FISHERIES RESOURCE OF PONG DAM LAKE, HIMACHAL PRADESH

AN ASSESSMENT FOR INTEGRATED MANAGEMENT

हिमाचल प्रदेश सरकार

IKI INTERNATIONAL CLIMATE INITIATIVE

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

On behalf of:

Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection

the Federal Republic of Germany

As a federally owned enterprise, GIZ supports the German Government in achieving its objectives in the field of international cooperation for sustainable development.

Published by
Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

Registered offices
Bonn and Eschborn

Address
Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH
Indo-German Biodiversity Programme (IGBP),
GIZ-India, A-2/18, Safdarjung Enclave, New Delhi - 110029, India

E-Mail: biodiv.india@giz.de
Web: www.giz.de & www.indo-germanbiodiversity.com

Programme/project description
Wetlands Management for Biodiversity and Climate Protection
Indo-German Biodiversity Programme

Implementing Partners
Ministry of Environment, Forest and Climate Change
Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH
Wetlands International South Asia, New Delhi

Responsible
Ravindra Singh, Director, Indo-German Biodiversity Programme, GIZ
Geetha Nayak, Project Manager, Wetlands Management for Biodiversity and Climate Protection, GIZ

Prepared by
ICAR-Central Inland Fisheries Research Institute (Indian Council of Agricultural Research)

Suggested Citation
ICAR-CIFRI (2023). Fisheries Resource of Pong Dam Lake, Himachal Pradesh- An Assessment for Integrated Management. Prepared for GIZ.

Authors
Basanta Kumar Das, Uttam Kumar Sarkar, Archan Kanti Das, Lianthuamluaia, Subhendu Mandal, Sangeeta Chakraborty, Kausik Mondal and Bigan Kumar Sahoo

Technical Contributions
Kunal Bharat, Avantika Bhaskar, Shambhavi Krishna (GIZ)
Ritesh Kumar, Harsh Ganapathi (Wetlands International South Asia)
Also acknowledging contributions from Debojyoti Mukherjee, Ridhi Saluja, Chaitanya Raj and Sakshi Saini.

Photo credits/sources
Carrot Films (cover page photo) and as specified against images.

Page Layout and design
Tryphena Kirubakaran
E-Mail: tryphenaa@gmail.com

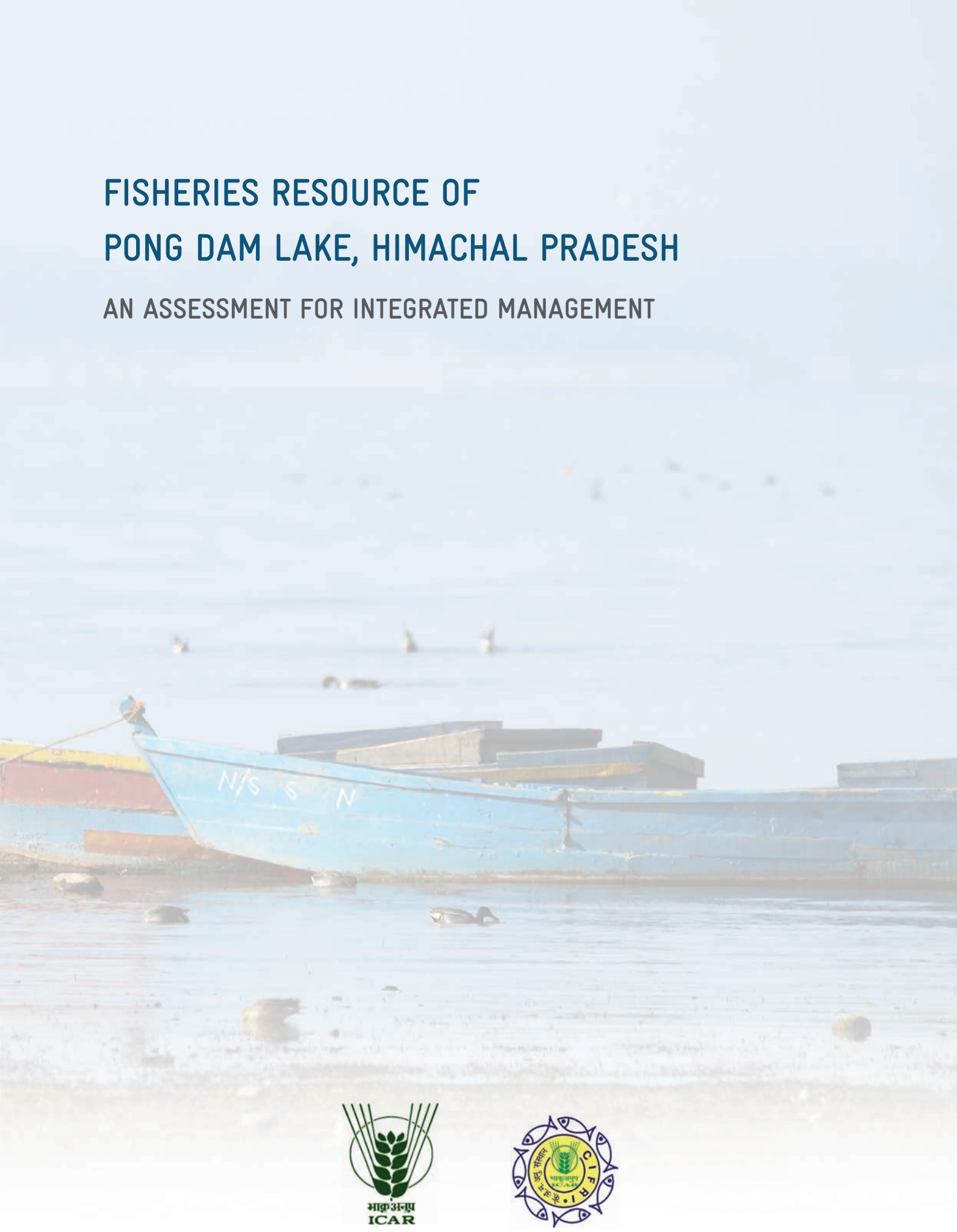
This project is part of the International Climate Initiative (IKI).

On behalf of
German Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection (BMUV).

New Delhi, 2023

FISHERIES RESOURCE OF PONG DAM LAKE, HIMACHAL PRADESH

AN ASSESSMENT FOR INTEGRATED MANAGEMENT



भाकृअनुप
ICAR

ICAR

EXECUTIVE SUMMARY

The study was carried out to assess the fisheries resources of Pong Reservoir, Himachal Pradesh for better management of the fisheries. Pong Reservoir is one of the large reservoirs of India. It is located in the northern part of India, and has a water spread area of around 15,000 ha. Two samplings were carried out during the study period: the first sampling was carried out in October 2020, and the second sampling was in December 2020. Biotic and abiotic components, including water and sediment parameters, the plankton dynamics and the macro-invertebrate diversity, were assessed to determine the ecological status of the reservoir. Most of the water quality and sediment parameters were in favourable ranges for fish production. The water and sediment parameters indicated that the reservoir is medium-productive in nature. The trophic status, determined on the basis of TSI (chlorophyll-a), indicated that the reservoir is in oligotrophic state. The water spread area of Pong Reservoir was highly fluctuating, with the greatest area (24,177 ha) in the monsoon months and the lowest area (16,796 ha) in the pre-monsoon months. An analysis of the time series data indicated that the rainfall showed a mild positive relationship with fish production. On the other hand, the annual mean temperature did not show any significant relationship with the annual fish production. Among the environmental parameters, water depth, dissolved oxygen (DO) and total dissolved solids (TDS) were the most influential parameters impacting the fish production in Pong Reservoir.

The estimated potential fish yield is of the order of 132–156 kg/ha/year (average 140 kg/ha/year) on the basis of the algal biomass model, which is very modest for this ecosystem. The estimated value of the maximum sustainable yield (MSY) according to the Gordon Schaefer model based on the time series data of fish production and fishing effort was 29 kg/ha/year, and the optimum fishing effort (fMSY) was 67 gill net per hectare per year. According to the Fox model, the MSY was 26 kg/ha/year, with an optimum fishing effort (fMSY) of 60 gill net per hectare per year.

