A REPORT ON

Local Fish Diversity in Tiger Lake and its Peripheral Areas in Chitwan District of Nepal

(Based on study conducted by MDI Nepal under the UNDP GEF SGP supported project entitled 'Promoting Local Fish Diversity in Selected Lakes of Chitwan through Ecosystem based Co-management Practices')

(Project Number NEP/SGP/OP6/Y3/STAR/BD/2018/05)

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Team Leader

Rahul Ranjan, Researcher
Assistant Professor- Agriculture and Forest University
Rampur, Chitwan

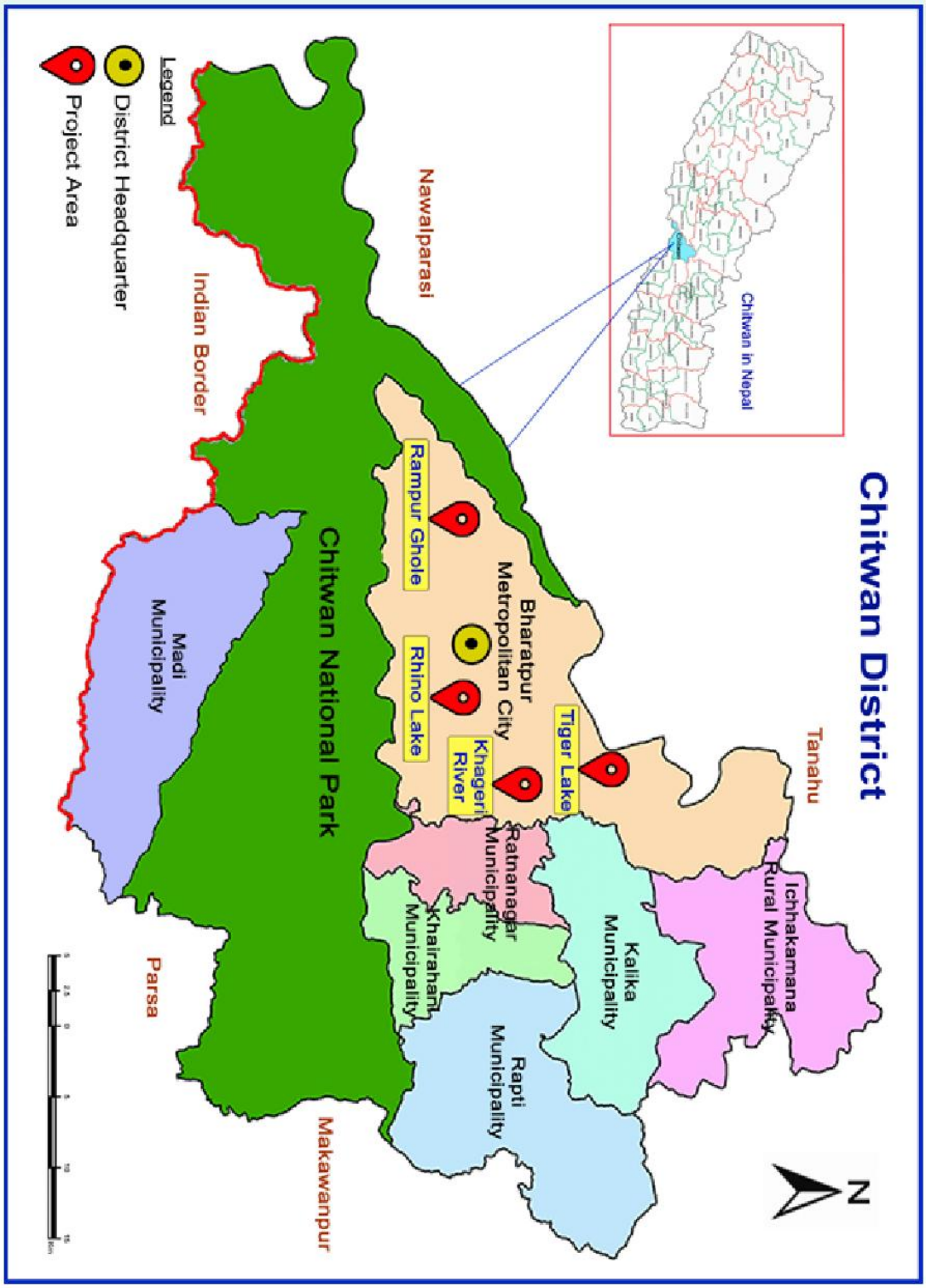
Supporting Intern Students

Krishna Paudel, B.Sc. Fisheries, Final Year
Sandeep Lamichhane, B.Sc. Fisheries, Final Year
Shobhakar Pandey, M.Sc. Fisheries, First Year

Agriculture and Forest University
Rampur, Chitwan

October 2020

DISTRICT MAP



BIOGRAPHY

Rahul Ranjan

Researcher

Mr. Rahul Ranjan is a young and native resident of Rajbiraj from Saptari district. He was born (11 September 1986) in this small city, Rajbiraj which is very much popular with respect to Maithili culture of Terai region of Nepal. He completed his M.Sc. Zoology from Tribhuvan University (TU), Nepal in 2010. After completion of his study, he came to Chitwan and established a fish farm in partnership with some young and energetic fellows in Shankarchok of Chitrawan Municipality. He worked almost 4 years in the farm as Farm Manager producing various species of food fishes for sales. Through his works on this farm, he has acquired substantial experiences in improving fish productivity applying proven form of culture methods. In 2013, he came in contact with Agriculture and Forestry University (AFU) of Rampur which is located near to his farm. He joined the AFU for the study of M.Sc. Fisheries (Aquaculture) in 2013 and completed his second master degree in 2015. Mr. Ranjan is the topper and gold medalist of his batch 2015 in the university. After completion of this degree, he worked for two years as Research Assistant in AFU under AquaFish Innovation Lab Project funded by USAID. Presently, he is an Assistant Professor in the Department of Aquatic Resources, AFU, Rampur, Chitwan, Nepal. In addition to his regular works in AFU, Mr. Ranjan has been involved as an expert for different research studies, particularly in fish biodiversity projects. He has applied this combination of practical and academic experiences to a variety of organizations in Nepal particularly USAID, MDI Nepal and some local organizations in designing appropriate fish biodiversity research works and aquaculture projects funded by different national and international organizations. He has written several scientific research papers related to aquaculture and fisheries, which have been published in various reputed journals and also presented various research findings in seminars and workshops. In addition, he is the author of 3 academic and scholarly books. He holds an executive position in Nepal Fishery Society (NEFIS) and is on the editorial board of NJAF.

Krishna Paudel

Mr. Krishna Paudel was born (6 July 1996) in Butwal, a small city of Rupandehi district. He completed his school level education from Nepal Evergreen Public English School and +2 education from Manimukunda Science College in the year 2015. Then, he joined B.Sc. Fisheries in Agriculture and Forestry University (AFU), Rampur, Chitwan in the same year 2015. He is currently in the final year of his B.Sc. Fisheries at AFU. During his study, he took a particular interest in biodiversity research works and volunteered for number of surveys works at the AFU as well as other organization. He was in the expedition team led by Prof. Mary C. Fabrizio from the Virginia Institute of Marine Sciences, USA working in fish diversity of fishes in four rivers in the protected areas of Nepal (Nepal Fish FACTS) during the summer of 2019. He has participated in surveys carried out by AquaFish Innovation Lab. Mr. Paudel have keen interest in fish biodiversity and taxonomy. His personal hobbies include gardening, sketching and drawing, reading about current affairs etc.

Sandeep Lamichhane

Mr. Sandeep Lamichhane is from Deurali village from Nawalparasi district. He was born on 18 November 1997. He completed the school level education from Reliance International Academy and started his Bachelor study in Fisheries (B.Sc. Fisheries) in Agriculture and Forestry University (AFU) in the year 2015. He is now in the final year of his study in Agriculture and Forestry University, Rampur, Chitwan, Nepal. He has keen interest in fish biodiversity and aquaculture and has completed several surveys works in fish biodiversity research projects. He prefers to play football, badminton and trekking during his leisure time.

Shobhakar Pandey

Mr. Shobhakhar Pandey was born in a famous place Devdaha, birthplace of Mayadevi (Mother of lord Buddha) in Rupandehi district. He was born on 20 August 1997. He completed his school level education from Kerwani Higher Secondary School and completed his +2 level from Glorious Higher Secondary School in 2014. He joined B.Sc. Fisheries in Agriculture and Forestry University (AFU), Rampur in 2014 and completed it in 2019. He then joined M.Sc. Fisheries (Aquaculture) in the same university and is now continuing his study in the final year. He was the president of Nepal Aquaculture & Fisheries Students' Association (NAFSA) from 2017 to 2018. Mr. Pandey is very much interested in pursuing a carrier in fish biodiversity and capture fisheries and has accomplished number of studies related to fish biodiversity and population dynamics. Mr. Pandey is fond of playing Badminton, Madal and singing Nepali lok song.

PREFACE

Nepal is blessed with a number of watersheds at different altitudinal variations having a total of 252 fish species. Among them, 236 species are indigenous while 16 species are exotic. The native fishes are important in several respects. They are preferred locally, grow better under local conditions and contribute to biodiversity because of their self-recruiting nature. They also maintain integrity in aquatic communities and ecosystems and can be used in ornamental and sports fishing attracting angling-based ecotourism. They are rich in micronutrients and can adequately aid in food security, nutrition and medicinal purposes as well.

To address this issue, UNDP GEF Small Grants Programme of Nepal has supported a wonderful fish biodiversity project to MDI Nepal which has been implemented at Tiger Lake in Bharatpur-11, Chitwan.

However, due to the pressure of extensive modern agricultural practices and indiscriminate fishing, stocks of native fish species are gradually declining and their habitats and breeding grounds are being deteriorated at a faster rate. Habitat degradation and loss probably has been more responsible for their decline. Of the total 236 native fish species, 23 species are said to be rare and near threatened at different levels. Among other reasons, uncontrolled and unconventional fishing in the open water bodies is the major threat causing decline of native fish species. This will continue to deteriorate the system further because of the lack of absolute regulations and lack of awareness of the surrounding communities. Thus, there is a need to increase awareness among local communities on conservation of such species so that our future generation would be able to see the fish diversity in our lakes, reservoirs, streams and rivers.

