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## **1. Introduction**

Bhutan is endowed with rich natural water bodies in the form of rivers, streams and lakes that display a rich diversity of aquatic life. To date, little work has been done to document Bhutan's aquatic biodiversity, and with the growing pressures on our water bodies it is crucial that this be done now. We have yet to discover how our fishes will respond to hydropower dam construction, or what the long-term consequences of habitat alteration from stone and sand mining in our riverbeds will be on their spawning grounds.

In this regard, it is important that there are sound aquatic resource management plans and effective mitigation measures in place to ensure that Bhutan's aquatic ecosystems remain healthy. However, for a sound aquatic resource management plan to be in place, it is imperative that a preliminary data on fish species and distribution first be developed.

Although the existing records, which include a few independent studies, report that 50 freshwater fish species have been collected from Bhutan's western watersheds (BAP, 2009), a truly comprehensive study has not yet been carried out to assess species composition and distribution of fish in Bhutan's rivers. The National Research Centre for Riverine & Lake Fisheries (NRCR&LF) within the Department of Livestock (DoL), devised this project/study to fill that gap and to assess the fish fauna both in terms of species composition and distribution in Bhutan's major river systems. The Bhutan Trust Fund for Environmental Conservation is funding the study.

The first phase of this project was to focus on the three major river systems in Western Bhutan: the Amochhu/Torsa, the Wangchhu, and the Punastangchhu/Sunkosh. The water bodies sampled covered nine Dzongkhags: Thimphu, Paro, Haa, Chukha, Samtse, Punakha, W/Phodrang, Dagana, and Tsirang. A total of 104 species of fish belonging to 16 families and 47 genera were recorded within the project timeframe. The second phase of the study focuses to expand the study in the remaining parts of the Bhutan that namely include Aiechhu in Central Bhutan, Nyera Ama chhu and Manas river basin in Eastern Bhutan.

## **2. Objective/Goal**

At the heart of the goals of the study is the need to develop a proper fishery database through comprehensive study of fish in Bhutan's water bodies, both in terms of species composition and distribution. However the specific objectives of the study may be outlined as follows:

- To develop a database on fishery resources of rivers and waters in Central and Eastern Bhutan
- To recommend a sound aquatic resource management plan based on the fishery database/baseline develop

### 3. Methodology

#### 3.1 Mapping

The team developed preliminary maps using Google Earth, and identified a list of potential sites as zones. This was done in the office as a desktop operation and no field visits were conducted for this. As a result 133 zones across the drainage of three river basins were identified and marked initially for prefeasibility assessment.

#### 3.2 Prefeasibility Assessment & Site Selection

The objective of this project is to assess the species composition and distribution of fish across river basins. Given the difficulties of sampling the rugged terrain, as well as constraints in manpower and time, a stratified sampling method was designed.

The stratification system used was adapted from the “Guide for Assessment of Fisheries and Fish Stocks in Rivers” (FAO, 1983). Each river system was subdivided into sampling zones, with each zone being 5 km in length. A representative 1 km sampling site was then identified within the zone to be site for data collection.

Using the Google maps developed earlier, prefeasibility assessment were carried out as a way to follow up on the site identification. All 133 zones within the three river systems were surveyed for their potential use as a sampling site. After this preliminary assessment and physical verification, only 90 sampling sites/stations were identified for data collection while the remaining 43 sites were found to be non-feasible.

SL No	RIVER NAME	DZONGKHAG	Status
1.	Chazam chhu	Trongsa	Prefeasibility conducted
2.	Chendebji Chhu	Trongsa	Prefeasibility conducted
3.	Rangsebji Chhu	Trongsa	Prefeasibility conducted
4.	Geezam Chhu	Trongsa	Prefeasibility conducted
5.	Mangdue chu(Main river)	Trongsa	Prefeasibility conducted
6.	Gyeltse chhu	Bumthang	Prefeasibility conducted
7.	Domkhar chhu	Bumthang	Prefeasibility conducted
8.	Chamkhar chu	Bumthang	Prefeasibility conducted
9.	Chumai Chhu	Bumthang	Prefeasibility conducted
10.	Mebar tsho	Bumthang	Prefeasibility conducted
11.	Chamkhar chhu	Bumthang	Prefeasibility conducted
12.	Gazam Chhu	Bumthang	Prefeasibility conducted
13.	Masangda chhu	Bumthang	Prefeasibility conducted
14.	Naktsang Chhu	Lhuntse	Prefeasibility conducted
15.	Gangzor Chhu	Lhuntse	Prefeasibility conducted
16.	Kurichu (main river)	Lhuntse	Prefeasibility conducted