Photo credit: CarrotFilms.GIZ

Photo credit: CarrotFilms.GIZ

During the study period, 20 fish species in seven orders and eight families were observed in the reservoir. The order Cypriniformes (11) contributed the largest number of species, followed by Siluriformes (3), Anabantiformes (2), Perciformes (1), Gobiiformes (1), Beloniformes (1) and Synbranchiformes (1). The lentic zone (reservoir) and lotic zone contributed the largest number of species, with 16 species each. The most abundant fishes among the small indigenous fishes were *Salmophasia phulo, Chanda Nama* and *Osteobrama cotio.* Among the commercial fishes, *Sperata seenghala* was the most dominant species. A decadal trend analysis of the fish diversity in Pong Reservoir indicated a decreasing trend from 34 species in 1990–95 (CIFRI, 2007) to 28 species in 2014 (Jindal et al., 2014) and 20 species during the present study. There are several inflowing streams (locally known as *khads*) at Pong Reservoir. Six breeding grounds and six probable breeding grounds of fish were identified where the khads flow into the reservoir.

Fishing was done commercially by 15 cooperative societies, covering the entire reservoir. Gill nets are the only fishing gear operated for commercial fish catches in Pong reservoir. Gil nets are operated throughout the reservoir by the fishermen except during the period of the fishing ban (15 June to 15 August). The reservoir is divided into different fishing zones, and 15 cooperative societies were involved in fishing using gill nets. Angling with rods and lines (sport fishery) takes place in six areas in the reservoir. A total of 3991 fishers are registered with the fishermen's cooperative societies for fishing in the reservoir. At present, there are 2995 license holders in the reservoir who have the right to fish using gill nets.

Only members of cooperative societies having fishing licenses are permitted to operate fishing nets in the reservoir. An annual license fee of Rs.100 is levied on two gill nets of length 80 m by the Fisheries Department, HP. The Fisheries Department also charges a 15% royalty on the sales of the fish caught by each fisherman. Gill nets of 80–140 mm mesh size and rods and line are the only fishing gear allowed to operate in the reservoir. The Fisheries

Department imposed a fishing ban season to avoid disturbance during the breeding seasons (15 June to 15 August). No fishing is allowed during this period. The Fisheries Department, HP has initiated a number of welfare schemes for the benefit of fishermen. Stocking of fish seed is regularly done by the Department of Fisheries, HP.

Among the 15 fish landing centres in the reservoir, fish landings were comparatively higher at Dehra, Nagrota Suriyan, Katihar and Barnali. The majority of the fish catch was of the catfish *Sperata seenghala* (65%) at all the landing centres except Sathana. At Sathana, *Cyprinus carpio* was the major fish catch. Indian major carp (IMC) also contributed a majority of the fish catch next to *Sperata seenghala. Tor putitora* was the single species that contributed most to the fish catch in the reservoir.

The decadal pattern of the fish yield showed a decreasing trend. During the decades 1976–1987 and 1987–1998 the fish yield was similar, 30 kg/ha/year. But the fish yield decreased to 24.5 kg/ha/year during 1998–2009 and further reduced to 23.19 kg/ha/year during 2009–2020. IMC was stocked regularly in Pong Reservoir every year. The average stocking density showed an increasing trend: 50, 138 and 367 (nos/ha/year) during 1990–2000, 2000–10 and 2010–20, respectively. The relationship between stocking and fish yield indicated a positive impact of stocking in each decade. Some of the major threats hindering sustainable fish production are increasing migratory bird abundance, erratic climatic parameters, inconsistent stocking patterns and presence of large predatory fishes.

The time series data on migratory bird abundance from 1988 to 2020 indicated that the number of migratory birds in Pong Reservoir showed increasing trends. The number of migratory birds were very low during the 1990s, but increased sharply since 1997. Regression analysis showed that the birds had a negative relationship with fish production, indicating a negative impact of the birds on the fish production.

Some of the important policies for sustainable development of the fisheries:

- Large-size fish seed of IMC (>100 mm), with a stocking density of 300 nos./ha/year is recommended for stocking Pong reservoir.
- In *situ* raising of fish in enclosures (pens or floating cages) is recommended to meet the requirement of large-sized fish seed.
- A larger number of fish seed is recommended not only to increase the fish production but also to reduce the GHG emissions as most of the carps are phytoplankton feeders.
- Closed seasons should be observed depending on the breeding seasons of some of the important fish species such as the Mahaseer.
- A multi-filament gill net is recommended for fishing in the reservoir, with mesh size >80 mm, for catching fish of weight greater than 1 kg.
- The recommended fishing effort according to the Schaefer model at Pong Reservoir is 67 gill nets per hectare or 1 million gill nets in a year.
- A protected area or sanctuary needs to be developed for protecting the potential breeding ground of important species such as Mahaseer, Seenghala and IMC.
- Sport fishery needs to be developed as important sport fishes such as Seenghala and Mahaseer are the major fish catch in Pong Reservoir.
- Value added fish products, especially Seenghala, can be introduced to attract tourists to the reservoir.
- Supporting the fishers of Pong through important fisheries development programmes such as *Pradhan Mantri Matsya Sampada Yojana (PMMSY)* and *Rashtriya Krishi Vikas Yojan (RKVY)* is highly recommended for safe and efficient fishing as most of the fishers do not having proper fishing gear and craft.

ACKNOWLEDGMENTS

ICAR-Central Inland Fisheries are grateful to the Director, Department of Fisheries, Government of Himachal Pradesh for rendering support to them when conducting the research work at Pong Reservoir, HP. The DoF, Government of HP provided data relating to stocking of fish seed and fish production at Pong Reservoir. The DoF, Government of HP also provided all possible support to experimental fishing, sampling ecological data, and collection of fisheries and socioeconomic data at Pong Reservoir. We would also like to thank the members of the following 15 fisheries cooperative society for assisting us with sampling and data collection:

i. Dehra Primary Fishermen Cooperative Society
ii. Haripur Primary Fishermen Cooperative Society
iii. Nandpur Primary Fishermen Cooperative Society
iv. Nagrota Surian Primary Fishermen Cooperative Society
v. Harsar Primary Fishermen Cooperative Society
vi. Jawali Primary Fishermen Cooperative Society
vii. Guglara Primary Fishermen Cooperative Society
viii. Sihal Primary Fishermen Cooperative Society
ix. Dhametha Primary Fishermen Cooperative Society
x. Katiyar Primary Fishermen Cooperative Society
xi. Sathana Primary Fishermen Cooperative Society
xii. Badnali Primary Fishermen Cooperative Society
xiii. Seul Khad Primary Fishermen Cooperative Society
xiv. Dadasiba Primary Fishermen Cooperative Society
xv. Jambal Primary Fishermen Cooperative Society

Table of Contents

List of Tables

Photo credit: GIZ_Neha

List of Figures and Maps

List of Annexures

List of Images

1. Introduction

India possesses an enormous resource in the form of reservoirs occupy an area of more than 3.5 million ha. Reservoirs provide scope for enhancing fish production to meet the high demand for fish in India and for improving the socio-economic status of many people displaced due to construction of dams. Reservoirs play many important roles in power generation, supplying for irrigation and drinking water, forming biodiversity hotspots, fish production, tourism, etc. In most cases, the construction of a dam is not intended for the production of fish, but the impoundment serves an important role in development of inland fisheries development by producing fish that support the livelihoods and nutrition of many rural people.