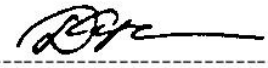
To address this issue, UNDP GEF Small Grants Programme of Nepal has supported a wonderful fish biodiversity project to MDI Nepal which has been implemented at Tiger Lake in Bharatpur-11, Chitwan. Though the project is running at small scale covering a limited aquatic area, it has identified 34 native species in total which is 14.4 % of the total native species found in

the entire country. In addition, some rare species like Mara (Amblypharyngodon mola) which was not reported earlier from Chitwan, have been identified and located only recently. These are the important species from a nutritional point of view.

Now, the big question is: how do we save and promote these species? Our mother earth has graciously bestowed us with a plethora of resources for the human kind to live a decent livelihood. While some of such resources are even unraveled as yet and few known resources have rather been used unscrupulously leading towards the brink of extinction. In this respect, we can imagine that there are daunting challenges conserving freshwater fish species in our aquatic systems which have freer access to all. As of now, there is not a single example in the country that native fish stocks have been conserved, protected and sustainably used for various economic purposes. Only government efforts are not adequate. Thus, to overcome the problems, adoption of community or cooperative based conservation could be one of the best approaches for restoring these native species. The proposed project will be directed to achieve this goal where all CFUG members and other general publics will actively participate in conserving local species in their natural lakes and develop the area as fresh water protected areas where people from all walks of life could see, learn best practices and disseminate it in similar other areas.

I complement the efforts of Mr. Khop Narayan Shrestha, Director, MDI and his team for bringing out this important report.

Thank you !



Prof. Dr. Dilip Kumar Jha
Aquatic Resource Specialist
Agriculture and Forestry University
Rampur, Chitwan, Nepal

FOREWORD

I am pleased to know that the "Fish biodiversity project" in Tiger Lake in Chitwan has been successfully implemented amidst COVID-19 crisis. It is a great pleasure to work with MDI in this project funded by UNDP GEF Small Grants Programme. Mr. Rahul Ranjan, Assistant Professor and three students from B.Sc. Fisheries final semester of Fisheries Program, Agriculture and Forestry University studied fish diversity in this project. I am very happy to know that the team has identified 34 native fish species including Small Indigenous Species (SIS) such as Mara, Dedhuwa and Pothi from the Tiger Lake and associated areas. These species are highly valuable source of micro nutrients. Vitamins and minerals are found to be much more in small fish than in large fish. SIS are self-recruiting and therefore can be harvested weekly and biweekly, favoring household consumption.

Though this Carp-SIS technology was primarily intended to promote SIS species such as Mara, Pothi and Dedhuwa from nutrition point of view and carps for income generation, but now it has been considered as a better conservation approach.

I know, MDI Nepal is a renowned organization in Nepal, working in livelihood and environmental sector to uplift the socio-economic status of rural people. In addition, MDI has been actively involved in promoting several aquaculture activities in rural areas of Nepal including a Carp-SIS technology which combines both SIS and big carps together.

Carp-SIS polyculture in earthen ponds was initially studied in Bangladesh by Bangladesh Agricultural University (BAU) during 2000. In this system carps (rohu, catla, mrigal, bighead carp, silver carp, grass carp and common carp) and SIS are grown together with potential of ensuring additional 10 percent surge in productivity. After the successful results obtained in Bangladesh, we implemented a pilot project on Carp-SIS polyculture in Chitwan and Kailali districts in Nepal during 2009-2011. The project was funded by Danida and technically supported by BAU. Since then I have myself been involved in various research works on Carp-SIS technology in Nepal.

MDI then replicated and multiplied it in Handikhola VDC of Makawanpur district with the financial support of UNDP GEF Small Grants Programme in 2012. Now more than 300 ponds around the Masine and Twangra Khola are stocked with Carp and SIS. I have visited the area where people are generating substantial income from selling big carps and, at same time, improving the household nutrition levels from SIS consumption by family members.

Though this Carp-SIS technology was primarily intended to promote SIS species such as Mara, Pothi and Dedhuwa from nutrition point of view and carps for income generation, but now it has been considered as a better conservation approach. With this approach, people have prevented fishing SIS in rivers and streams. This has also helped reduce indiscriminate killing of SIS and has ensured conservation of natural SIS stocks in their natural habitats. On the other hand, since ponds being the ideal breeding grounds for SIS, the fries escaped from the ponds have entered the natural water bodies. People have marked that SIS population is starting to show signs of recovery in rivers and streams after the Carp-SIS project launched in Handikhola.

This production cum conservation practice is highly sustainable creating a ray of hopes on SIS conservation and consumption for household nutrition while the carps are sold for household income. I believe that the Carp-SIS technology have already been acknowledged by the local communities and their perception about SIS conservation has become widened. I hope MDI will be able to carry out such a sustainable approach in future to conserve and manage local fish stocks and sustain income of the rural households so that people will be encouraged to participate in such conservation efforts without any fuss.

Thank you !

Prof. Dr. Sunila Rai
Programme Coordinator
Fisheries Programme
Agriculture and Forestry University
Rampur, Chitwan, Nepal

FOREWORD

Fish diversity is the highest among other living creatures. However, threats over their existence have been looming vividly by over fishing, pollution, habitat alteration and poor understanding of fish ecology. Natural water bodies have been home to freer access to all. Thus, there is indiscriminate killing of fish stock including young fingerlings from these resources. Though, there is Aquatic Animal Protection Act, 2017 (1960), but it is poorly enforced. People use different kinds of gears including those seriously destructive fishing methods such as insecticides, dynamiting and electric shock fishing. This has been tremendously hampering the fish biodiversity in the natural water bodies. It is reported that out of the total 236 native fish species recorded in Nepal, 34 species are found threatened at different levels. This will continue even in the coming days unless a concerted effort is made for conservation of aquatic resources especially the fish fauna.

The current degradation in native fish conservation might be challenging not only to fish diversity but also impact over food security and income of several million people dependent on fishing.

The current degradation in native fish conservation might be challenging not only to fish diversity but also impact over food security and income of several million people dependent on fishing. Therefore, to ensure native fish conservation, significant improvement in law enforcement with high level of wisdom is inevitable. However, successful fisheries management is not simply the result of applying rules and regulations, it is rather the sincere adoption of community or cooperative based conservation which could be one of the paramount approaches for fish restoration in the long run.

The fish museum and biodiversity centres (FMBC) developed in coordination with Division Forest Office, Chitwan will serve as an educational centre using interactive exhibits that focuses on Chitwan's rich diversity of freshwater fishes and in raising local and national awareness of the

need to change fishing practices to conserve and ensure the sustainability of aquatic fauna. FMBC hopes to achieve this through inspiring educational exhibits, by maintaining and developing scientific collections for display and by fostering links with other museums and research centres nationally and internationally.

I take this opportunity to thank Division Forest Office, Chitwan for their gracious support and in bringing coordination with different stakeholders including Bharatpur Municipality ward # 11, Nava Jagriti Community Forestry Users Group and other concerned authorities for this endeavor. I thank MDI team for their initiatives on this important plan and making well coordination with Agriculture and Forestry University in technical matters. For this, I would like to thank the study team led by Mr. Rahul Ranjan, Asstt. Professor and his intern students Mr. Krishna Poudel, Sandeep Lamichhane and Mr. Shobhakar Pandey and the technical consulting team members especially Prof. Dr. Sunila Rai, Programme Coordinator and Prof. Dr. Dilip Kumar Jha, Aquatic Resource Specialist from Agriculture and Forestry University (AFU), Rampur, Chitwan

I hope that this project will help at least in some ways to bring awareness among local communities to understand biodiversity, aquatic eco-systems maintenance and importance of native species on income generation and not least to sustainable fishing practices in the days to come.

Thank you !

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Gopal Raj Sherchan
National Coordinator
UNDP GEF Small Grants Programme

ABBREVIATIONS

AFU	Agriculture and Forestry University
BAU	Bangladesh Agricultural University
CFUG	Community Forest Users Group
COVID	Corona Virus Diseases
DANIDA	Danish International Development Agency
FMBC	Fish Museum and Biodiversity Centres
GEF	Global Environment Facility
IUCN	International Union for Conservation of Nature
LC	Least concern
MDI	Manahari Development Institute
NAFSA	Nepal Aquaculture & Fisheries Students' Association
NEFIS	Nepal Fishery Society
NJAF	Nepalese Journal of Aquaculture and Fisheries
NT	Near Threatened
SIS	Small Indigenous Species
SGP	Small Grants Programme
TU	Tribhuvan University
USAID	United States Agency for International Development
UNDP	United Nations Development Programme
USA	United States of America
VDC	Village Development Committee

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1. Introduction

1.1 General introduction

Chitwan district lying in Central Terai of Nepal is endowed with a lot of natural beauty. Nepal's first national park, Chitwan National Park lies in this district and covers more than 30% of the district's total area. Along with this, a large area is also covered by forests under the buffer zone and community forest. All these forests have a number of small to large lakes as well as associated wetlands. These wetlands support great variety of floral and faunal diversity including different fish species. Despite of many conservation efforts by government, there is less attention towards the conservation of fishes.

A project entitled "Promoting local fish diversity in selected lakes of Chitwan through eco-system based co-management practices" was launched by MDI Nepal (Manahari Development Institute-Nepal), in Bharatpur Metropolitan City-11, Chitwan with the financial support from United Nations Development Programme (UNDP), Global Environment Facility, Small Grants Programme (GEF/SGP) of Nepal. The project is targeted to improve fish stock in some of the lakes through management measures. One of the objectives of the project was to prepare inventory of indigenous fish species and maintain museum for the preserved species as well as live aquarium at the respective destination sites.

This report is based on the field study mainly in Tiger lake and its peripheral areas such as Rhino lake and Different sections of Khageri stream. The Rampur ghole was taken as a reference site for comparison as it has some conservation initiatives managed by Agriculture and Forestry University (AFU), Rampur. The study was conducted by a team of fisheries technicians from Agriculture and Forestry University, Rampur, Chitwan lead by Asst. Prof. Rahul Ranjan including intern scholars Mr. Krishna Paudel, Mr. Sandeep Lamichhane and Mr. Shobhakhar Pandey.

The main purpose of this study was to assess the fish diversity in concerned areas and to formulate the conservation plans accordingly.

1.2 Objectives

The main objective of present work was to assess the fish diversity in Tiger lake and peripheral areas.

The specific objectives were:

1. To prepare inventory of indigenous fish species from targeted project area.
2. To give taxonomic classification of the collected fish species
3. To observe & compare the fish diversity status of different aquatic habitats.
4. To create an educational exhibit such as Fish Museum and Biodiversity Centre (FMBC) in raising awareness in sustainable fishing by maintaining and developing scientific collections for display.