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17.	Gangzor chhu 2	Lhuntse	Prefeasibility conducted
18.	Rongman chhu	Lhuntse	Prefeasibility conducted
19.	Unger chhu	Lhuntse	Prefeasibility conducted
20.	Karmashangshog chhu	Lhuntse	Prefeasibility conducted
21.	Phawen chu	Lhuntse	Prefeasibility conducted
22.	Autso chhu	Lhuntse	Prefeasibility conducted
23.	Rewan chhu	Lhuntse	Prefeasibility conducted
24.	Dunkharling chhu	Lhuntse	Prefeasibility conducted
25.	Orongchali chu	Lhuntse	Prefeasibility conducted
26.	Gangola Chu	Mongar	Prefeasibility conducted
27.	Jabarakari Chhu	Mongar	Prefeasibility conducted
28.	Sheri chhu	Mongar	Prefeasibility conducted
29.	Kurichu	Mongar	Prefeasibility conducted
30.	Refendang Chhu	Mongar	Prefeasibility conducted
31.	Uzorong Chhu	Trashigang	Prefeasibility conducted
32.	Rolong Chhu 2	Trashigang	Prefeasibility conducted
33.	Drangmi chhu(Main river)	Trashigang	Prefeasibility conducted
34.	Gamrichhu	Trashigang	Prefeasibility conducted
35.	Khardi chhu	Trashigang	Prefeasibility conducted
36.	Thungdi chhu	Trashigang	Prefeasibility conducted
37.	Banridang Chuu	Trashigang	Prefeasibility conducted
38.	Bodidang Chhu	Trashigang	Prefeasibility conducted
39.	Khanling chhu	Trashigang	Prefeasibility conducted
40.	Khaling 1	Trashigang	Prefeasibility conducted
41.	Deothang chhu	Samdrup Jongkhar	Prefeasibility conducted
42.	Bapulay Chhu	Samdrup Jongkhar	Prefeasibility conducted
43.	Warong chhu	Trashigang	Prefeasibility conducted
44.	Degli chhu	S/Jongkhar	Prefeasibility conducted
45.	Nyera ama chhu (Main river)	S/Jongkhar	Prefeasibility cum real time fish sampling conducted
46.	Bokeli	Bangtar( S/jongkhar	Prefeasibility cum real time fish sampling conducted
47.	Deklai khola	Bangtar( S/jongkhar)	Prefeasibility cum real time fish sampling conducted
48.	Demala zam Chhu	S/Jongkhar	Prefeasibility conducted
49.	Marthang zam	S/Jongkhar	Prefeasibility conducted
50.	Zampa Chhu	S/Jongkhar	Prefeasibility conducted
51.	Narphung	S/Jongkhar	Prefeasibility conducted
52.	P/gytshel zam	P/gytshel	Prefeasibility conducted
53.	Yuri Chhu	P/gytshel	Prefeasibility conducted
54.	Kerongchu	Ngalam(P/gytshel)	Real time sampling conducted (1 season)
55.	Bidhu chhu	Ngalam(P/gytshel)	Real time sampling conducted (1 season)
56.	Dingru	Yangbari, P/gytesshel	Prefeasibility conducted
57.	Mangde chhu(Main river)	Zhemgang	Prefeasibility conducted
58.	Berti chhu	Zhemgang	Prefeasibility conducted
59.	Dagphe chhu	Zhemgang	Real time sampling conducted (2 season)
60.	Randegang chhu	Zhemgang	Prefeasibility conducted
61.	Kirigang chhu	Zhemgang	Prefeasibility conducted
62.	Chamkhar chhu(Main river)	Zhemgang	Prefeasibility conducted

63.	Dirang chhu	Zhemgang	Prefeasibility conducted
64.	Manas (Main river)	Zhemgang	Real time sampling conducted (2 season)
65.	Udang gang chhu	Zhemgang	Real time sampling conducted (2 season)
66.	Marangduut chhu	Zhemgang	Real time sampling conducted (2 season)
67.	Sarpang khola	Sarpang	Real time sampling conducted (2 season)
68.	Rong Khola	Sarpang	Real time sampling conducted (2 season)
69.	Moa khola	Sarpang	Real time sampling conducted (2 season)
70.	Bhur Khola	Sarpang	Prefeasibility conducted
71.	Taklai khola	Sarpang	Real time sampling conducted (3 season)
72.	Pipsu khola	Sarpang	Not approached
73.	Thawar khola	Sarpang	Real time sampling conducted (2 season)
74.	Kalikhola chhu	Sarpang	Real time sampling conducted (1 season)

### 3.3 Local Interviews

As part of the prefeasibility Assessment, the team set out to collect preliminary data and first hand information on the fishery. Semi-structured interviews as well as Rapid Rural Appraisal (RRA) methods were used as tools to collect information.



Fig. (Left) Team conducting local interview and preliminary data collection; (Right) Hiking to a sampling site for physical verification/sampling

### 3.4 Physical Sampling

In addition to the local interviews, the team also conducted preliminary sampling operations at designated sampling sites to collect further information. This is a great way to not only capture the first hand fishery scenario of a sample site but also contributes greatly towards future planning of real time sampling operations especially with regards to deciding/planning the type of gears to use in a particular sampling station.



Fig. (Above) Physical sampling to rapidly capture first hand information

## 4. Real Time Sampling

### 4.1 Sampling Methods & Gears

Since the study is still on-going, complete sampling has not been conducted. Out of the total 90 feasible sites, sampling has been carried out in 53 stations. However, a set of protocols was followed to sample the 53 station, which is described hereunder.