Though India has a huge potential and resources for enhancement of fish production through reservoir fisheries, the fish production in the country is low due to unscientific stocking and several other reasons. Using innovative management strategies is needed for using reservoirs sustainably. Scientific management of reservoirs is required to tap the fish production potential of the reservoirs in a sustainable manner and to conserve the biodiversity associated with reservoirs. Proper management of inland water bodies is essential for maintaining a healthy ecological status and the fish diversity and for the sustainability of fisheries. Assessment of fish biodiversity and assemblage patterns on spatial and temporal scales gives a thorough understanding and baseline information for better management of reservoirs. Proper scientific assessment of the ecology, fisheries, associated animals and plants and socioeconomic status is crucial for formulating a management plan for the sustainable development of a reservoir. Pong reservoir in Himachal Pradesh is one of the large reservoirs of India. It is located in the northern part of India. Pong Reservoir has huge potential fisheries resources, with an average water spread area of 15,000 ha. Pong provides nutritional and livelihood support many to poor fishermen who are fully dependent on its resources. But over the years, the fish production has gone down due to several reasons. Thus, the development of suitable management strategies is needed to enhance the fish production in a sustainable manner.

In this context, a study titled “Assessment and Management of Fisheries Resources of Pong Reservoir, Himachal Pradesh” was carried out to assess the ecology and fisheries status and to develop guidelines for sustainable and sustained enhancement of the fish production of Pong Reservoir.

The period of the project assignment was from 4 June 2020 to 16 December 2020. However, the project period was extended up to the middle of February 2021 due to the situation created by COVID-19 pandemic.

The study had the following scientific team:

i) Dr. B.K. Das, PI & Director, ICAR-CIFRI
ii) Dr. U.K. Sarkar, Principal Scientist & HoD, RWF Division
iii) Dr. A.K. Das, Principal Scientist, ICAR - CIFRI
iv) Dr. Lianthuamluaia, Scientist, ICAR - CIFRI
v) Mr. Subhendu Mandal, STA, ICAR - CIFRI
vi) Mrs. Sangeeta Chakraborty, TA, ICAR - CIFRI
vii) Mr. Kausik Mondal, TA, ICAR - CIFRI
viii) Mr. Bigan Kumar Sahoo, Young Professional - II

Due to the death of the consultant Dr. B.C. Jha, Mr. Subhendu Mandal was included in the team. The GIS map was outsourced to Ms. Hena Chakraborty and Ms. Tania Kayal.

Image 1 *Project team*

2. Objective

The present study, conducted under the project "Wetlands Management for Biodiversity and Climate Protection" (Project no. 16.9020.5-001.00), has three broad objectives.

OBJECTIVE 1: Ecology and fish abundance pattern in pong reservoir

- Determining of the current status of the hydrological, geological, physico-chemical features and primary productivity of the reservoir, which have direct and indirect impacts on the fisheries resources.
- Assessing the existing diversity and abundance of fish fauna, along with mapping and delineation of species-specific breeding grounds within the reservoir
- Determining of the current status of the commercial fishing within the reservoir with reference to the diversity, landing size, annual yield, stock characterisation (total and species-specific) and fishing effort.
- Mapping the existing fishing zones within the reservoir.

OBJECTIVE 2: Spatial and temporal trends of the fisheries within pong reservoir

- Delineating trends during the last three decades with respect to the fish diversity and abundance, trophic state of the reservoir, stocking and catch, market trends within specific management and governance regimes.
- Identifying the impacts of different management and governance regimes on resource production as well as extraction.
- Identifying the impact of migratory birds on fish production.
- Identifying threats to sustainable extraction of fisheries resources from Pong Reservoir.

OBJECTIVE 3: Develop suitable resource extraction models and guidelines to ensure sustainable and sustained resource extraction

- Evolving suitable stocking policies for the reservoir through studies on important commercial fishes in the reservoir.

- Suggesting suitable fishing gear and intensity of exploitation of different commercial fishes
- Proposing suitable reservoir zonation that could ensure sustainable resource extraction and could check overexploitation of resources
- Assessing trade-offs between fisheries and tourism as well as wetland use by waterbirds and propose suitable mitigation measures.
- Developing guidelines along with the capacities of local fisher community and other stakeholders regarding best practices, alternate methods and dos and don'ts to ensure sustainable and sustained resource extraction from the Pong Reservoir.

3. Sampling and methodology

Pong Reservoir is located in the state of Himachal Pradesh. Sampling was carried out at 12 sampling stations which covered the lotic, intermediate and lentic (dam and reservoir) zones of the reservoir. The first sampling was carried out during October 2020, and the second sampling was carried out during December 2020. Biotic and abiotic components were collected from the 12 sampling stations. Some of the water quality analysis was done at the site itself, and the other parameters were preserved for further analysis in the laboratory. Plankton was collected by filtering water using standard plankton net and preserved in formalin and Lugol's solution for further analysis and identification. Benthos and sediment samples were collected using a grab from the different zones of the reservoir. The fish diversity was assessed through experimental fishing using a gill net in the different zones of the reservoir. The fish catch data and socio-economic data were collected from the cooperative societies as well as from the Department of Fisheries, Government of Himachal Pradesh, India.

Assessment of fish diversity, catch composition, etc.

- Experimental fishing was conducted using multi-mesh-size fishing gear at different sampling sites covering the lotic, intermediate and lentic (dam and reservoir) zones of the reservoir.
- Information was also collected from the local fishers and landing centres to assess the catch composition and fishing effort involved.
- Historical data on the seed stocking, fish production and fishing effort were collected from the State Fisheries Department, Himachal Pradesh.
- Identification of fish species was carried using keys mentioned by Jayaram (2010), Talwar & Jhingran, (1991), etc.
- Spatial and temporal fish diversity, fish catch pattern and species richness were assessed using suitable diversity indices and other standard methodologies using PRIMER, R software, etc.

MARGALEF'S RICHNESS INDEX (D)

$$d = \frac{S - 1}{\ln n}$$

Where S is the number of species and n is the total number of individuals observed in the sample.

SIMPSON INDEX (Λ')

$$\lambda' = \sum_{i=1}^{S} \frac{ni\ (ni - 1)}{n\ (n - 1)}$$

Where, *ni* is the total number of individuals in the i^{th} species and, *n* is the total number of individuals in the sample.

SHANNON INDEX (H')

$$H' = -\sum_{i=1}^{S} (pi \ln pi)$$

Where *S* is the number of species in the sample and *pi* is the proportion of i^{th} species in the total sample.

PIELOU'S EVENNESS INDEX (J')

$$H' = \frac{H'}{\ln S}$$

Where *S* is the number of species in the sample and *H'* is Shannon index.

- The fish assemblage pattern vis-à-vis environmental factor was assessed to identify the important factor for fish assemblage pattern with Canonical Correspondence Analysis (CCA) (ter Braak, 1986) using R software.

Assessment of plankton and benthic communities

- Phytoplankton and zooplankton were sampled using standard plankton net at different sampling sites in the lotic, intermediate, and lentic (dam and reservoir) zones of the reservoir.
- Qualitative and quantitative assessments of the plankton were carried out using standard methods (APHA, 2012).
- Benthic organisms (macro-invertebrates) were sampled using a benthic grab in different seasons at different sampling sites.

Assessment of environmental parameters including water quality and soil parameters and other meteorological data

- Environmental parameters such as water and sediment parameters were sampled in the different zones of the reservoir.
- Water quality parameters such as temperature, depth, transparency, pH, specific conductivity, total alkalinity, total hardness, dissolved oxygen (DO) and dissolved nutrients such as nitrate-nitrogen, phosphate-phosphorus and silicate-Silica were analysed using standard methods (APHA, 2012).
- Estimation of the primary productivity of the water was done using the light and dark bottle oxygen method.
- Climatic parameters such as rainfall and temperature will be recorded during different seasons.

Assessment of productivity, fish yield potential, trophic status and impact of stocking

- The fish yield potential was assessed using a tropho-dynamic model (Waldichuk, 1958).
- The trophic status of the reservoir was assessed using the Trophic State Index (TSI) (Carlson, 1977)

TROPHIC STATE INDEX (TSI) (CARLSON, 1977).

$$TSI\ (SD) = 10\left(6 - \frac{\ln SD}{\ln 2}\right)$$

$$TSI\ (Chl) = 10\left(6 - \frac{2.04 - 0.68 \ln chl}{\ln 2}\right)$$

$$TSI\ (Chl) = 10\left(6 - \frac{\ln \frac{48}{TP}}{\ln 2}\right)$$

- The impact of stocking was assessed from the pattern of increase of the fish yield in relation to the stocking density. Regression analysis was employed to assess the response of the fish production to different stocking densities.
- The optimum stocking density and fishing effort were assessed using the surplus production model (Schaefer, 1954).