2. Literature review

Native or local fish species are important from several perspectives. They are eco-friendly compared to exotic carp and other fishes due to their self-recruiting habit in appropriate environment. Different works on the fish diversity in water of Chitwan district and surrounding areas have been carried out.

Several studies have been carried out to assess the fish diversity in different water bodies of Chitwan district (Rajbanshi, 2012; Ng, 2003; Shrestha & Edds, 2012; Jha, 2018; Oli et al., 2013). However, most of them are focused towards the study of ichthyofaunal diversity in Narayani river system and major lakes. Small lakes and minor river systems have not been in focus. Oli et al. (2013) in their study have recorded 22 fish species from Rampur ghol belonging to 13 families and five orders. Similarly, Jha (2018) have recorded a total of 111 fish species belonging to 9 orders and 27 families from different sampling sites in Narayani and Rapti river of Chitwan district.

3. Materials and Methods

Present study was carried out at four locations in Chitwan district including Tiger lake, Rhino lake, a stretch of Khageri river and Rampur ghole. Details of study locations is provided in Table 1.

Table 1: *Brief description of different sites*

S.N.	Location Name	Latitude, Longitude	Approx. Area
1.	Tiger Lake	27°40'51"N 84°27'56"E	3.9 ha
2.	Rhino Lake	27°39'55"N 84°28'20"E	6.2 ha
3.	Khageri river	27°40'40"N 84°27'47"E	
4.	Rampur Ghole	27°40'26"N 84°27'00"E	

3.1 Sampling sites and frequency

Sampling sites at different locations were selected considering habitat variation, anthropogenic activities and easiness of the operation for sampling and study. Sections of lakes, river stretches and gholes were made based on the abundance vegetation and anthropogenic activities. Each location was visited at least four times during the survey on monthly basis which included summer, rainy, autumn and winter season. Table 2 shows the dates of field visit on different locations. Along with this, fish samples were also collected from local fishermen who catch fish from these sites which is considered as secondary collection for the purpose of this report. Fish samples collected during sampling procedure is considered as primary collection.

Figure 1: *Casting net at Khageri stream for sample collection*

Figure 2: *Processing of collected sample in field (live photography and identification)*

Table 2: *Fish sampling dates at different sites*

Tiger lake	Rhino lake	Khageri river	Rampur ghole
25 May 2019	1 June 2019	15 June 2019	22 June 2019
29 June 2019	13 July 2019	20 July 2019	27 July 2019
10 August 2019	17 August 2019	3 August 2019	24 August 2019
31 August 2019	14 September 2019	7 September 2019	21 September 2019
28 September 2019	16 November 2019	9 November 2019	19 October 2019
7 December 2019	23 November 2019	30 November 2019	14 December 2019
28 December 2019	4 January 2020	11 January 2020	anuary 2020

3.2 Gears used and sampling

For the sampling purpose cast net (1 cm mesh size, 12 m circumference) and bag seine (1 cm mesh size, 10 m length and 1 m height, bag size 1x1x1 m^3) was used. Cast net was deployed in each location for 10 times in different section during each visit. Similarly, seining with bag seine was done 2 times at each location in possible sections.

3.3 Sample processing

All fish caught in one effort were collected in a bucket fitted with battery-operated bubbler. Fish were kept alive as far as possible. Fish were then photographed in appropriate sized photarium and identification were done according to key provided by Shrestha (2008). For identification, first of all fish were compared with the diagrams provided in reference book and then all measurements were taken for the confirmation. Data on length and weight of all captured fish were recorded using tabletop/palm top electronic balance and a dial Vernier caliper. After taking the necessary measurements, fish were released in their natural habitat. Sample of each species were collected in 10% formalin solution and brought to laboratory for their fixation as museum specimen.

3.4 Species diversity indices

All identified species were classified up to family level and data entry was done for all different sites. Different diversity indices for fish were calculated from primary data that included species richness, relative species abundance and Simpson's diversity index.

Species richness is the simplest diversity index and provides information only on number of different kinds of organisms present in a particular area. It is simply the count of species in a community. Relative species abundance is a component of biodiversity and refers to how common or rare a species is relative to other species in a defined location or community (Hubbell, 2001). Relative abundance is the percent composition of an organism of a particular kind relative to the total number of organisms in the area.

Simpson's index (D) measures both richness as well as evenness of a species and the value ranges between 0 and 1. Greater the value of D, lower is the diversity with 0 representing infinite diversity and 1 representing no diversity. It is calculated using following formula:

$$\text{Simpson's Index (D)} = \frac{\Sigma n(n-1)}{N(N-1)}$$

Where,
n= total number of organisms of a particular species
N= total number of organisms of all species

Example:
Let us consider two sites having following fish population (as sampled)

Fish Species	Site A	Site B
Puntius spp.	10	35
Esomus danricus	4	12
Channa spp.	2	
Pethia spp.	3	20
Xenentodon cancila	2	2
Salmostoma spp.	3	
Barilius spp.	1	
Total	**25**	**69**

Here, Site B have larger number of fish than Site A. Let us calculate the Simpsno's index.

Fish Species	Site A	n(n-1)	Site B	n(n-1)
Puntius spp.	10	10x9=90	35	35x34= 1190
Esomus danricus	4	4x3= 12	12	12x11=132
Channa spp.	2	2x1=2	-	
Pethia spp.	3	3x2=6	20	20x19=380
Xenentodon cancila	2	2x1=2	2	2x1=2
Salmostoma spp.	3	3x2=6	-	
Barilius spp.	6	6x5=30	-	
Total	**30**	**148**	**69**	**1704**
N(N-1)	30 x 29=870		69x68= 4692	

Simpson's index for Site A= 148/870= 0.17

Simpson's index for Site B= 1704/4692= 0.36

Here, we can see that although the number of fish at Site A is lower than the number at Site B, Site A has more diverse population than Site B. This is also indicated by the Simpson's index calculated.

Simpson's index: Site A< Site B

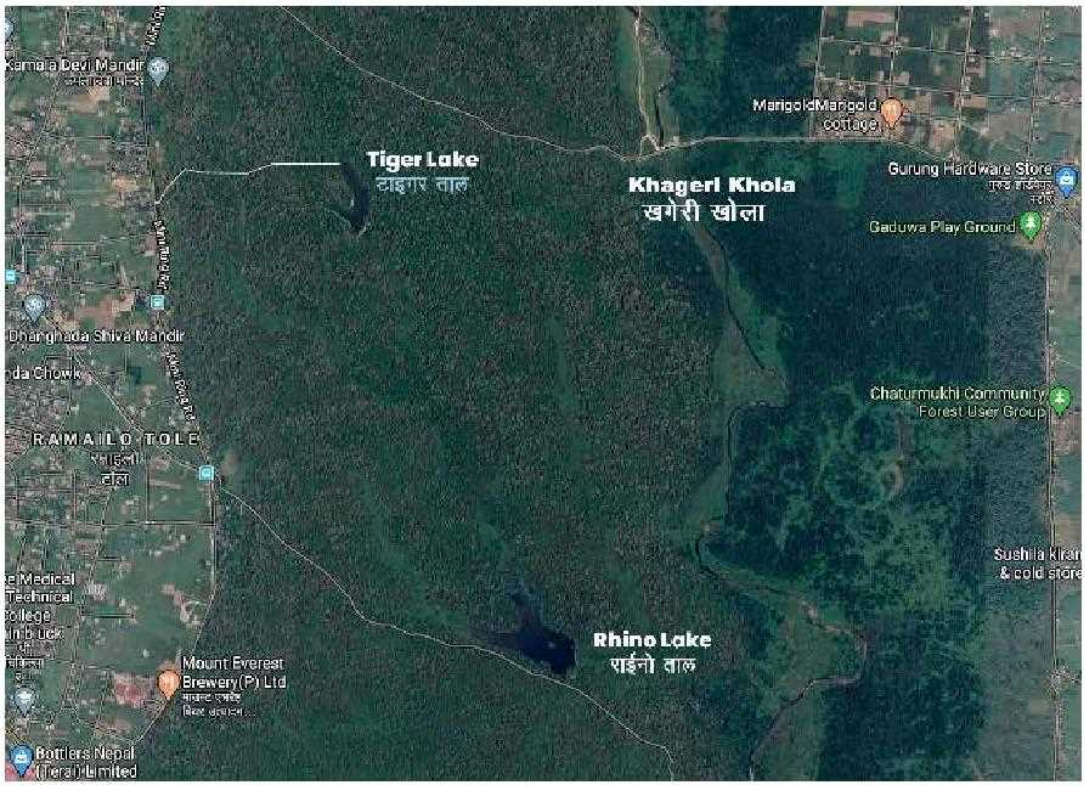
Thus, lower the Simpson's index higher the diversity is.

4. Result and Discussion

4.1 Habitat diversity

A. Tiger Lake

The Tiger lake is a beautiful lake about 730 meters (aerial distance) away from the Mini Ring Road. The lake is situated inside the Nava Jagriti Community Forest and got its name based on its shape like tigers foot.. The total estimated area of the Tiger Lake is about 39,683 m^2 (Google zearth). The lake is not too bottom is mostly muddy with submerged vegetations in almost all part of lake. Tiger lake is rich in aquatic biodiversity. This lake is observed



with high vegetation supporting much terrestrial and aquatic life. There is slight change in water level in Tiger Lake with season but has enough water to support the aquatic life like fishes and aquatic birds throughout the year. Submerged plants like Nelumbo, hair grasses etc. are mostly present, except in some shallow area along the shores of Lake. This lake is seen with many shoreline vegetations and invertebrates that have food value as many local people nearby the lake were found collecting those thing around the lake. This lake not only supports the aquatic life but also serves as the source of water for drinking to many terrestrial wild animals like tiger, deers, rhinos and other animals and birds as well. During our sampling work, our team has observed people catching fish in the lake, which shows that this lake is also supporting the people in their day-to-day food requirement. Such activities show that there is little impact on lake ecosystem due to human activities.

Figure 3: *Repair works in Tiger Lake is in progress*

B. Rhino lake

The Rhino lake is larger than Tiger lake and is about 1.40 km from the Mini Ring Road. It is also situated inside community forest and named as Rhino Lake as it is famous from encounter of Rhinos frequently. Total estimated area of Rhino Lake is 62,367 m^2 (Google earth). The lake is deeper at some part and shallow some part but mostly the bottom is muddy. This lake by nature is provided with many species of aquatic and terrestrial animals, which directly or indirectly are benefited by the lake. It inhabits many fishes and vegetation in and on shore of the lake, which shows that the lake is having good species diversity. During sampling in this lake, our team has observed some construction works around the lake in order to promote local visitors for the promotion of lake from ecotourism prospective. Construction work for the channel of irrigation was going on and some people were observed to catch fish in the lake. Such activities shows that Rhino lake is a lake with high potential for eco-tourism but increasing of such anthropogenic activities have great impact on the diversity of lake in the near future.

