and spring. Fishermen used different types of locally available implements like hook, rod and line, mosquito net and without gear.

ii) **Part-time fishermen**: Part-time fishermen were those who had agricultural land or other source of income for their livelihood. They did fishing during the leisure period because their income source was not sufficient to fulfill their needs. They used all the types of fishing implements. The fishing activities were higher during spring and summer due to low water level and easier for fishing.

iii) **Full-time fishermen**: The fulltime fishermen in the Rapti River generally belonged to Bote, Majhi, Tharu and Darai groups. They were professionally expert on fishing. They did fishing to fulfill their basic requirement. The income from selling fish was found to use in running their livelihood. All the family members except children were found to be involved in fishing. These fishermen used most of the time around the river bank of Rapit River. The fishermen built temporary huts for shelter on the side of the riverbank to do fishing for few months during the fishing season. The fishing equipments used them were different types of net like cast net, tiyari net etc.

5.6.1 Economic Conditions

Economically the fishermen inhabiting around the Rapti River were very poor. The major occupational castes were Majhi, Bote, Darai, Tharu, Magar and Chepang. Generally, a house comprised 9 family members with about 5 family members involved in fishing. The houses of fishermen were small huts with roof made up long grass called khar (*Imperata* sps.) and the wall is tapped with soil. Only few fishermen had brick house with tiled roofs.

Mostly fishermen of 20-60 years of age were engaged in fishing. Fishermen kept themselves totally busy during the fishing season (Feb-Sept.). Fishing was done mostly during the morning and evening. They used various types of fishing gears like nets, basket implements, hook, rod and line. Fish caught was brought directly in the market for selling and the remaining preserved by smoking and sun drying. In the Rapti River, a fisherman was found harvesting about 1-2 kg fish per day during fishing season. The fish quantity decreased in the slack season. According to the local fishermen, the amount of fish in the river had significantly decreased over the years due to various reasons like over exploitation, flood and irrational fishing. The total income of fisherman during the fishing seasons was about Rs. 100-200/day and in the slack season the income was very low i.e.Rs.30-50/day.

During the survey, it was noticed that male was found involved in fishing more than women. The young boys also joined fishing. The women did all the housework including cooking, rearing children and looking after cattle. They visited river side to help their husband, supply food when men busy in fishing.

5.6.2 Education

Most of the fishermen near the Rapti River were illiterate. Only 10% had got school education. Fishermen were not aware about the family planning, so only few fishermen took benefit of it. It was very hard to find the educated person within the fishermen community. The main reason behind it was that they were financially weak and could not afford the fee. The fishermen near

the river bank were also found unaware about sanitation and used shore of the river as toilet.

5.6.3 Fish Market

The fish market system in the study area was not well managed. The main fish marketing sites were Manahari bazaar, Tandi bazaar, Gitanagar and Jagatpur. The fish were also sold in Narayangadh but here the fish market was occupied by the fishes from the Narayani River. Some times fishermen carried fish door to door to sell in village. Fishermen sold both fresh and dry/smoked fish. Sometimes the fishermen exchanged fishes with rice, green vegetables, potatoes etc. of local villagers.

5.7 Fishing practices and fishing implements in Rapti River

Different kinds of fishing practices had been found in Rapti River. Two types of fishing practices i.e. fishing with gear and without gear were most common for capturing different fish species. Fishing is mostly done in the morning and evening. Fishes were collected in basket called Phurlung made up of bamboo. The most common fishing implements used in Rapti river were:

5.7.1 Fishing with gears

The fish catching practices using various implements was common practice. In Rapti River, different types of implements were used for catching fish:

A. Nets

5.7.1.1 Gill Net

Gill net is locally known as Mahajal. This net is rectangular and tied accros the river in a fixed stand horizontally overnight. The fishes were collected in the next morning. Sinkers were tied in the lower border of the net so as to make it sinkable. More than two fishermen were found involved to operate the net. The fishermen prepared this net themselves with transparent synthetic or cotton fibres. Such type of net was found operated in rainy season when there

was sufficient water in river. Fishes such as *Labeo rohita*, *Wallago attu* etc were caught in this net.

5.7.1.2 Tiyari net

It was similar to gill net. It is commonly known as Tiyari Jaal or Tehari Jaal. The fishermen prepared this net with transparent synthetic or cotton fibre.