THE SCHAEFER SURPLUS PRODUCTION MODEL:

$$(Y_t / f_t) = a + b\, f_t$$

Under this model, the catch per unit effort will be maximum when

$$f_t = \frac{-a}{b}$$

The maximum sustainable yield *(MSY)* for the model is

$$MSY = \frac{-a^2}{4b}$$

And the corresponding effort is

$$f_{MSY} = \frac{-a}{2b}$$

The coefficients a and b can be calculated by linear regression of the catch per unit effort (Y_t / f_t) *(CPUE)* on the effort f_t

Socio-economic status of the fishers and governance mechanisms

- The socio-economic status of the fishers was assessed on the basis of a structured questionnaire developed by ICAR-CIFRI for inland fishers.

- The governance mechanisms and the role of the stakeholders were assessed through stakeholder meetings and interactions.

Mapping of the fisheries and ecological data in a GIS platform

- A GIS map of the reservoir was created on the basis of different attributes of the fisheries such as fish catch, fish diversity (including species richness) and different diversity indices.
- Basic physico-chemical parameters were depicted in a GIS platform.
- The decadal trend of fish production was depicted in a GIS platform.

Assessment of the impact of migratory birds on fish production

- Regression analysis was conducted of the time series data relating to fish production and migratory bird abundance to assess the impact of the birds on the fish production.

Assessment of the impact of climatic variables on fish production

- Regression analysis was conducted of the time series data relating to fish production and climatic variables to assess the impact of climatic variables on the fish production.