C. Khageri Stream/ River

Khageri river originates in Mahabharat range and with some tributaries flows along the side of Barandabhar forest before finally emptying in east Rapti river. It has a perennial flow with fluctuation in level during different season. The river bed is sandy and muddy at places. This

Figure 4: *Fishing and swimming done by local boys in Khageri river*

river also supports the communities around there by many ways, people dug out the river for construction materials, collect aquatic vegetations. During our survey works, some fishing communities were also found catching fish using local gears in the river. Such activities shows that river is facing continuous impact on diversity. Samplings during present study was done around the bridge over this river on the way to Padampur from Bharatpur.

D. Rampur Ghole

Rampur ghole is a wetland having water source from the nearby cultivated lands. It is a marshy wet land supporting various aquatic life forms. Rampur ghole is extended in length of about 3 kilometers. Rampur ghole has been chosen as sampling site for this project because it is a study hub of fisheries program and frequently observed with many aquatic life forms like fish. Many aquatic vegetations having food value, migratory birds, wet land vegetation of medicinal value and many species of fish are the inhabitant of this area. This site is often seen with high anthropogenic activities like construction of houses and mega structure like Cricket stadium, collecting edible plants, catching fish and grazing animals which directly have impact on the fish species diversity. A part of this ghole is protected by making impoundment by Agriculture and Forestry University for study purpose. Current sampling was done in and around this impounded area.

Figure 5: *Reservoir made for fish conservation in Rampur Ghole*

4.2 Fish species collected

Altogether 34 different fish species were collected from different sites that includes all fish species either collected during sampling procedure (primary collection) or collected from local fishermen (secondary collection) (Annex 1). Taxonomic information of different species collected is given in Table 3.

Table 3: *Taxonomic information of fish species captured and collected from different locations.*

S.N.	Fish species	Order	Family	Local name
1	*Badis badis*	Anabantiformes	Badidae	Sudure sidra
2	*Channa punctatus*	Anabantiformes	Channidae	Bhoti
3	*Trichogaster lalia*	Anabantiformes	Osphronemidae	Khasre sidra
4	*Xenentodon cancila*	Beloniformes	Belonidae	Kauwa machha
5	*Oreochromis niloticus*	Chichliformes	Chichlidae	Tilapia
6	*Amblypharyngodon mola*	Cypriniformes	Cyprinidae	Mara
7	*Barilius barila*	Cypriniformes	Cyprinidae	Fageta
8	*Barilius bendelisis*	Cypriniformes	Cyprinidae	Fageta
9	*Brachydanio rerio*	Cypriniformes	Cyprinidae	Chitripothi
10	*Cirrhinus mrigala*	Cypriniformes	Cyprinidae	Naini
11	*Danio devario*	Cypriniformes	Cyprinidae	Bhitti
12	*Esomus danricus*	Cypriniformes	Cyprinidae	Dedhuwa
13	*Rasbora daniconius*	Cypriniformes	Cyprinidae	Dehaura
14	*Garra nasuta*	Cypriniformes	Cyprinidae	Buduna
15	*Naziritor chelynoides*	Cypriniformes	Cyprinidae	Halundae
16	*Pethia conchonius*	Cypriniformes	Cyprinidae	Sidra/ Pothi
17	*Puntius guganio*	Cypriniformes	Cyprinidae	Sidra/ Pothi
18	*Puntius sophore*	Cypriniformes	Cyprinidae	Sidra/ Pothi
19	*Puntius terio*	Cypriniformes	Cyprinidae	Sidra/ Pothi
20	*Puntius ticto*	Cypriniformes	Cyprinidae	Sidra/ Pothi
21	*Systomus sarana*	Cypriniformes	Cyprinidae	Bada pothi
22	*Salmostoma phulo*	Cypriniformes	Cyprinidae	Chilwa
23	*Lepidocephalichthys guntea*	Cypriniformes	Cobitidae	Gadela
24	*Paracanthocobitis botia*	Cypriniformes	Nemacheilidae	Baghe latta
25	*Glossogobius giuris*	Gobiiformes	Gobiidae	Bulla
26	*Chanda nama*	Perciformes	Ambassidae	Sisa machha
27	*Mysutus tengara*	Siluriformes	Bagridae	Tengara
28	*Clarias magur*	Siluriformes	Clariidae	Magur
29	*Heteropneustes fossilis*	Siluriformes	Heteropneustidae	Singhi/ Kande
30	*Ompok pabda*	Siluriformes	Siluridae	Nauni
31	*Walago attu*	Siluriformes	Siluridae	Badari
32	*Macrognathus aral*	Synbranchiformes	Mastacembelidae	Dhare baam
33	*Macrognathus pancalus*	Synbranchiformes	Mastacembelidae	Dhare baam
34	*Monopterus cuchia*	Synbranchiformes	Synbranchidae	Andhuwa baam

Species collected from different sites belong to 8 orders and 16 families (Fig. 6).