Sampling protocols were adapted from FAO's guideline for fish monitoring in fresh waters. All sampling operations were carried out during daytime from 07:00 AM till 05:00 PM. Fish collections used the following gear types: cast nets, small gill nets, and seines were used in deeper, larger water bodies; backpack electrofishing was used in smaller and heavy duty electroshocker for bigger rivers. In addition the above, snorkelling and use of under water cameras were also used for visual sampling. Segregation of species, species identification, and partial processing for photography was performed in the field.

Specimens collected were fixed using 10% formalin. Depending on the size of individual specimens, a minimum fixing time of 10-14 days was followed for all specimens, which were

then transferred into a 70-75% ethanol solution for long-term preservation. Each specimen was vouchered using labels containing: collection site information (name and GPS coordinates), collector's name, date of collection, and collector's remarks on the habitat.



Fig. Fish Sampling Operation using diverse fishing gears and methods; Clockwise from the top A. Heavy duty electroshocker; B. Backpack electroshocker being used; C. A seine net being operated and; D. A trammel net being set across a stream.



Fig. (Above) Snorkeling and under water camera trapping (visual sampling) using GoPro Camera

## 4.2 Sampling Sites/Station

Samples taken from wild populations were collected from 53 stations across 7 Dzongkhags (Sarpang, Pema Gatshel, Zhemgang, Mongar, Trongsa, Tsirang & Samdrup Jongkhar). Samples have been collected from the following river basins and their side tributaries:

Sl. No	Basin	Tributary/Stream	No of Stations
1	Manas	Drangmechhu	15
		Mangdechhu	12
		Chamkharchhu	4
2	Nyera Amachhu	Nyera Ama chhu	10
3	Aiechhu	Aichhu	8
		<b>Total</b>	<b>53</b>

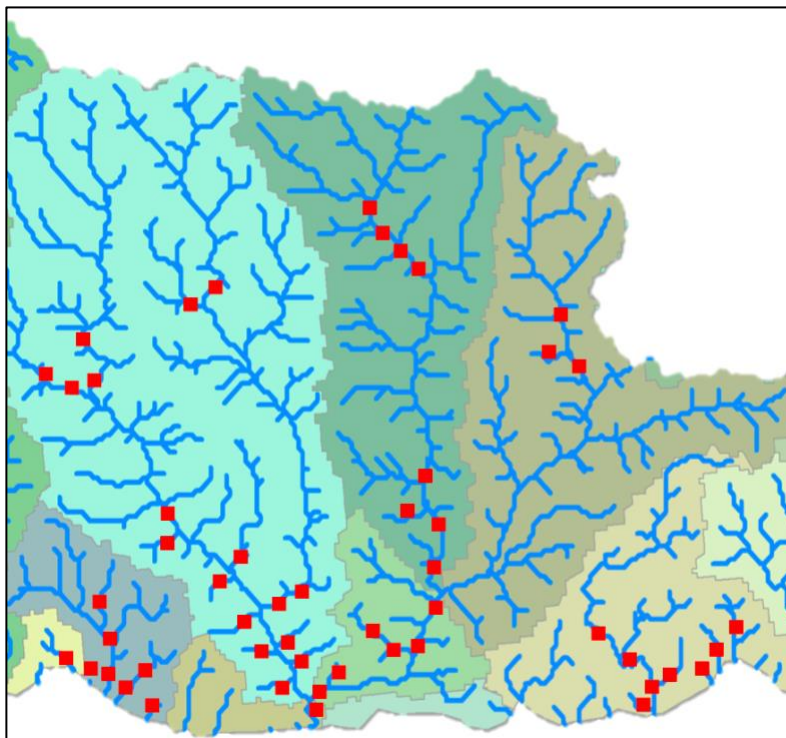


Fig. Map showing sample collection points. A total of 53 stations have been sampled and fish samples collected are currently at the Fish Repository at NRCCR&LF, Haa

## 4.3 Measurements and Counts (Data Analysis)

Morphometric measurements and counts followed the methods of Ng & Kollalat (2007). All measurements were made on the left side of specimens using digital vernier calipers to the nearest 0.1 mm. Head length (HL) and measurements of body parts are presented as proportions of standard length (SL) and subunits of head as of head length (HL). For fin formulae, the number of spinous and soft rays is presented in the form of a fraction, wherein the numerator (number on the top of a fraction) denotes the number of spinous rays, and the denominator denotes the number of soft rays. For each specimen/sample, a total of 38 counts and measurements records were taken.



## 5. Preliminary Findings/Results

From the preliminary assessment and partial real time sampling of 53 stations, the team has collected 18 new species of fish previously not recorded in Bhutan. This is in addition to the 104 species record already collected from Western Bhutan. As and when the remaining real time sampling is carried out, the team expects this figure to increase. Further, the project has already sent over 600 + fin clips for DNA analysis to the University of Arkansas, USA. DNA analysis is far more accurate than conventional taxonomic methods in identifying a species. Therefore, the project expects more species diversity as a result of detailed and more accurate study (DNA) once the analysis is completed.



Fig. Above. Some of the new species record for fish in Bhutan (Tentative)