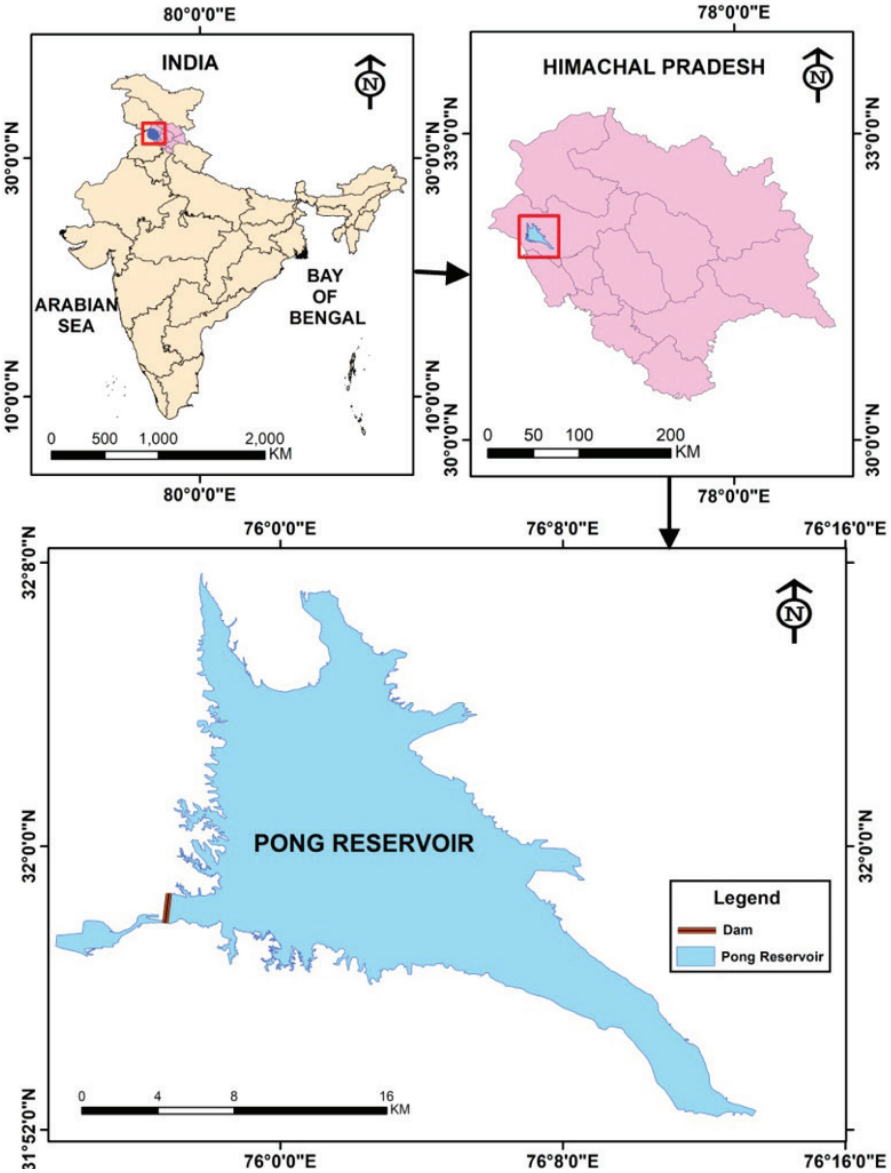


Figure 1 *Location of Pong Reservoir*

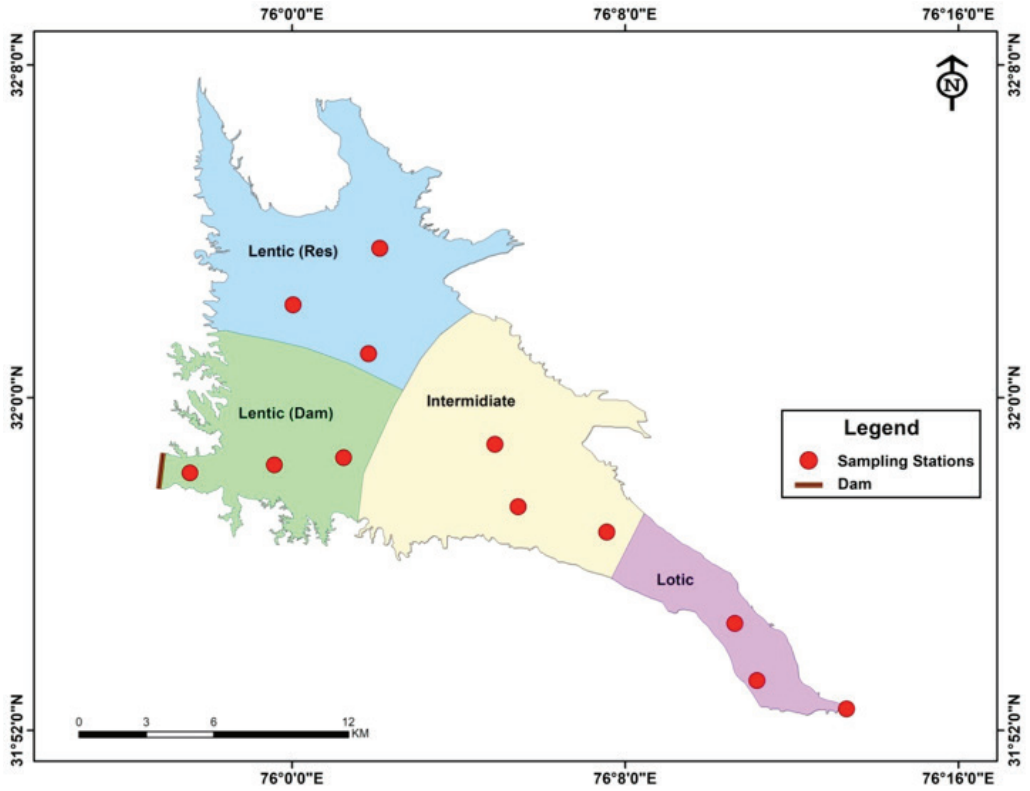


Figure 2 *Sampling stations in different zones of the reservoir*

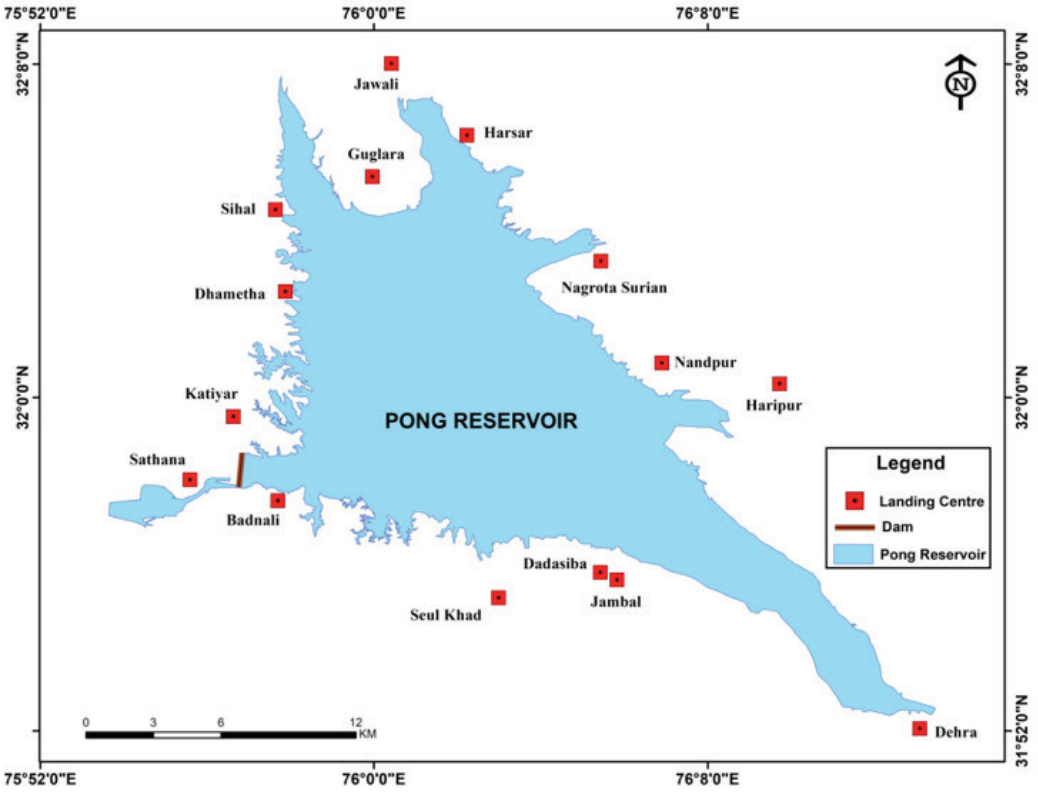


Figure 3 *15 fish landing centres of Pong reservoir*

Table1 *Geographical co-ordinates of sampling stations of Pong Reservoir, Kangra, HP*

Sampling station	Zone	Latitude (N)	Longitude (E)
1	Lentic (dam)	31° 58′ 11.47″	75° 57′ 32.54″
2		31° 58′ 22.89″	75° 59′ 34.43″
3		31° 58′ 33.38″	76° 1′ 14.00″
4	Lentic (reservoir)	32° 02′ 13.96″	76° 0′ 1.14″
5		32° 03′ 35.54″	76° 2′ 6.18″
6		32° 01′ 3.43″	76° 1′ 49.99″
7	Intermediate/ transitional	31° 58′ 52.64″	76° 4′ 51.98″
8		31° 57′ 22.59″	76° 5′ 25.64″
9		31° 56′ 46.03″	76° 7′ 33.24″
10	Lotic	31° 54′ 34.10″	76° 10′ 37.92″
11		31° 53′ 11.76″	76° 11′ 9.69″
12		31° 52′ 30.93″	76° 13′ 18.74″

Image 2 *A view of the lentic zone (dam site) of Pong Reservoir*

Image 3 *A view of the lentic zone (reservoir site) of Pong Reservoir*

Image 4 *A view of the transitional zone of Pong Reservoir*

Image 5 *A view of the lotic zone of Pong Reservoir*

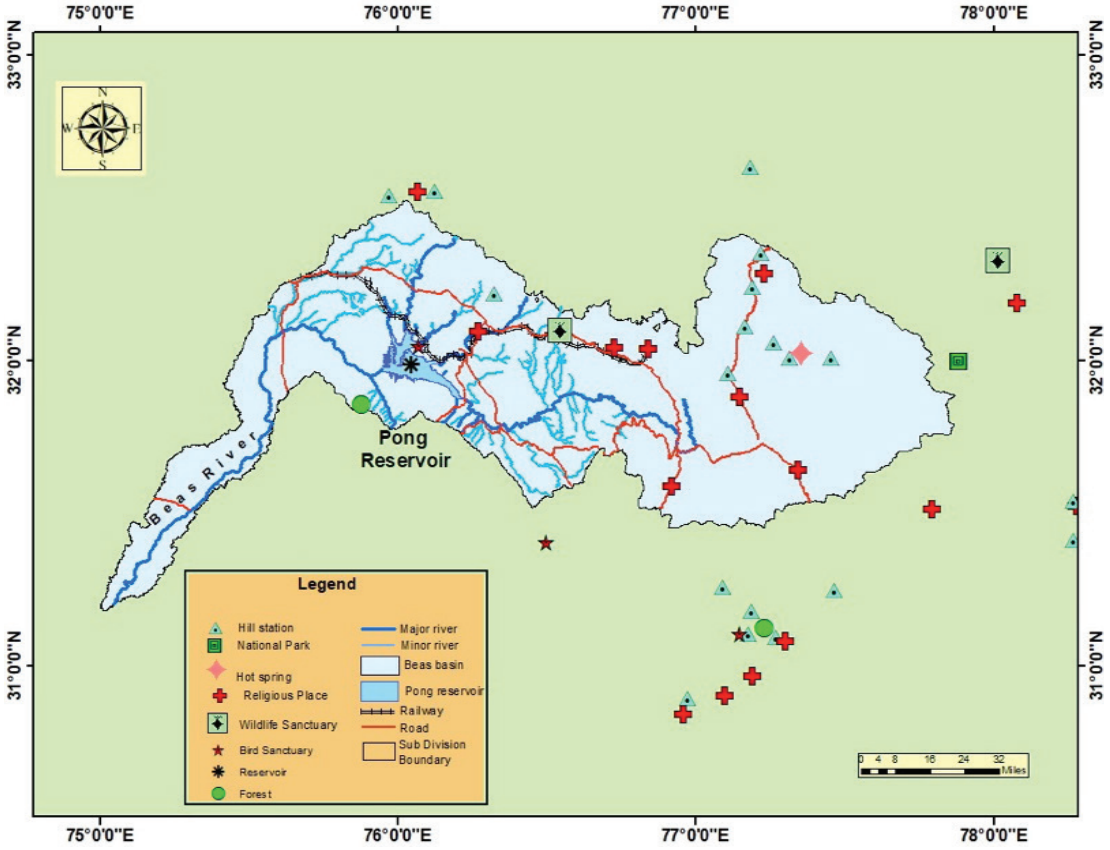


Figure 4 *Important places around Pong Reservoir*

4. Ecology and fish abundance pattern in Pong Reservoir

The pattern of the water spread area in Pong Reservoir was depicted in a GIS platform. The water spread area was greatest in the monsoon months (24,177 ha), whereas the water availability was lowest in the pre-monsoon months (16,796 ha) in Pong Reservoir. The pattern of the water spread area in the reservoir clearly indicated the significant impact rainfall had on it. Due to the rich flora and fauna, the sport fishery opportunity, boating facilities, natural beauty of the lake and catchment and presence of important places near the reservoir (including a wildlife sanctuary, bird sanctuary, national park and religious places), Pong Reservoir is highly attractive to many tourists.