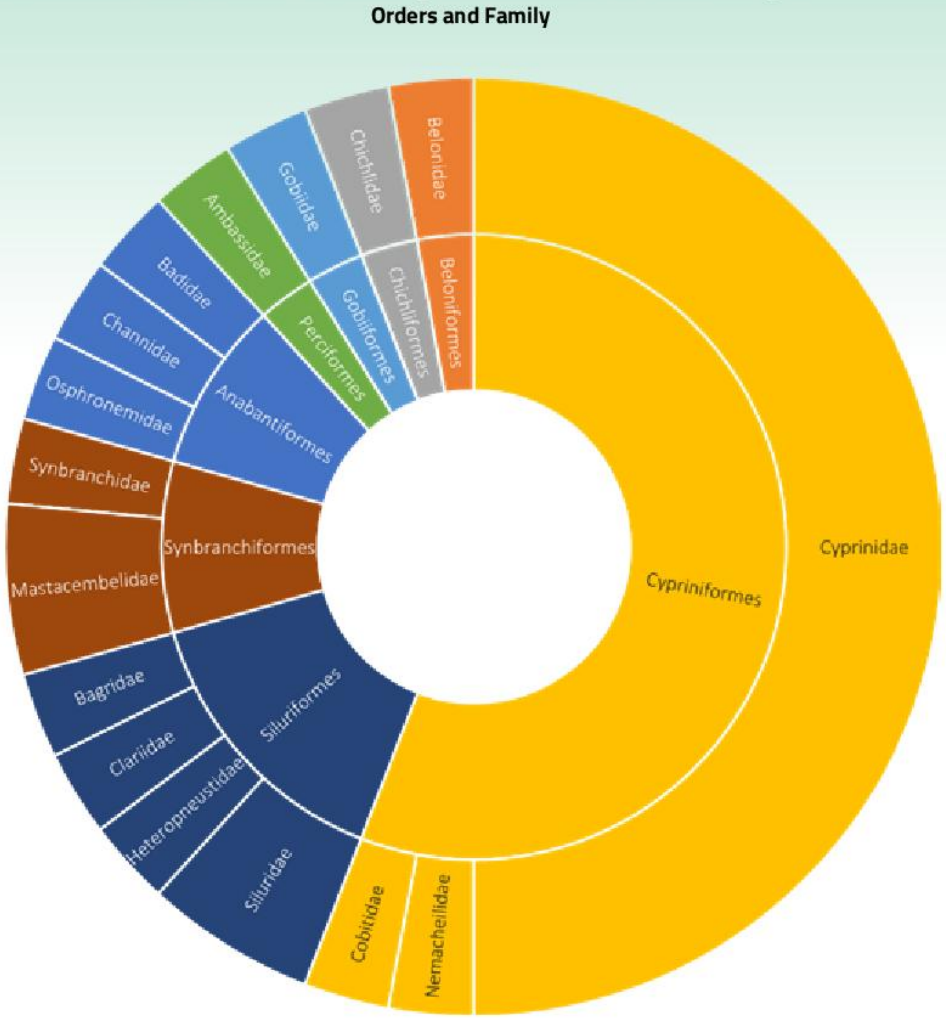


Figure 6: *Different orders and families of collected fish species in overall*

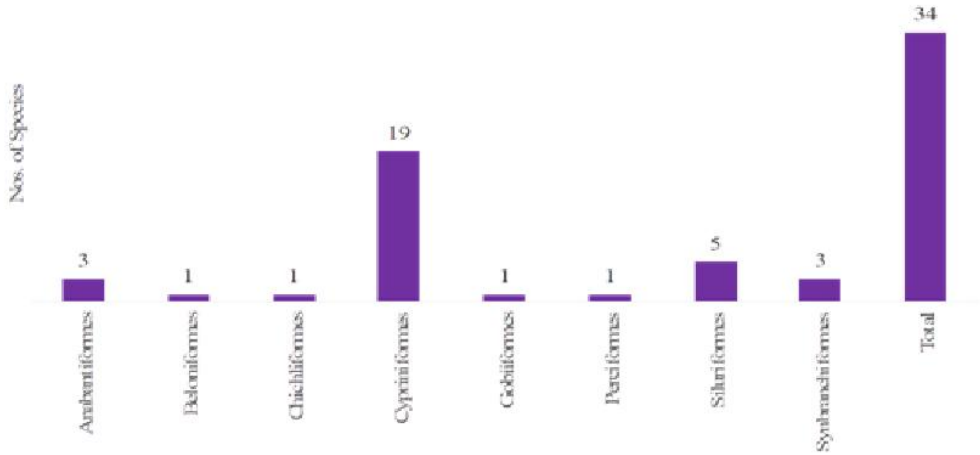


Figure 7.a: *Number of fish species belonging to different order*

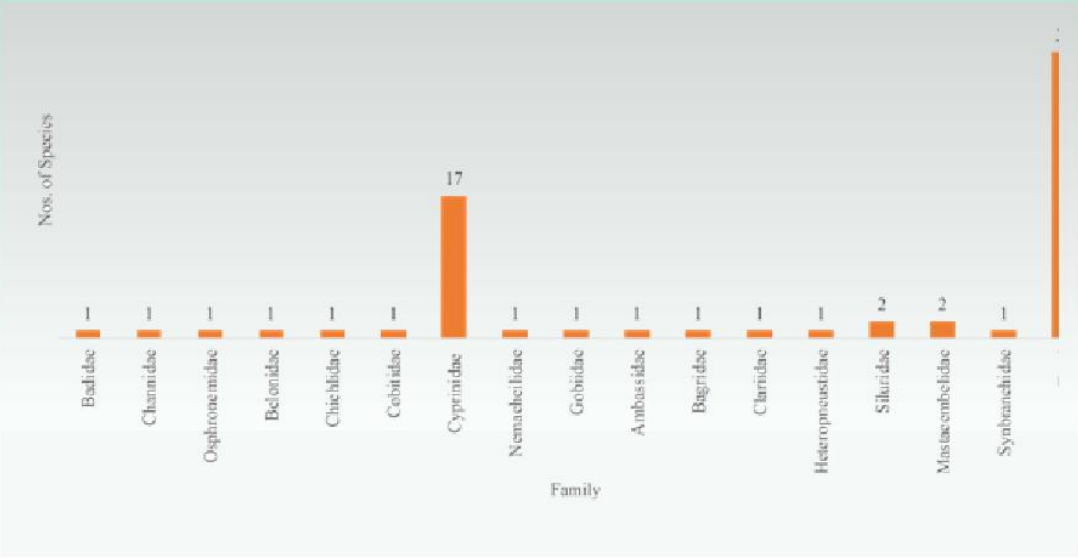


Figure 7.b: *Number of fish species belonging to different families*

Order anabantiformes was represented by 3 species belonging to 3 different families while order beloniformes and chichliformes were represented by single species in each. Order cypriniformes was represented by 19 fish species belonging to 3 different families. Similarly, order gobiiformes and perciformes were represented by single fish species. Order siluriformes was represented by 5 fish species belonging to 4 different families while order synbranchiformes was represented by 3 fish species belonging to 2 different families. Figure 7.a shows the number of fish species belonging to different orders and Figure 7.b shows fish species belonging to different families respectively.

4.3 Site-wise distribution of fish species

Table 4 shows the site-wise distribution of different fish species including both primary and secondary collection.

Table 4: *Fish species collected from different sites during study*

S.N.	Fish species	Tiger Lake	Rhino Lake	Khageri River	Rampur Ghole
1	*Badis badis*	✓			✓
2	*Channa punctatus*	✓	✓		✓
3	*Trichogaster lalia*	✓	✓		✓
4	*Xenentodon cancila*			✓	✓
5	*Oreochromis niloticus*	✓			✓
6	*Amblypharyngodon mola*		✓		
7	*Barilius barila*			✓	
8	*Barilius bendelensis*			✓	
9	*Brachydanio rerio*	✓	✓	✓	✓
10	*Cirrhinus mrigala*	✓			✓

S.N.	Fish species	Tiger Lake	Rhino Lake	Khageri River	Rampur Ghole
11	*Danio devario*	✓	✓	✓	✓
12	*Esomus danricus*	✓	✓		✓
13	*Rasbora daniconius*	✓	✓	✓	✓
14	*Garra nasuta*	✓		✓	
15	*Naziritor chelynoides*	✓	✓	✓	
16	*Pethia conchonius*	✓	✓	✓	✓
17	*Pethia guganio*	✓		✓	
18	*Puntius sophore*	✓	✓	✓	✓
19	*Puntius terio*	✓	✓	✓	✓
20	*Puntius ticto*	✓	✓	✓	✓
21	*Systomus sarana*	✓	✓		✓
22	*Salmostoma phulo*			✓	
23	*Lepidocephalichthys guntea*	✓	✓	✓	✓
24	*Paracanthocobitis botia*	✓		✓	✓
25	*Glossogobius giuris*			✓	✓
26	*Chanda nama*	✓		✓	✓
27	*Mysutus tengara*	✓	✓		✓
28	*Clarias magur*	✓			✓
29	*Heteropneustes fossilis*	✓			✓
30	*Ompok pabda*	✓			✓
31	*Walago attu*				✓
32	*Macrognathus aral*	✓			✓
33	*Macrognathus pancalus*			✓	✓
34	*Monopterus cuchia*	✓			✓

Altogether 26 different fish species were collected from Tiger lake while the number of species collected from Rhino lake, Khageri river section and Rampur ghole were 15, 19 and 27 respectively. During present study it was found that Amblypharyngodon mola was exclusively limited to Rhino lake and was not found at other sites. Similarly, Barilius bendelensis, Barilius barilla and Salmostoma phulo were found only in the section of Khageri river which might be due to the preference of lotic water bodies by these species. There were 8 fish species that were recorded from all sites and may be considered as common. All species listed above were not collected during sampling. Oreochromis niloticus was not collected during sampling from Tiger lake but was only collected from fishermen collection.

4.4 Fish species description

(1) Badis badis

Locally known as 'Pasari or Kheaslei or Sungure Sidra', this fish is commonly found in ditches and wetlands. It is a small fish with slender, elongated and compressed body profile. It has 10-12 alternate bands of black and dark green color in mature fish. It has a distinct bluish-black or light green spot behind the gill opening. A similar spot at the base of caudal fin is also seen. The color and its size (maximum 5-8 cm) makes this species a suitable candidate as ornamental fish. The fish is also able to change its color depending on the environment and mood which adds to its aquarium fish attribute. Due to rapid color changing habit, this fish is also known as 'dwarf chameleon fish'.

It inhabits freshwater bodies like lakes, ditches, wetlands, slow moving river and especially in areas with slight vegetation. It is a micro-predator feeding upon the small invertebrates, insect larvae, worms, crustaceans and zooplanktons.

This species is listed under Least concerned (LC) in IUCN conservation status and Common (C) in the list of Conservation status of fishes of Nepal.

(2) Channa punctatus

Locally known as 'Hile or Garai or Bhoti', this fish is found in streams, lakes, swamps and ponds. It is generally found in muddy areas and can easily breathe air with help of accessory respiratory organ. It has an elongated and cylindrical body with somewhat dorso-ventrally flattened head. The coloration is olive in upper portion and greenish yellow in the lateral section. It has fine dark and light stripe above and below the lateral line. The larval form has longitudinal yellow band throughout the length.

It is one of the game fish in terai region of Nepal, where it is fished easily with the help of hook having earthworm as bait. Local people also collect them in large amount from ditches, which once was filled with water during rainy season along with from rice fields once the water dries up into small patches. It is one of the commercially important food fish consumed by cooking also consumed by sun-dried. Some authors also debate on its value as ornamental species, but customers in Nepal do not prefer it due to large size and dominating behavior. It is predatory voracious feeder that feeds on small fish and fries. It also feeds on mollusks, insects. The favorite food of the species is small fishes, yolk flies and fish larvae. In natural habitat it also consumes crustaceans, mollusks, insects, small fishes, semi-digeszted materials and sometimes plants also. Feeding intensity changes during mature phase of fish. The spotted snakehead also exhibits cannibalism.

The spotted snakehead is listed as Least Concern (LC) in IUCN, due to lack of major threats to the species by human activity as well as a natural activity.

(3) Trichogaster lalius

Locally called as 'rangin sidra or khasre sidra', the 'dwarf gourami' is a beautiful fish inhabiting densly vegetated areas of lakes, ponds, or slow moving water bodies. This fish shows sexual dichromatism with male being colorful and female being dull. The males have scarlet color with oblique bands of pale blue and red or orange. The fins are also banded with red margin in anal fin.

The beautiful coloration and small size (maximum 5 cm) makes this species one of the suitable candidate for aquaria. In aquaria, they hide away in foliage and are hardy. The filiform (needle like) pelvic fin of this fish adds beauty to its ornamental value.

It is an omnivore, feeding mainly on planktonic materials in natural habitat while accepting both plant and animal based flake feeds in aquaria. It is considered as Least Concerned (LC) in IUCN list of fishes. This fish breeds during the rainy season in vegetated areas of lakes. Sustainable collection of fry or even adult and supplying to aquaria shops may be a beneficial venture. The vegetated lakes like Tiger and Rhino Lake is suitable place for its breeding and rearing in natural condition and are found in large number.

(4) Xenentodon cancila

Locally known as 'Kauwa machha', the needlefish is found in the fresh water habitats like large lakes and streams. This species is also found in small streams and lakes but need somewhat lotic habitat (running water). The body is greenish above and whitish below with a series of four or five lateral blotches between pectoral and anal fins in adult. It is an elongated fish with beak like jaws. There is arrow of sharp and widely separated teeth present on both jaws helping to catch and hold the prey. This fish is also considered as important fish for aquaria due to its different form, but the aggressive and predacious nature limits its distribution in most of the aquaria.

It is reported to be carnivorous fish, which feeds on small fishes, crustaceans, immature forms of odonata and sometimes ephemeroptera and hemiptera. The needlefish is listed as Least Concern in IUCN, due to lack of major threats to the species by human activity as well as natural activity.

(5) Oreochromis niloticus

Commonly known as 'Nile tilapia', this is an exotic species to Nepal and has been imported in about 3 decades ago. It has distinct brownish bands on the body as well as caudal fin. This fish have disrupted lateral line. The dorsal fin is spine with 16-17 spines followed by 11-15 soft rays. The pectoral fin also have a spine with three spines in anal fin. This species is a prolific breeder, attaining the sexual maturity within 5 months in the climate of terai and having mouth-brooding habit. Due to this feature, this fish can overpopulate a water body in short time and outcompete other species leading to extinction from that water body. This species has a wide range of temperature tolerance and is also a very hardy which aids to its outcompeting nature. A number of researches are being carried out to control overpopulation of this species and only mono-sex male tilapia is allowed to culture in Nepal.

This is a good table fish and can be cultivated in ponds easily. It is an omnivore and accept all types of feed. Being a dominating species, this fish should not be allowed to enter natural water bodies owing the biodiversity conservation.

(6) Amblypharyngodon mola

Locally known as 'Mara or Dhawai', this mola carplet is a silvery fish with compressed body and silvery lateral band. This fish exhibits a benthopelagic behavior and is found in ponds, canals, beels, slow moving streams and paddy fields. The dorsal profile of body is more convex than the ventral. The mouth is obliquely upturned and it has incomplete lateral line. Body coloration is silvery in the sides and beneath, greenish like color on the back.

This fish has not been reported in Chitwan district since long time as suggested by many researches, however, during present study, this fish was seen in large number in Rhino lake. It is a surface feeder and mostly feed on protozoa, rotifer, crustaceans and unicellular algae. This fish is also integrated in carp-polyculture with successful results.