5.7.1.3 Cast net:

It is locally called 'Jaal' which is circular net made up of cotton or nylon thread. The circumference of the net is wide which tapers gradually towards the apex. Along the rim of the net cylindrical pieces of iron called sinkers are attached so as to make the net sinkable in water. While throwing the net, the fisherman throws it with a jerk into water; it spreads out in the water in a rounded way. After some time with the help of a central rope, the net is dragged and the fishes are collected in a basket made up of bamboo called dhadiya. Generally the cast net was about 15-25ft in dimension. The cast net is mostly applied in shallow water. Fishes such as *Barilus, Puntius, Neolissocheilus* were caught in large amount by this implements.

5.7.1.4 Bangla net

It is also called dip net. This is one of the most popularly used net by the fisherman. This net was made up of two long bamboo poles about 4-5 m long; between them the rectangular net of about 6×2 m. in size was found fixed. It was operated by two fishermen by dipping the net under water and moving for sometimes here and there and lifting it out. Bangla net is used in shallow water during summer months.

5.7.1.5 Scoop net

It is locally called Ghorlang. It consisted a long wooden or bamboo handle of varying sizes. The handle was joined to a circular frame made up of bamboo or niyalo. The dimension of circular frame was about 130 cm deep. It is also known as dip net.

Scoop net could be handled easily by a single man. Fisherman held the net with the help of handle and dips the net into water and lifted out suddenly with jerks. Fisherman repeated the operation till he collects a good catch. It was mostly used in rainy season when the current of water was rapid.

B. Basket implements

5.7.1.6 Ganj

It is a typical basket implement with open wide and round mouth. Body tapers from mouth curving slightly ending into a blunt end which was used as handle and suddenly lifting it out of the water. The catches were poured in another basket called dhadiya. This was used when water is shallow and low current.

5.7.1.7. Dhadiya

It was another mostly used basket implement with a wide month and tapering body. Mouth was covered with bamboo sticks except in one side where there was a small opening. In the interior of the opening there was such an arrangement of bamboo sticks that once fish got inside could not come out. Only small fishes like *Barilius, Puntius*, fingerlings of *Labeo* etc were caught.

C. Other fishing implements

5.7.1.8 Rod and Line

Rod and line is locally known as 'Balchhi'; which consisted a long rod slightly curving at the tip. Fine cotton or nylon thread is tied at the curved tip of rod. The end of the line is attached to the hook. Just above the hook there is a sinker made up of lead or stone attached. Bait like earthworms, small fishes. insects or cereals were kept in hook and placed overnight under water to attract fishes around the bait and caught in hook. Small fishes are generally used for catching fish like *Tor*.

5.7.1.9 Paso

Paso is another device used for catching fish. In Rapti River, flattened match box, long rod, nylon cord and lead weight are used to make paso. At one end

of the rod, loops are made to entangle the fish. In paso no bait is used, fishes are attracted to overhanging lead weight. This device was found used from September to April when the water was clear.

5.7.1.10 Fish spearing

Fish spearing was very easier and common method for catching fishes in Rapti River. It consisted of a spear fixed at the tip of long bamboo or wood pole. It is used to capture the eel and loaches. During the summer season, at low water level, fish spearing method was used in Rapti River. Spearing was done at night with the help of torch light.

5.7.2 Fishing without Gear

Fishing without gear is also another fishing practice done in Rapti River. The fish collection was found to be done manually. This method is very simple and the most primitive method of fishing. It was practiced during day time during summer in areas dried after flood or in shallow shore area. Fishes hiding under the stones or in mud were caught directly. To grasp fish by hand, fisherman dipped his arms quite slowly into water and tried very cautiously to reach hiding fish in crevice. When he succeeded in catching fish, he moves his hand very carefully to hold struggling fishes. Sometimes when the shore area was dried-up during summer after flood, the fisherman lift water in bucket and throw in the shore and the fishes are collected in basket.

5.8 Statistical Analysis

The statistical analysis to determine the coefficient of correlation between the different physico-chemical parameters and number of fish for all the stations have been calculated by using the relation of Karl Pearson (Gupta 1988). Table 16 shows the coefficient correlation between some physico- chemical parameters and the fish number collected from each station. The correlation between physico- chemical parameters and number of fish

shows the temperature and P^H is positive but the fish number with Carbon dioxide shows highly negative correlation in Rapti river.