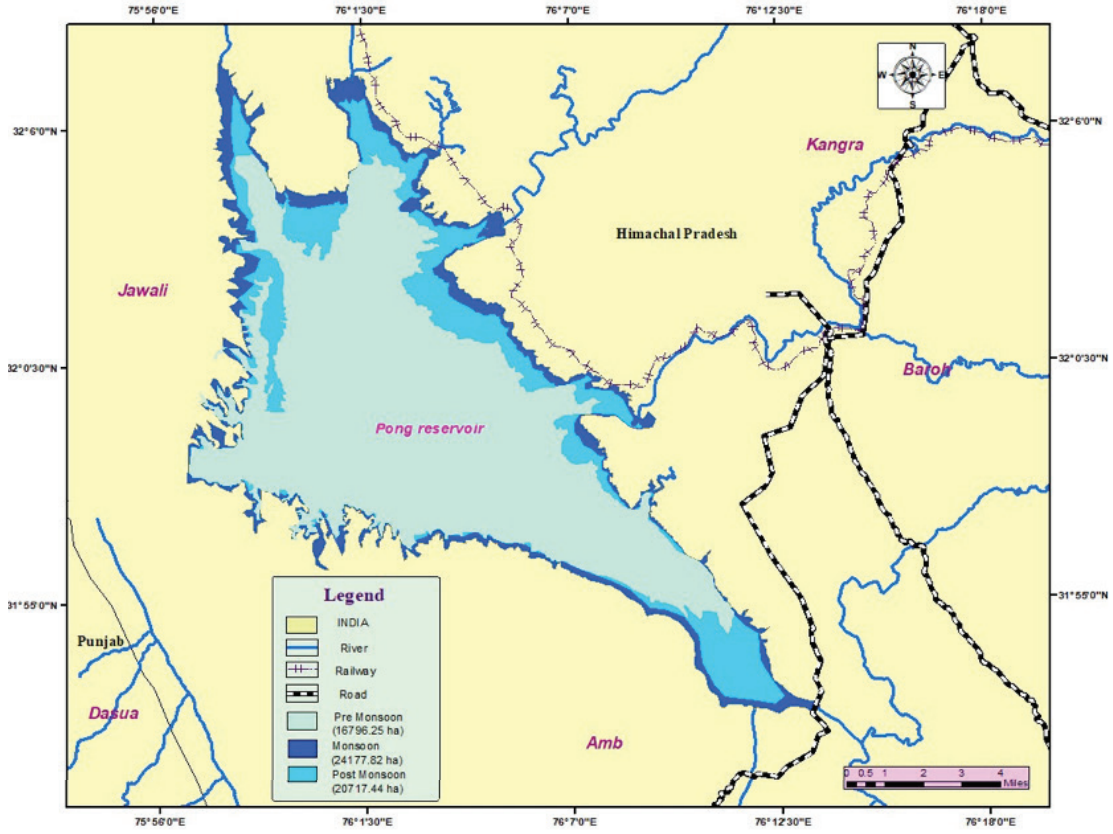


Figure 5 *Water spread area of Pong Reservoir during the pre-monsoon season, the monsoon and the post-monsoon season*

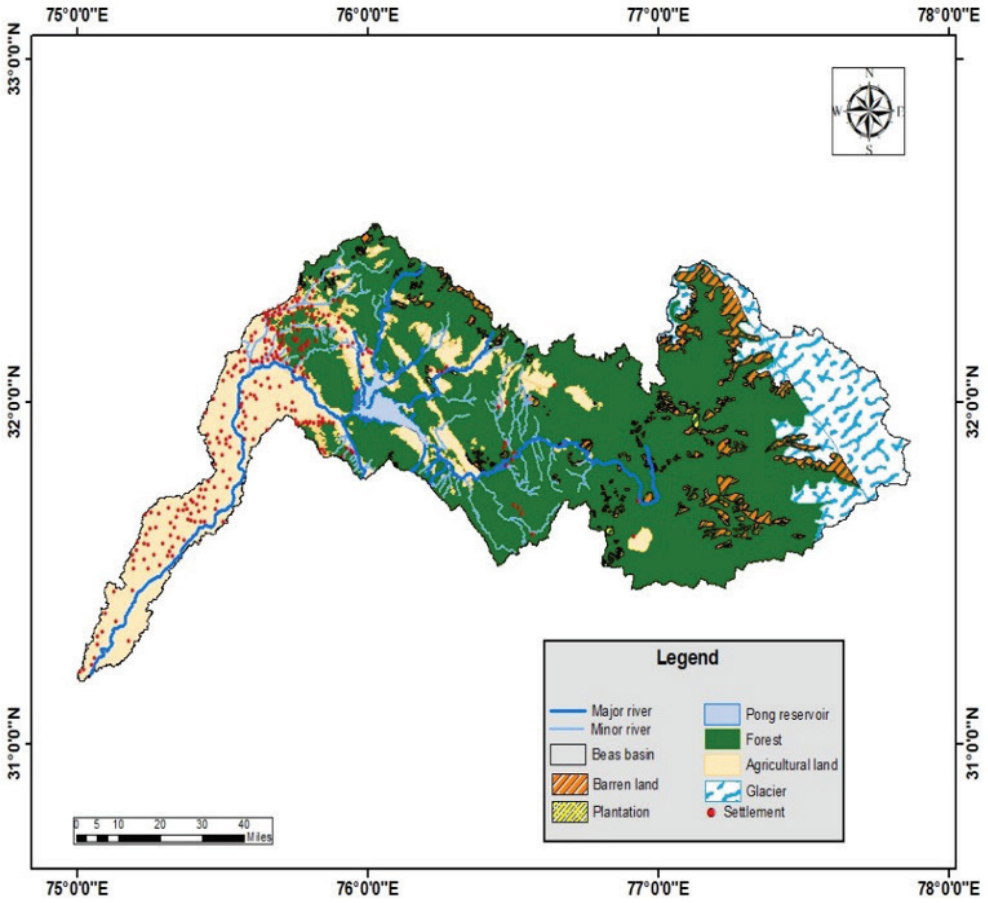


Figure 6 *Catchment map of Pong Reservoir*

Table 2 *Basic details of Pong Reservoir*

Location	Himachal Pradesh, India
Connected river	Beas
GPS location	31° 58′ 17″ N, 75° 56′ 48″ E
Elevation at top of dam	433.36 m (1430 ft)
Maximum reservoir level	433:12 m (1421 ft)
Maximum reservoir area	24,000 ha
Dead storage level	384.05 m (1260 ft)
Dead storage area	6000 ha
Average area	15,000 ha
Catchment area	12,561 km2
Gross storage capacity	8570 million m3 (6.95 million ac. ft.)
Live storage capacity	7290 million m3 (5.91 million ac. ft)
Maximum reservoir depth	97.84 m (321 ft)
Mean depth	35.7 m
Shore development at 1260 ft	2.48
Volume development	1.08
Annual irrigation	1.6 million ha (4 million acres)
Electrical energy delivered per annum	400 million units approximately

4.1 PHYSICO-CHEMICAL WATER QUALITY PARAMETERS

Image 6 *In situ water quality analysis*

Most of the samples were analysed *in situ,* and the other samples were preserved in the field and brought to the laboratory for further analysis. A total of 26 water quality parameters were analysed from the samples from the 12 sampling stations of the reservoir. The water temperature ranged from 22.3°C to 29.4°C in October 2020 (post-monsoon, POM), with a mean temperature of 26.51°C, while it was lower in December 2020 (winter), 14.4°C to 14.8°C, with a mean at 14.5°C. The lotic zone had the lowest water temperatures, 22.3°C and 14.4°C in the POM and in winter in 2020, respectively, but the highest water temperature was in the lentic zone, which is obvious as it is the entry point of the cold Beas water into the reservoir.