A small fish (growing upto maximum of 20 cm), this fish is a good source of Vitamin A. Rhino lake may serve as a good source of seed of this species. Incorporation of this species in carp-polyculture could be much more beneficial in terms of family nutrition. Thus, promotion of this species in aquaculture and creating awareness about its status will be of great value.

(7) Barilius barila

Local name of this species is 'Chiple Faketa' and is commonly known as Hamilton's Baril. This is a small fish of maximum length 10-15 cm. They are generally found in large hill stream and shallow Clear River along foot hills.

This silvery white fish is one of the torrent minnows. 14 to 15 vertical dark bands across the whole body length above the lateral line make this fish easily identifiable. One pair of barbel is present in this fish. This fish has golden shiny operculum. Deeply forked caudal fin has the lower lobe longer. This fish is mainly depended on animal matter. It has been observed that this fish is predominantly larvivorous i.e. feeding on insect larvae.

This fish have been adjusted as a group of great economic importance from aesthetic, medical, fisheries and game points of view. This fish usually used for feeding due to its superior taste as well as baits.

It has been considered as least concern species as evaluated by IUCN not being a focus species for conservation. In Nepal it is common.

(8) Barilius bendelisis

Locally known as 'Fageta', Barilius bendelisis, is commonly known as Indian Hill Trout and Khoksa or joia These species dwell in shallow, moderate to fast-flowing rivers and streams. It is found in the benthopelagic region and is potamodromous.

These species are generally characterized by their relatively elongated compressed with the moderately cleft mouth. Two short pairs of barbels are present (rostral and maxillary), blue-black bars, or spots on the body and dorsal fin which is inserted behind the middle of the body. The morphometric characters between the two sexes did not differ significantly. The maximum length recorded for this species is 22.7 cm.

This species is a surface feeder and prefers aquatic and terrestrial insects, sometimes small fishes and small invertebrates. This fish also accepts the aquarium feed but should be supplemented regularly with live feed. This fish is fast swimmer and vigorous feeder so it should not be kept with smaller slow moving fishes in aquarium,

This species is categorized as of Least Concern in IUCN but in the future; the major threat to this species is overexploitation and habitat destruction due to human activities. B. bendelisis is a popular ornamental species among aquarists as well as a food fish for the local population, but it is poorly studied.

(9) Brachydanio rerio

Locally known as ' Chithari pothi' , a zebra fish is a very popular aquarium fish and also used very intensively in scientific research purpose for the development of any types of drug and medicine. It also has been modified by many researchers to produce transgenic strain.

The maximum length this fish can reach is 4 cm and become mature when it reach length of more than 2 cm. This fish is identified by the presence of five uniformly pigmented horizontal stripes on the side of the body and all of them extending to the end of the caudal fin that resembles the zebra stripes. The body is small, slightly elongated. They have centrally located eye and thin elongated mandibles with protrusive lower jaw that results the mouth to point upward. Anal fin is stripped, absent of lateral line. Two pairs of barbell is present in which roastral barbell extends up to anterior margin and maxillary barbell extends up to middle of opercula. Male and female can be distinguished easily as male have more yellow coloration and also has larger anal fin than females.

Adults inhabit in streams, canals, ditches, ponds and beels. Zebra fish mainly occurs in slow moving and stagnant water bodies like lower reach of the streams. Feed on worm, small crustacean, on insect larvae and phytoplankton. It is also one of the popular aquarium fishes and also used as the model for developmental biology.

It has been considered as least concern species as evaluated by IUCN not being a focus species for conservation.

(10) Cirrhinus mrigala

Locally known as Naini or Mrigal. This fish is commonly known as Mrigala around the globe. Body bilaterally symmetrical, its body depth is equal to the depth of the body. The body of fish is covered with cycloid scale, usually dark grey on above and silvery on beneath. Pectoral pelvic and anal fins orange-tipped where caudal fin is deeply forked. Its breeding season is in between June to August during monsoon.

The maximum sized attains is 90 cm and 30 kg. It is a bottom feeder, omnivorous and feeds on detritus, mud organisms decaying plant and animal matter, however young one feeds on zooplankton.

Cirrhinus mrigala have Common (C) status on both list of IUCN conservation status and the list of conservation status of fishes of Nepal. Mrigal is popular as a food fish and important freshwater aquaculture species throughout the South Asia. It is widely farmed as a component of Polyculture system of carp species in Nepal. It is the valuable commercial fish species from economic point of view.

(11) Danio devario

Locally known as 'Bhitti or Chitripotthi', this small fish inhabits all short of freshwater habitat from ponds to lakes and small streams to large rivers. However, it is mostly found in moderately flowing water than the stagnant ones. It is a colorful fish with silvery greenish body. A broad dark blue stripe extends from the rear part of the mid-section, back to the fork of the caudal fin. There are some bluish and greenish markings on sides of body adding ornamental value. The mouth is oblique and directed upwards. This species is found in large number in all surveyed lakes and streams and is one of the food source to local fishermen.

This fish feeds on zooplanktons. The breeding season is June to July and it deposits eggs in spawning den of moss. It is enlisted as Common (C) in IUCN red list of fishes of Nepal.

(12) Esomus danricus

Locally known as 'Dedhuwa', the flying barb inhabits shallow, slow moving or stagnant water bodies. It is a common larvivorous fish and thus have own ecological value. This fish has elongated, slim and compressed body. It has olive green color with bright pearly iridescences. The dorsal part is dark with silvery violet to reddish flanks. A dark band from behind the eye to the base of caudal fin is present. The pelvic fins are reddish while other fins are brownish orange. The dorsal fin is present in the posterior half of the body.

They are very active fish and can jump up to considerable height. They prefer habitat rich in aquatic vegetation. Two pairs of barbels are present which differentiate them from Rasbora daniconius. The maxillary barbells are extremely long extending about the middle of body while rostral barbells short. This is small fish reaching maximum length of 15 cm. This fish is rich in Iron (Fe) and very nutritious. Successful rearing of flying barb in carp polyculture can be done. Being a SIS, this fish can provide nutrition to pond owner's family. This fish also makes considerable share in a fisherman's catch in local water bodies but rarely used by aquarium hobbyist due to its very active and jumping behavior.

It has been considered as least concern species as evaluated by IUCN not being a focal species for conservation.

(13) Rasbora daniconius

Locally known as 'Dedhaura', this Blackline rasbora inhabits pools, ditches, paddy fields, ponds, lakes and small streams. It is medium sized fish growing upto 15 cm. this fish has oblong and compressed body with deep yellow to silvery grey coloration. It has a deep black band present along the sides of body. The caudal fin is forked and deep yellow in color. The abdomen is silvery and fin tips are yellowish orange. This is one of the common fish and mostly found in the ditches, pools, lakes, streams and paddy field also. This fish is a surface feeder omnivorous fish and feeds mainly on aquatic insects and detritus.

Presence of black band along the side of the body, bright coloration and its hardy nature make this fish a candidate species of aquarium. This is a peaceful, schooling fish. And easily accept the aquarium foods. This species is listed on the IUCN Red List as Least Concern (LC).

(14) Garra nasuta

Locally known as 'Buduna', this fish is popularly known as sucker head or Khasi Garra. The body of this fish is strongly depressed. Presence of distinct snout and trilobed proboscis make this species easily identifiable. Generally this fish is well adapted in moderate to fast flowing river with rocky bottoms, streams, canals and wetlands.

Differing from other cyprinid their body is slim and a sucking mouth so it can be concluded that the fish are rheophilic. Their lower lips is expanded to form round or oval sucking pad, vomero-palatine organ is much reduced almost completely lost. The pectoral fin has first two fin rays enlarged and unbranched. The dorsal fin has 10-11 rays and fin starts little anterior from pelvic fin. Sucker mouth barbs are omnivorous, eating algae, plankton and small invertebrates. The

food attached in the substrate is scraped off with keratinized border of jaws and ingested in via suction.

This species is listed on the IUCN Red List as Least Concern (LC) while in the conservation list of Nepal it is under Lower risk category.

(15) Naziritor chelynoides

Locally known as 'Halundae or Ratar' is a native species of Nepal. It is commonly known as Dark Mahseer. This fish thrives well in cool to cold water in the moderate to fast moving rivers and lakes with good vegetation.

This fish is reported upto maximum length of 80 cm. The body of this fish is deep with small head. This fish seems dark golden above and silvery below. Many fine black dots are seen on the rim of scales. There is distinct black mark behind the opercle. The body of this fish is covered with large scale but the head is scale less. Dorsal fin is placed just above the pelvic fin. Lower lip has continuous folds. The thick lips can be feel easily. This fish have many glands over the opercles. Two pairs of barbels are present. This fish is omnivorous and feeds upon aquatic insects, larvae, snails, crustaceans and small aquatic plants materials.

The fish has good potential as food and ornamental fish and candidate species for coldwater aquaculture. It is listed as vulnerable and critically endangered category in IUCN red list while in list of conservation status of Nepal it is listed under Uncommon or lower risk (UN) category.

(16) Pethia conchonius

Locally called as 'Sidhre or Pothi', the rosy barb is a deep bodied silvery fish, with darkish back and silvery belly. The bases of scale is dark and a black blotch is present at the caudal region. The males assume a brilliant pink red color during breeding season. The fins have dark tips. This fish is generally found in shallow water stream and lakes and breeds in June- July in freshly flooded shallow water of rivers with abundant algal blooms.

Rosy barbs are omnivorous and opportunistic feeder feeding on plant matter, insects, worms and crustaceans. In aquaria, it needs live foods as long as they are small enough like insects, worms and crustaceans. This fish also make a major portion of catch by local fishermen.

(17) Puntius guganio

Locally known, as 'Tilke Pothi' is a small fish reaching maximum length of 8 cm. This fish is commonly known as Glass-barb. This fish is native in Nepal. Glass barb inhabits slow-moving rivers and canals or standing bodies of water such as pools, ditches, lakes and minor rivers.

The body of this fish is elongated where head is small in comparison with body length Mouth is terminal in position, upper jaw is slightly longer than the lower with no barbels. Scales are small and deciduous. Lateral line incomplete. Body of this fish is diaphanous and brownish silvery in color with silvery band alongside. A small black spot present at the base of anterior dorsal fin rays and black blotch present at the vase of caudal fin. It is omnivorous in nature feed on small invertebrates, worms, crustaceans , zooplanktons and plant matter.