Table –16: Coefficient of correlation between physico- chemical parameters and fish species in Rapti river

S.N.	Parameters	Correlation(r)	Probable Error
1	Water temperature vs. fish sps. composition	0.84	0.035
2	P^H vs. fish sps. composition	0.018	0.22
3	Carbon dioxide vs. fish sps. composition	-0.57	0.15

CHAPTER-VI

6.0 Discussion

The Rapti River formed by the confluence of several rivers of Mahabharat hills at the elevation of 2000-3000m. The Rapti River is one of the significant river of Chitwan National Park which flows east to west for about 30 km inside the Park and confluence with Narayani river.

Nepal is endowed with vast water resources providing shelter, nourishment and subsistence for valuable fish and many fishermen communities. Diverse water systems have different habitats and ecology; similarly, varied watersheds have different physical, chemical and biological components. Both systems function as a single system to affect fishes. Within the running surface water system, considerable differences can occur in water velocity, volume, depth and river bed materials. Ecological factors exhibiting a significance progressive change in value along the length of river, are current velocity, substratum, flow, temperature, dissolved oxygen, hardness and other organism which are interdependent (Whitton,1975).

The physicochemical and biological properties of water and soil are recorded at Sauraha, Jagatpur and Manahari stations. It is seen that the physical quality

of water environment appear to be basically more important then the chemical ones in many respect in governing the distribution of fishes (Hynes,1970). Among the physical parameters, temperature is the most important factor which affects the distribution and growth of the fishes in all three stations. The water temperature of Rapti River was 16-30^{o}C, 16.5^{o}C-32.^{o}C and 16.5 to 33^{o}C in Manahari, Sauraha and Jagatpur respectively. Coefficient of correlation value of water temperature with the fish number was found positive (r=0.84) with probable error 0.035. This showed that fish species composition increases with the rise of temp in Rapti River. The water temperature was recorded varied in different months with variation in fish catch also. The fish catch in the month of April and May was high at increase in water temperature before the onset of monsoon and in the month of September and October before the onset of winter. Air temperature was recorded 13^{o}C to 33^{o}C, 13^{o}C to 33.3^{o}C and 14^{o}Cto 34^{o} C in Manahari, Sauraha and Jagatpur respectively.

The chemical parameters also greatly affect the distribution of fish species in the river. Among all the chemical factors, the concentration of dissolved oxygen is the most important factor of all. Dissolved oxygen above 5 ppm is suitable for the support of diverse biota (APHA, 1976). The dissolve oxygen of station I, II and III ranged between 5.0-8.5 ppm, 5.0-8.1 ppm and 5.5 – 8.5 ppm respectively. The fish number increased with the increase of dissolved oxygen of water. The increased number of fish with the increase of dissolved oxygen may be due to sufficient oxygen to carry out different physiological activities properly.

It is considered that the alkaline water up to 9.5 ppm is suitable for fish growth. According to Jhingran (1991), the fish can not survive PH value above 11.0. According to Welch (1952), the current of lotic environment tend to keep PH uniform over considerable distance. Swingle (1867) stated that PH value more than 9.5 is unsuitable, because in such condition, carbonate is not available. The water of Rapti River was slightly alkaline during the investigations. It ranged from 6.9-8.2, 7.1– 8.5 and 7.1 to 8.6 at stations I, II and III respectively. The PH value was recorded slightly increased

progressively after each station. The correlation between fish composition and PH was recorded positive (r = 0.018 and probable error 0.22) showing slight increment in the number fish species composition with the rise of PH value.

The carbondioxide help in the formation of carbonates and bicarbonates and keep the fluctuation of PH under control. Carbondioxide in river comes from the decomposition of organic matter and from respiration of organisms. The free carbondioxide at various stations ranged from 10-29.2ppm, 11-29.5ppm and 11.2-29.5 ppm at station I, II and III respectively. Variation of free carbondioxide value in the Rapti river shows the negative correlation (r = -0.57 and probable error is 0.15) with the composition of fish species which explains the negative effect of free carbondionide on the composition of fish species.

The total hardness of the Rapti River were from 126 to 205 ppm,129 ppm to 182 ppm and 125 ppm to 195 ppm, from stations I, II and III respectively. The sums of concentration of alkaline earth metals (Ca^{++} and Mg^{++}) form the total hardness in the natural water. Lind (1974) reported that hardness more than 100mg/l of $CaCO_3$ is common in Nepal. The alkalinity of water in the Rapti river ranged from 152 to 172 ppm and152.5 to175ppm, at stations I, II and III respectively. The total hardness at each station showed good for riverine fishes.