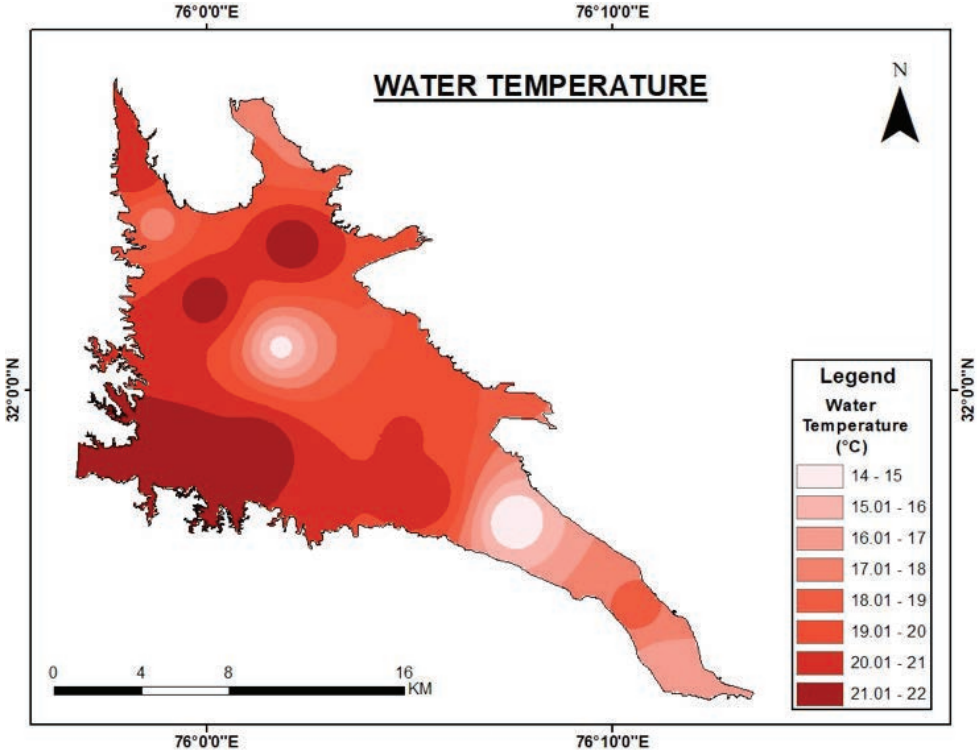


Figure 7 *Spatial variation of the average water temperature in Pong Reservoir*

The water depth was greater at the dam site as compared with other parts of the reservoir, the mean specific conductivity was 234.4µS/cm and 209.0 µS/cm during the post-monsoon (POM) and winter months, and the maximum values were 346 µS/cm and 212.0 µS/cm and the minimum values were 170 µS/cm 206 µS/cm, respectively. The maximum specific conductivity was in the lotic zone during the POM, and in the intermediate zone during winter, while the minimum was in the lentic zone in both the seasons. The specific conductivity is one of the most widely used parameters for estimating the fish productivity in a reservoir. The mean conductivity indicates that Pong Reservoir has medium productivity from a fisheries point of view. The total dissolved solid (TDS) value is also one of the most important indicators of productivity in lakes and reservoirs. The mean TDS value was 114.16 mg/l and 111.0 mg/l in POM and in winter, respectively, and the maximum TDS value was observed in the lotic zone in POM and in the intermediate zone in winter, while the minimum was in the lentc zone of the reservoir in both the seasons.

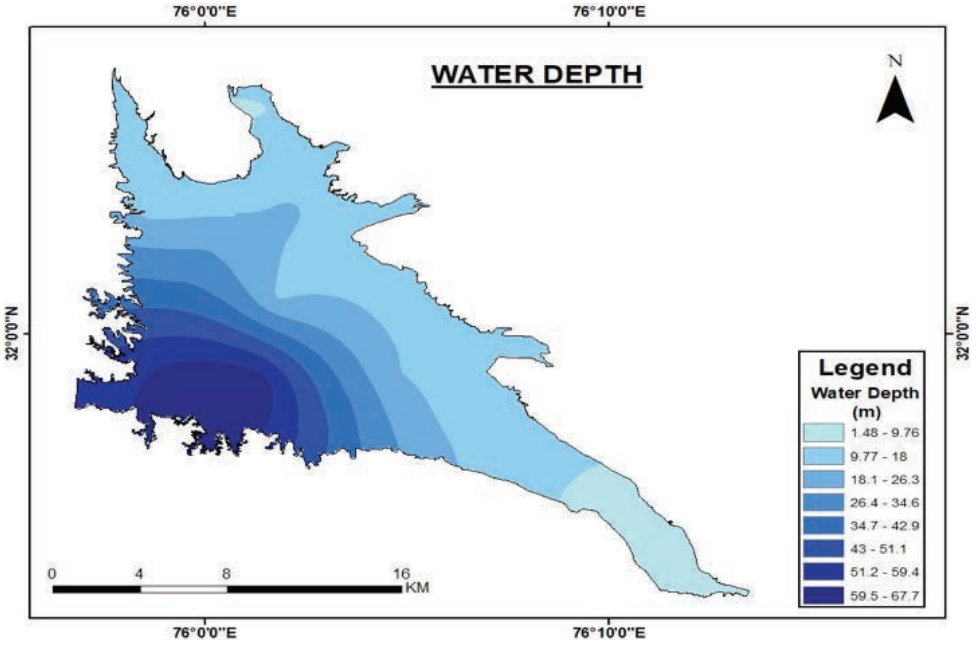


Figure 8 *Spatial variation of average water depth in Pong Reservoir*

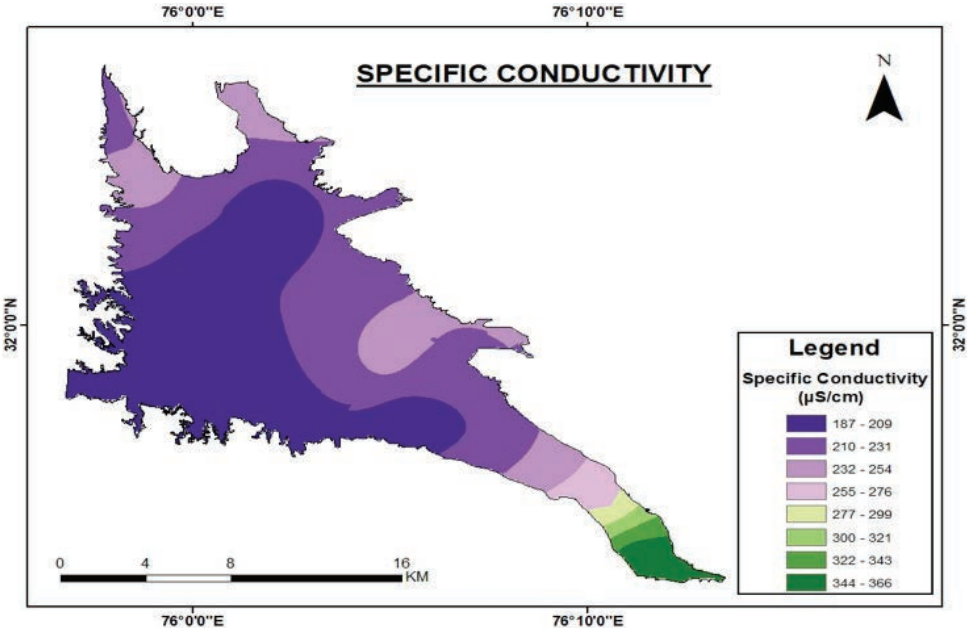


Figure 9 *Spatial variation of average specific conductivity in Pong Reservoir*

The water transparency was measured as the Secchi depth using a Secchi disk. The average transparency ranges from 130 cm to 394 cm, with a mean value of 258.1 cm in POM, while it was 120–328 cm, with a mean value of 240.5 cm, in winter. The transparency was lowest in the lotic zone in both the seasons, but the other two zones had very similar transparency values. The transparency values also indicated that the reservoir has medium productivity from the fisheries point of view. The mean turbidity (NTU) was 1.57 and 6.28 and ranged from 0.89 to 4.01 and from 3.28 to 8.99 in POM and in winter, respectively. The turbidity value was lowest in the intermediate zone in POM and in the lotic zone in winter, and the highest turbidity value was in the lentic zone in both seasons.