Puntius guganiois the species of Least Concern (LC) on list of IUCN and Uncommon (UN in the list of conservation status of fishes of Nepal. This fish has no interest in fisheries. Although it is the good source of food and micronutrients. Some authors also mention this fish has aquarium imopirtance because they are likely be peaceful and do well in 8-10 specimens in aquarium.

(18) Puntius sophore

Locally known as 'Pothi or Sidre', the spotifin swamp barb is the most common barb found in almost all type of water bodies. This fish is widely distributed throughout Nepal and is found in small ponds to lakes and lowland rivers with slow water flow. It has a beautiful silvery, back-grey-green to brownish; flanks with a somewhat bluish lustre, underside white; a deep black round blotch at the base of the caudal fin, a similar black blotch on central part of dorsal fin or also on anterior part of body adjacent to dorsal fin. Fins hyaline in mature females; anal and pelvic fins brick red in mature males. Mouth is small, terminal and upper jaw is slightly longer than the lower. Barbells are absent and complete lateral line is present. Pectoral fin is long excluding head.

One of the commonly found, spotfin swamp barb is rich in calcium and provides good nutrition to fishermen family as it is eaten whole. Integration in carp polyculture have shown enthusiastic results. The small indigenous species cultured with carps fulfill the nutritional requirement of pond holding family as they sell large fish to customers and consume small fish themselves.

This fish is also omnivorous feeding both on plant and animal matter. Being a bottom feeder, it feeds on aquatic insects and small crustaceans found in the pond mud as well as some detrital matter.

(19) Puntius terio

Locally known as 'Pothi', this one-spot barb is also a small fish with metallic green color above and whitish below with weak reddish luster. A large round black blotch is present with golden margin over anal fin. Fins are yellowish in color. Dorsal fin often provided with numerous dark spots and streaks, which all unites to form a longitudinal band. The fins are yellowish with their rim marked with black. This fish is also found in almost all types of freshwater habitat. This fish is also found in abundance in many water resources and covers a large portion in the catch of local fishermen. Like other species of Puntius, it is also rich in nutrition.

(20) Puntius ticto

Locally known as 'Tite Pothi', it is a small fish growing maximum upto 25 cm. This fish are actively swimming schooling fish. Ticto barb or two spot barb is the common name of this fish. This fish is found in subtropical freshwater and is widely distributed throughout Nepal. Many people get confused with Odessa barb and P. ticto but P. ticto can be distinguished easily by the absence of reddish-orange color in males. It can be easily found in the still shallow water, marginal waters of lakes, and river which usually has muddy bottoms. It resides near to the substrate of shallow water. Ticto barb usually feeds on small crustaceans, insects and plankton.

Deep silvery body with two black spots one on the anterior and another near base of caudal peduncle is the distinguishing feature of this fish. It is also widely used as food by drying but as it has a bitter taste so it is not selected for consuming.

It has been considered as least concern species as evaluated by IUCN not being a focal species for conservation.

(21) Systomus sarana

Locally known as 'Thulo Pothi or Darha' is a small fish that is commonly known as Olive Barb. It reach the maximum length of 40 cm. This species of fish is native to Nepal. It inhabits rivers, lakes, and beels. They are believed to tolerate salinity.

It is small to moderate silvery dark fish having deep compressed oblong body and small head. In fresh fish, there are horizontal bands along the rows of scales in the upper half of the body. Two pairs of Barbels are present they reddish brown. Fins are whitish or yellowish white and are externally stained with gray where caudal, pelvic and anal fins are tipped with red.

They form schools or group of four or five to several dozens. They feed on aquatic insects, fish, algae and shrimps. Spawning occurs in running water among submerged boulders and vegetation.

Systomus sarana is the species of Least Concern (LC) on list of IUCN conservation status and common on the list of conservation status of fishes of Nepal. This fish have limited demand in the aquarium trade. It has minor commercial importance. It is also a popular fish in bait fishing as gamefish.

(22) Salmostoma phulo

Locally known as 'Chela or Phulo-Chela', this fish is popularly known with its common name Finescale Razorbelly Minnow. This is a small sized fish reaching maximum length of 12 cm This fish prefers benthopelagic niche and inhabits lower reaches of rivers, lakes, ponds, beels canals and ditches.

The body of this fish is elongated and compressed laterally. Eye is placed at the anterior part of head. Abdominal profile is cutting behind the base of pectoral fin. Lower jaw extend up to the front margin of the orbit. Pectoral fin does not reach to the pelvic. Caudal fin is deeply forked with lower lobe slightly longer. Lateral line is complete and curves downward.

This fish is surface feeder and It feed on insects, larvae and sometimes other benthic invertebrates.

Salmostoma phulo is the species of Least Concern (LC) on list of IUCN conservation status and common on the list of conservation status of fishes of Nepal. This fish is of little commercial importance but is extensively used as food.

(23) Lepidocephalichthys guntea

Locally called as 'Goira or Lata', this beautiful loach inhabits water resources with muddy or sandy bottom where it can burrow easily. It also prefer vegetated habitat. They have accessory respiratory organs in intestine to help in air breathing in case of hypoxia. It is a small cylindrical fish with elongated caudal peduncle. Generally, body color is dirty yellowish white with black patterns and a bright dark band.

A black ocellus is found at the base of caudal fin. The fish is common in lowland waters. This fish is able to burrow in the mud, sand or gravel and disappears quickly when disturbed. This fish is caught by local fishermen as food and has been found some place in aquaria too with other local fish species. It is listed as Least concerned species in Conservation status of fishes of Nepal.

(24) Paracanthocobitis botia

Locally known as 'Pate Gadela or Baghe', this loach inhabits rocky, pebbly, sandy or muddy bottoms of clear freshwater. It is commonly known as mottled zipper loach. It is a small fish of size of about 8 cm length predating mainly on insect larvae of chironomids found among bottom materials. It is a small, elongated fish where body depth is slightly increasing from head to dorsal fin then decreasing to caudal peduncle. Color pattern consists of 8-10 dark oblong to squarish blotches alongside just below lateral line and dark bands on caudal fin. A distinct black ocellus is found at caudal peduncle above lateral line.

This species has got Least Concerned (LC) status on list of IUCN conservation status. This fish has slight commercial importance from point of view as aquarium fish by their color pattern. Fishermen capture this fish by using garland of earthworm pinned in a splinter as bait.

(25) Glossogobius giuris

Locally known as 'Bulla or Vulvule', this tank goby is found in ponds, lakes or rivers with stony or sandy bottom. The head is depressed with a protruding lower haw while the body takes the compressed appearance toward the caudal region. Generally brown or light brown with various darker brown spots and flecks along the sides of body. Dorsal fins with small spots forming longitudinal stripes. Their pelvic fins jointed but attached to the anterior part of the body. Some living on very light substrates show an ivory coloration in their body.

This bottom dweller has ventral mouth and feeds on a wide variety of benthic organisms including invertebrates, insects, crustaceans and even small fish. Cannibalism is commonly seen in this species. It is enlisted as Least Concerned (LC) in list of IUCN conservation status while have common (C) status among fishes of Nepal. Due to its color and some other peculiar properties (fin structure), this species also has some place in aquarium trade.

(26) Chanda nama

Locally known as 'Chanerbijuwa or Sisa machha', this elongated glass perchlet inhabits freshwater with vegetation coverage. The body is deeply compressed with yellowish silvery transparent color. It has some purple tints and black dots scattered all over the body. The air bladder and skeleton can be easily seen in strong light. A distinct bright silvery line runs from eye to caudal fin. Dorsal and ventral profile of fish is almost equally convex. Lateral line is partly distinct and partly absent. Scales are minute and rounded in the body. Spines of first and second ray are gradually decreased in height.

Its smaller size (maximum length 11 cm) and transparent color makes it an ideal fish to be kept in aquaria. This fish is found in standing and running waters, clear streams, canals, beels, and ponds and inundated paddy fields and is abundant in rainy season. It is a shy and diurnal active fish with schooling habit, so, can be caught in large number in one attempt of cast net. It is omnivorous but feeds voraciously on insect larvae, thus have been used to control of guinea worms as well as malarial.

It has Least Concerned (LC) status on the list of IUCN conservation status and common (C) in the conservation status of fishes of Nepal. In the economic point of view, this fish is well known as small indigenous species (SIS), is good source of nutrition and micronutrients. Apart from their nutritional role, this species is also popular in aquarium trade too due to its transparent body.

(27) Mystus tengara

Locally known as 'Tenger or Tengra', this siluriform fish is found in flowing as well as stagnant water bodies with macrophytes and sandy and muddy bottom. It is an elongated fish with slightly depressed head. The general body color is yellowish with five longitudinal dark bands on either side of the body and a black shoulder spot. Four pairs of barbells are present, among which the maxillary barbell reaches upto the base of ventral fin. It has pectoral spine with 10-13 denticulation and longer than dorsal spine which is used as offence organ. It has a short adipose fin commencing just behind the rayed dorsal fin. Upper lobe of the caudal fin is slightly longer than lower.

The maximum reported length of this fish is 18 cm. It is carnivorous and moderate mover and feeds on insects, larvae, worms, crustaceans and small fishes. It has Least concerned (LC) status on list of IUCN conservation status and common (C) on the list of conservation status of fishes of Nepal. This fish used as food and nutrition in many countries including Bangladesh due to their taste and calcium content.

(28) Clarias magur

Locally known as 'Magur', the walking catfish inhabits different types of freshwater bodies but prefer marshy lands and paddy fields. They are greyish black fish with splashes of yellow brown color. The head is broad and flat while the tail is compressed laterally. The dorsal and anal fin are long and continued upto the caudal fin but separated. The lips are fleshy, where upper is slightly longer than lower. It possess very small eye located dorsally on head. It has long dorsal and anal fins each terminate in a lobe near but free from the caudal fin. The pectoral fin has stiff spines accompanied by a back and forth flexion of the body that walking catfish accomplish their locomotion. The have 4 pairs of well-developed barbells in the head region.

The fish reaches upto a maximum length of 100 cm and possesses tree-like accessory respiratory organ known as aborescent organ due to which it survives some hours without actual contact with water. It is omnivorous in nature where fingerlings takes insects, crustaceans debris and adults take smaller and larger crustaceans, worms, insects and small fish. Because of their mobility and highly tolerance nature and indiscriminate feeding habits they have been labeled an aggressively invasive species and blacklisted in several countries including the US where it has been accidentally introduced.