Phytoplankton are passively floating microscopic plants with or without chlorophyll. Only qualitative analysis of phytoplankton was recorded. During the investigation period, there are altogether 8 different genera like *Navicula, Synendra, Spirogyra, Fragillaria, Microspora, Nostoc, Oscillitaria* and *Closterium* were recorded. The most dominant phytoplankton in the Rapti River was *Spirogyra*.

The correlation coefficient between altitude and phytoplankton genera composition showed negative correlation. It explained phytoplankton genera numbers composition decreased with the rise in altitude. Phytoplankton genera composition showed the negative correlation with water velocity explaining

decreased phytoplankton with the rise in water velocity. As phytoplankton is the primary producer in the river ecosystem. The fish diversity showed a positive correlation with the phytoplankton composition. That is fish diversity increases with the rise in phytoplankton composition. Few zooplanktons were recorded such as rotifers, copepods, cladoceran and Monostyla during the investigation period.

The fishes of Nepal have wide distribution according to the climatical condition and altitudinal variation. A total of one hundred and eighty six indigenous fish species belonging to 79 genera, 31 families and 11 orders are distributed in different river systems and other water bodies of Nepal. (Shrestha,1998). In present investigation, a total of 59 fish species were recorded from Rapti River. Majority of the fish species collected from the river fall under the family cyprinidae. Among them, few important ones are *Labeo rohita, Neolissocheilus hexagonolepis, Labeo angra, Labeo dero, Labeo gonius, Labeo bata, Barilius barna, Puntius sophore, Puntius conchonius, Tor tor, Catla catla, Cirrhinus reba, Oxygaser bacaila, Rasbora daniconius.* Out of these, few species like *Barilius, Catla, Labeo, Puntius* species are widely distributed in all three stations.

Family Cobitidae included 2 species only consisting *Lepidocephalus guntea and Botia lohachata.* Lepidocephalus guntea was found at stations I and III whereas Botia lohachata was found at station II only.Family Balitoridae consists of 3 species with 2 genera. *Noemacheilus corica,* was found at station I and III.The genus Schistura included two species i.e.Schistura botia and Schistura rupecola found in all stations. Family Siluridae consists of only two species *Ompok bimaculatus* found at station II and III and *Wallago attu* was found in all three stations. Family Bagridae included two genus i.e. *Mystus* and genus *Rita*. *Rita* had only one species i.e. *Rita rita* and *Mystus* consisted four species i.e. *Mystus bleekeri*, *Mystus cavasius, Mystus tengra* and *Mystus vittatus. Mystus* were found in almost all the stations. Family Sissoridae consisted of 3 genera i.e. *Bagarius*, *Gagata* and *Sisor. . Bagarius yarelli* locally known as gonch was found at stations II and III. The genus

Sisor was found in station III only. One species from family Heteropneustidae i.e. *Heteropneustes fossilis* was recorded from all the stations. The family Claridae consisted *Clarias batrachus* found in all the stations. The family Anguillidae included *Anguilla bengalensis* and family Belonidae included *Xenentedon cancila*. The family Channidae included *Channa* with four species: *Channa striatus, Channa barca, C. marulius, C. punctatus. Channa gachua, C. marulius, C. punctatus* were found in all stations but *Channa striatus* was found in II and III stations only.

Two species of genus *Chanda* from family Chandidae was found in very few numbers. The C*handa nama* was found at all stations and Paraambasis *ranga* was found at only III station. The family Belontidae included only one species that was *Colisa fasciatus*. It is small fish found in all stations. Three species of family Mastacembelidae like Macrognath*us puncalus, Mastacembems armatus* and *Macrognathus aral* were recorded from all the stations.*Monopterus cuchia of family Synbranchidae was recorded from all three stations.*

The villagers around Rapti River were very poor and illiterate. The income source was low barely enough for living; due to which they were unable to provide education to their children. Most were found unaware of free education in government school. The fish markets system was not good in the rural areas; which compelled them to exchange fish catch with rice, green vegetables etc. The fishermen of Jagatpur had worse economic condition in compare to other stations.

During the study period, many aquatic predators were observed. Predatory birds like kingfishers (*Ceryle rudis*) and *Pelargopsis capensis*, reptiles like turtles (*Apsideretes gengeticus*), Gharial (*Gavialis gangeticus*) were also recorded. The Rapti River, being one of the important rivers of Chitwan National Park, has great ecological significance. The river is the site for number of immigrant birds from different parts of the world. The good management may help the protection of important species of fish in Rapti

River including rare birds along with the increase in the total production of capture fishery,.

6.1 Conservation and management of Rapti River

The Rapti River is an extremely important water resource providing shelter to about 59 species of biologically diverse ichthyofauna with predominance of family Cyprinidae. There are several factors which are not only hampering the productivity of the water bodies but responsible for the extinction of certain fish species. Rapti River had undergone an accelerated rate of ecological changes following tremendous demographic growth.

6.1.1 Habitat degradation

The woody debris deposited on river shoreline outside the Chitwan National Park was found quickly removed by villagers for fuel wood consumption. The removal of woody debris decreased stream productivity eliminating essential habitat for several fish species. Extraction of sand and stones from river for a construction purpose was another problem disturbing the area of development and shelter of small juveniles during monsoon.

6.1.2 Over fishing and irrational fishing

There were number of Tharu and Bote communities on the river bank involved in over fishing with the decrease in the total fish population. However, there are number of fishing prohibited areas around the Sauraha periphery. In Rapti River, the fishes are killed by non-selective methods and fishing gears like poisoning and dynamiting resulting severe depletion of fish stocks. Due to this, non targeted fish species were affected.

Proposed East Rapti Irrigation Project

The proposed "East Rapti Irrigation Project" is going to be implemented for irrigation of east Chitwan. The ecology of river will be affected by construction of irrigational canal affecting fishery resource.

7.0 Recommendation

As due priority has not been given to the development of natural water fishery in past years, there is a serious lack of trained and experience man power for the planning and programming of the development of fishery production and management system in the riverine systems like Rapti River. The initiation towards conservation and management of indigenous biotic resources in Rapti River was not taken seriously. The fisherman and local community must be aware of the importance of riverine fishery. Due to lack of awareness, the populations of many economically important fishes are declining. There is no previous recorded study on the fish diversity in this area. For successful management and conservation of existing fish species, the following recommendations are made:

7.1 Ban of Harmful Fishing Implements

- The fine meshed cast net which destroys fish juveniles must be banned to revive the survival rate of fish species

- Fish poisoning method used in diverted channel stations I, II and III, by applying various poisonous plant products. Such as Khirro (*Sapiuns insignes*) and sihudi (*Cactus species)* must be banned,

- Dynamiting frequently done by the security forces of Chitwan National Park had been recorded near Sauraha. It is very destructive fishing method. Such method destroys all types and age groups of fishes. Sometimes fishes are being killed by applying electric current. It is also a harmful fishing method, hence, all, these harmful means and methods of fishing must be checked and totally banned.

7.2 Closed Fishing Season

Different kinds of fishes breed in different seasons. *Mystus* sps. recorded as major fish from Rapti River, spawn during June and July. Many small hill stream fishes breed in March. Fishing should be stopped during these months.

During breeding seasons, female fishes with thousand of eggs in the ovary are caught; due to which large number of quality eggs are perished. The closed seasons are quite common device for the protection of fish stocks. This will allow fish freedom to complete spawning cycle and early life cycle without. Closed season program should launched immediately; for which, time of spawning of various fishes should be known.

7.3 Habitat Improvement

Habitat improvement is the most important factor towards the conservation of fishes. Most of fishes deposit their eggs in fine oxygenated water over the gravel. The destruction of eggs is encountered due to soil erosion and silt deposition. It has to be preserved the upland ground and soil binding tress for the protection of fish seed from over silting. The water pollution affects all kinds of riverine fisheries. The Rapti River seemed to be polluted mostly by domestic sewages and agricultural pesticides. Hence awareness of villagers is necessary - regarding sanitation system and use of insecticides in farm.

7.4 Establishment of Research Centers

In order to monitor physicochemical and biological properties of riverine systems and develop awareness about fish conservation and fisheries development around Rapti River, a research centre should be setup.

7.5 Establishment of Fish Sanctuaries

The majority of fish species are extremely sensitive to the environmental changes. Fish sanctuaries establishment will help to protect rare fish species.