This species has Least concerned (LC) status on list of IUCN conservation status and common (C) status on the list of conservation status of fishes of Nepal. This species of fish is used in commercial fisheries, aquaculture and aquariums. In the most of countries it is used as food and nutrition in variety of ways. A proper study on its habits is required to adopt this species in aquaculture in Nepal.

(29) Heteropneustes fossilis

Locally known as 'Singhi or kande', the stinging catfish inhabits ponds, ditches swamps and marshes and rarely found in muddy rivers. It is a dirty brown purplish catfish with four faint bands along the body. It has short dorsal fin with pectoral fin has a stout spine. The anal fin is separated from the rounded caudal fin by a deep notch. The fish have accessory respiratory organ in form of a pair of air sac (pharyngeal diverticula) imbedded in skin dorsal to the lateral line.

This helps fish to thrive in water with very poor oxygen as well as out of water for considerable period. It has 4 pairs of barbells. It inflict painful wounds with its pectoral spines because of its aggressive nature.

This fish can attain a maximum size of 30 cm and have food as well as medicinal value. It is considered that flesh of this helps in blood production in body and is thus very nutritious especially for pregnant and lactating women. It also has invigorating quality and thus is recommended to malaria patient after recovery. Some variants of this species has also got place in aquarium trade.

(30) Ompok pabda

Locally known as 'Papta', this Pabdah catfish inhabits rivers, canals, lakes and ponds. It has a strongly compressed elongated body. The head is depressed and snout is round. General body color is silvery-grey with tinge of yellow, dark on back, fading to dull grey on belly with two lateral dark bands. A dark oval shoulder spot is found on lateral line. Mouth is large and oblique. Two pairs of barbells are present with maxillary extending upto the middle or tip of pectoral fin. It feeds on crustaceans larvae, algae, protozoans, a little mud and sand.

It is listed as Near Threatened (NT) on list of IUCN conservation status and common (C) on the list of conservation status of fishes of Nepal. It has great demand and market price on account of its good test, flavor and invigorating effect. It has a good commercial importance due to nutritional value. Although it is also used in Aquarium trade.

(31) Wallago attu

Locally known as 'Buari or Badari', the whiskered catfish is a large catfish inhabiting in rivers, lakes, swamps and wetlands as well as in aquaculture ponds (accidental entry). The head of this fish is broad with depressed snout. Body is elongated, strongly compressed in nature. Mouth is deeply cleft its corner reaching far behinf eyes. Teeth in jaws set in wide bands, vomerine teeth used to hold the prey. There are two pairs of barbels maxillary and mandibular. Dorsal fin is very small and anal fin is very long. Mandibular barbell is longer than pelvic fin. Eye is present in front of vertical through corner of mouth.

It can reach a maximum size of 3m and weigh upto 11 kg in 5 years. It looks for food on the soft bottom especially in evening and night and is a voracious predator. It predates on insects, crustaceans and small fishes. This fish is considered as havoc if enter an aquaculture pond.

This fish is commercially important due to its food and nutritional value. Its market demand is also high although this fish is popular for game purpose in many countries. Wallago attuis the species of Near Threatened (NT) on list of IUCN conservation status and common (C) on the list of conservation status of fishes of Nepal.

(32) Macrognathus aral

Locally called as 'Gainchi or Dhare baam', this stone eel inhabits rivers, lakes and ponds especially with vegetation. It is an elongated fish having eel like look with brownish or greenish above dorsal and yellowish or lighter ventral color. A distinct band beginning from eye and extending throughout the length is found on either side of the body. As series of 4 or 5 large black ocelli with a white boundary situated along the base of soft dorsal on either side is found. Dorsal

fin started from the posterior part of the body. The anterior part of dorsal fin is spinous. Anal fin is also long and end toward the tip of the peduncle forming a lobe. Caudal fin is rounded in shape. It has trilobed fleshy snout and the barbells are absent.

This fish is a nocturnal feeder feeding on insects and worms. It has commercial important due to food value and somewhat ornamental value too. It is listed as Least Concern (LC) in the list of IUCN conservation status and common (C) in the list of conservation status of fishes of Nepal.

(33) Macrognathus pancalus

Locally known as 'Gainchi or Kathgainchi' the barred spiny eels also inhabits canals, rivers, beels, lakes and ponds. It has an elongated and compressed body with dark brown above and yellow green below coloration. The dorsal, caudal and anal fins are splashed yellow color and shot with many black spots. The anal fin has transverse bars. The dorsal, anal and caudal fin are not united.

Reaching upto a maximum size of 18 cm in length, this fish feeds on crustaceans and insects. This fish is kept under Least Concern (LC) in the IUCN conservation status and common (C) on the list of conservation status of fishes of Nepal. This fish is highly esteemed as food. It is also kept in aquaria by hobbyists.

(34) Monopterus cuchia

Locally known as 'Andho Bam', this Gangetic mud eel inhabits in mud holes near water sides of swamps and paddy fields. It is a serpentine amphibious fish having and cylindrical body. Generally it is darn brown in color with shades of green and many black spots. The underparts is creamy white or slightly orange. All fins are absent except rudiments of dorsal fin as a fold of skin. The eyes are small and do not have any barbells.

The maximum recorded length of this fish is 82 cm. It is a carnivorous fish and nocturnal in habit feeding on animal based food like small fishes, molluscs and worms. The fish is said to hibernate during cold season. The economic importance includes food as well as medicinal value. This fish is also believed to have invigorating quality and helps in blood production. It is listed as Least Concerned (LC) species on the list of IUCN conservation status of fishes as well in the conservation status of fishes of Nepal.

4.5 Fish diversity indices

Species richness of Tiger lake, Rhino lake, Khageri river and Rampur ghole were 26, 15, 19 and 27 respectively which simply shows the fish species recorded. However, the number of fish species found at all sites may far exceed the current study due to limited samplings and limited types of gears used. Number of fish species recorded from Rampur ghole was a bit more than recorded by previous study (Oli et al., 2013) which might be due to establishment of impoundment and different types of gears used. However, total number of fish species recorded in all areas was lower compared to study done in Narayani and Rapti river system in Chitwan district (Jha, 2018). This might be due to much more species recorded in lotic and larger water body studied in previous study.

Relative abundance of *Puntius sophore* was highest at Tiger lake, Khageri river and Rampur ghole with 28.3, 23.3 and 20.6% respectively at three sites. Amblypharyngodon mola was most abundant at Rhino lake which was not found at any other sites studied during present study. Amblypharyngodon mola had 22.9% relative abundance at Rhino lake. The following species in case of relative abundance at all sites differed. However, the abundant fish species were from order cypriniformes in all cases. Amblypharyngodon mola was not recorded from any other site than Triveni in previous study (Jha, 2018). Thus, record of this species in large abundance in Rhino lake is a milestone for present study and opens further ways for the intensive study of ichthyofaunal diversity in different smaller lakes within Chitwan National Park, it's buffer zone and allied forests.

The Simpson's index for Tiger lake, Rhino lake, Khageri river and Rampur ghole were respectively 0.12, 0.13, 0.12 and 0.08 respectively. Simpson's value ranges between 0 to 1 with smaller value showing system that is more diverse. A value around 0.1 shows high biodiversity, thus, all the sites studied have high biodiversity. However, due to increasing anthropogenic activities certain conservation measures must be taken for sustainable and long-term conservation. The higher biodiversity of Rampur ghole might be due to some conservative efforts and shows that conservation efforts at other lakes could also be beneficial in terms of promoting biodiversity conservation.

4.6 Maintaining specimen and museum

At least one specimen of each species collected during the study is preserved in 10% formalin. Process for establishing a fish museum and live aquarium is underway and all the designing for that have been done. A museum to keep all the collected specimen and live fishes has been established at Bhojad in Bharatpur-11 in Fish Museum and Diversity Centre (FMBC) which is under the co-ordination of District Forest Office for the study purpose.

5. Conclusion and Recommendations

During present study at four sites, altogether 34 fish species belonging to 8 orders and 16 families were recorded. *Amblypharyngodon mola,* which is rich in vitamin A and is not reported from Chitwan since long was collected from Rhino lake in abundance. Similarly, other species with high food, ecological and ornamental value have been also collected during present study from different sites. Similarly, biodiversity index at all four sites have shown that these sites are rich in biodiversity. However, presence of Oreochromis niloticus in Tiger lake and Rampur ghole have shown that they are under high anthropogenic pressure and introduction of exotic species to natural water bodies may lead to deterioration of indigenous population. Similarly, during all field it was found that all studied sites are under high fishing pressure. Studies have shown that small indigenous fish species are rich in micronutrient like Puntius sophore rich in calcium, Esomus danricus rich in iron and Amblypharyngodon mola rich in vitamin A. Further studies on the nutrient profile of other small indigenous species could further open door for the conservation of these species and wise utilization in the diet of local people.

Thus, from present study it could be recommended that proper conservation efforts must be taken immediately for the conservation of indigenous fish species. Introduction of exotic species to natural water bodies must not be allowed at any cost. Similarly, there must be some control over fishing practice by the governing agencies in natural water bodies.

However, rich biodiversity in lakes (Tiger and Rhino) as well as their proximity to city center opens up further opportunity to develop these places as biodiversity hotspot that may serve well for the development of eco-tourism. Development of eco-tourism can be best done the utilization of local materials available rather than constructing mega structures. Awareness programs on the biodiversity of small lakes and its importance to local peoples will also add up in the conservation efforts.

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Annex 1:

Different fish species collected during study from different sites

Amblypharyngodon mola

Badis badis

Barilius barilla

Barilius bendelisis

Brachydanio rerio

Chanda nama

Channa punctatus

Cirrhinus mrigala

Clarias magur

Danio devario

Esomus danricus

Garra nasuta

Glossogobius giuris

Heteropneustes fossilis

Lepidocephalichythys guntea

Macrognathus aral

Macrognathus pancalus

Monopterus cuchia

Mystus tengara

Nazirator chelynoides

Ompok bimaculatus

Oreochromis niloticus

Paracanthocobitic botia

Pethia conchonius

Puntius guganio

Puntius sophore

Puntius terio

Puntius ticto

Rasbora daniconius

Salmostoma phulo

Systomus sarana

Trichogaster lalius

Wallago attu

Xenentodon cancila

CONTACT

MDI Nepal

New Manakamana Road, House No. 36,
Hetauda Sub-metropolitan City-2, Hetauda-2,
Bagmati Province, Makawanpur, Nepal
Phone: +977 57 521133
Email: mdi@mdinepal.org
Website: www.mdinepal.org

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