7.6 Stocking Fish Population

Population of economically important fishes such as *Tor* (Sahar) and *Anguilla* are decreasing due to high fishing pressure and many other reasons. Hence, river can be rehabilitated by releasing hatchery reared fry of some important fishes.

7.7 Government should provide employment for improvement of livelihood of poor fishermen.

7.8 Special trainings or other activities should be launched to local fishermen so that they can do other works also except fishing.

8.0 Summary

The present study entitled "Study on Fish and Fishery Resources of the Rapti River" was conducted since January to September 2005 covering three different seasons - winter, summer and rainy. The present work included some physicochemical parameters and biological parameters like fish fauna, their distribution patterns, management in the Rapti river. This study also included the socio-economic status of fishermen, fishing implements used in Rapti River and fish marketing systems.

The physical and chemical parameters of the river being important factors were analyzed at all the stations. The optimum temperature and some chemical factors provide a suitable environment/habitat for a large number of fish species. The water of the river was found rich in dissolved oxygen with a good concentration of total hardness. The water was never found acidic in nature.

The total 59 species of fish fauna of 7 orders, 19 families and 38 genera were collected from three stations of the Rapti River. During the study the fishes were sampled from local markets also along with catch of local fish. Among 59 fish species, *Neolissocheilus hexagonolepis, Anguilla bengalensis* and *Tor tor* are vulnerable and recommended for legal protection by Shrestha (1995), had been reported in this river during investigation period. The distribution of fish species was found influenced by the water current, velocity, water temperature, altitude and nature of river bed.

The present study showed the poor socio-economic condition of fishermen. Most of the fishermen were belonging to castes Bote, Majhi, Tharu, Darai, Magar and Chhetri group. The number of fishermen was low in this area and they were dominated by higher castes i.e. Brahman, Chhetri and Newar

community. The fishermen inhabiting near river bank are illiterate, only few had an education up to school level. Fishing is the main profession. The present study of fish and fishery resources of the Rapti River would help for the planning, development, management and conservation of the riverine fisheries in Nepal.

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APPENDIX – I

The statistical analysis to determine the coefficient correlation between the different physico- chemical parameters and fish species composition have been calculated by using the Karl Pearson formula (Gupta, 1988)

$$\text{Correlation (r)} = \frac{N\phi XY \; \mathrm{Z}(\phi X)(\phi Y)}{\sqrt{N\phi X^2 \; \mathrm{Z}(\phi X)^2}\sqrt{N\phi Y^2 \; \mathrm{Z}(\phi Y)^2}}$$

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

APPENDIX – II

A sample of questionnaires used in interview with fishermen of Rapti river to study their socio economic condition and demography was as follows:

Zone: District V.D.C. Ward No:

1) Name of Fisherman:

Cast: Age: Sex: Religion:

2) Number of members of family.

Total: Male: Female:

3) Are you literate?

…….

4) Are you giving school education to your children?

……..……

5) If no, then why?

……..…

6) Do you know about family planning?

……..

7) How many members of your family are involved in fishing?

…….

8) How many fishermen come for fishing at this site?

……..

9) Is fishing your main profession?

Yes No.

10) In which category of fisherman do you fall?

Full time fisherman, Part time fisherman, Occasional

11) Does the income from fishing cover your family expenditure?

Yes No

12) Which fish species are abundant/common/uncommon in this river?

Name of the Fish	Abundant	Common	Uncommon	Remarks

13) What do you do with captured fish?

Consume Sell Both

14) Where do you sell the captured fish?

Place	Market/Village	Distance from home	

15. How much fish do you capture per day/month?

……

16. What type of fishing gears do you use in different time of year?

……

17. What do you think fish population has increased or decreased in the recent years?

Increased Decreased Unknown

18) If increased/decreased, please give the reason?

Over-fishing use of dynamite use of pesticides /herbicides.

Electrifying establishment of fishing prohibited zone other.

19) Which fish species are mostly captured by you?

……

20) What are aquatic predators of this river?

…….

21) Do you observe or hear about fish spawning/ breeding?

…….

22) In which season or month, you have observed fries and fingerlings in the Rapti river in your catch?

…….

23) Do you have any facilities from public or private institutions at present?

……..

24) Would you like to give any suggestions for the improvement of fishery in Rapti river?

……..

Thanks !