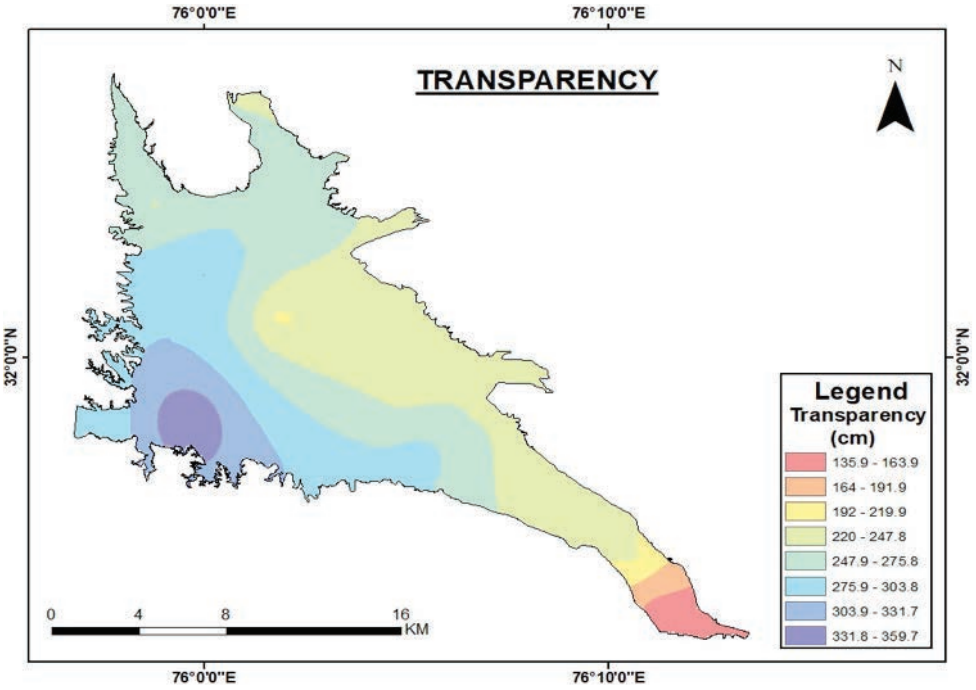


Figure 10 *Spatial variation of average transparency in Pong Reservoir*

The water pH ranges from 8.23 to 8.68 and from 7.78 to 8.21 in POM and in winter, with mean pH values of 8.5 and 7.9, respectively. The pH values are very similar in all the sectors of the reservoir. The pH value obtained indicateds that the reservoir is moderately productive. and it is one of the most important parameters for ecological health and fish productivity.

The dissolved oxygen (DO) value ranges from 5.2 mg/l to 8.2 mg/l and from 6.0 mg/l to 8.2 mg/l, with the mean DO value being 6.86 mg/l and 6.92 mg/l in POM and in winter, respectively. The DO value was highest in the lotic zone compared with the lentic and intermediate zones of the reservoir in both these seasons. Free CO2 was absent in POM, and its value was in the range from 2.8 mg/l to 6.0 mg/l in all the zones of the reservoir, with a mean value of 4.5 mg/l during the winter sampling period.

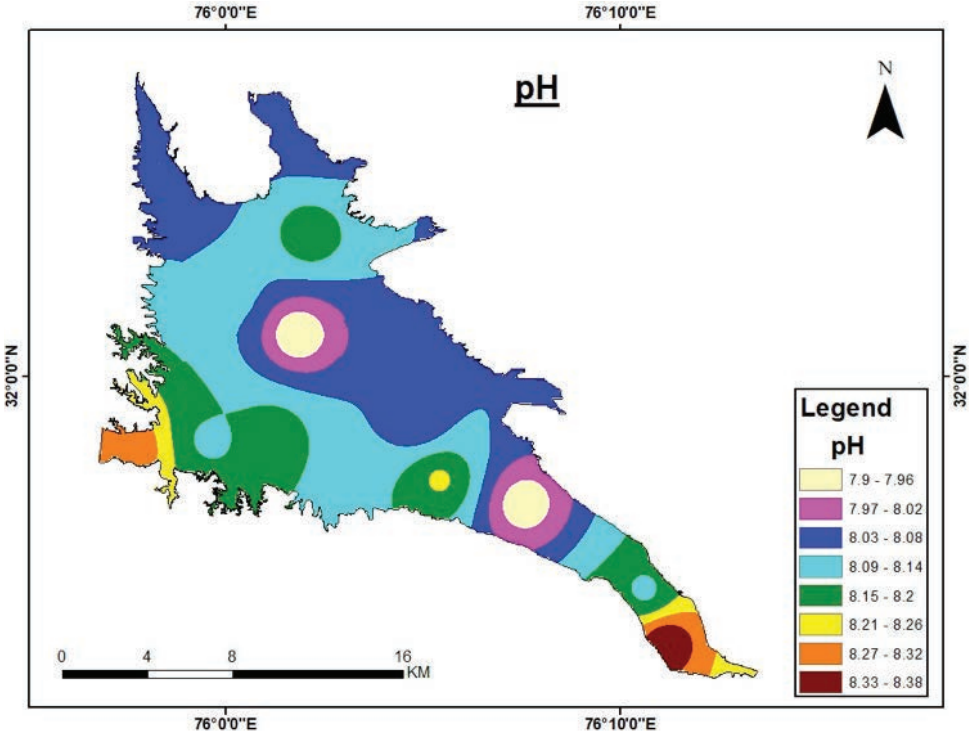


Figure 11 *Spatial variation of average pH in Pong Reservoir*

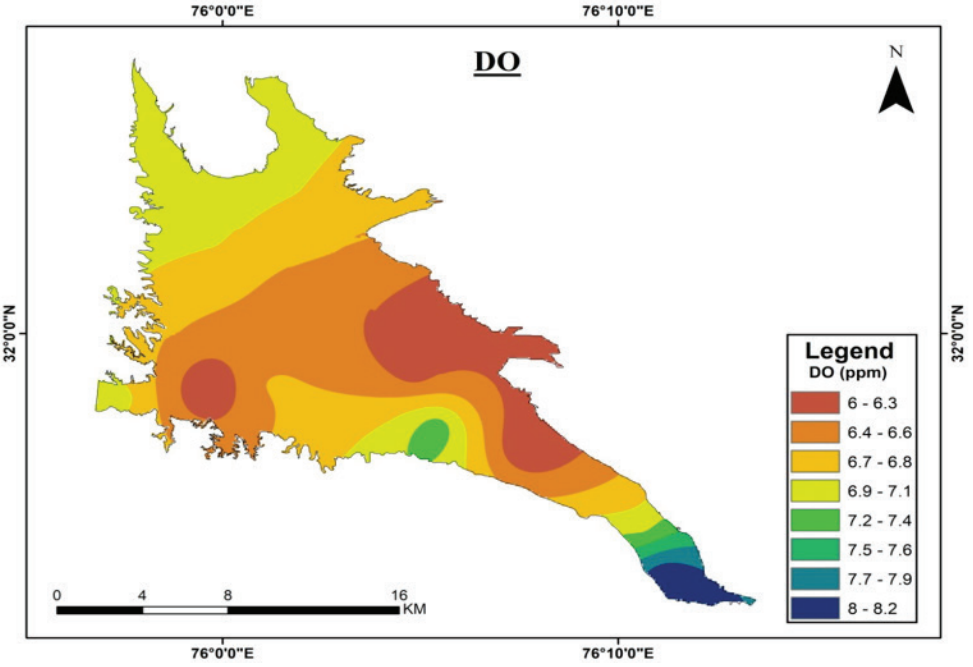


Figure 12 *Spatial variation of average DO in Pong Reservoir*

The total alkalinity (TA) measures the buffering capacity, which controls the fluctuations of the pH value. The mean total alkalinity was 81.8 mg/l and 80.92 mg/l, with a maximum of 94 mg/l and 104 mg/l and a minimum of 70 mg/l and 74 mg/l in the POM and in winter, respectively. The maximum alkalinity value was in the lotic zone, and the minimum was in the lentic zone. The mean alkalinity indicated that the reservoir is medium-productive from a fisheries point of view. The total hardness (TH) ranged from 62 mg/l to 100 mg/l and from 74 mg/l to 108 mg/l, with a mean value of 77.6 mg/l and 83.25 mg/l in the POM and in winter, respectively. The lentic zone had the lowest TH value, followed by the intermediate zone, with the lotic zone having the highest value in both the seasons.

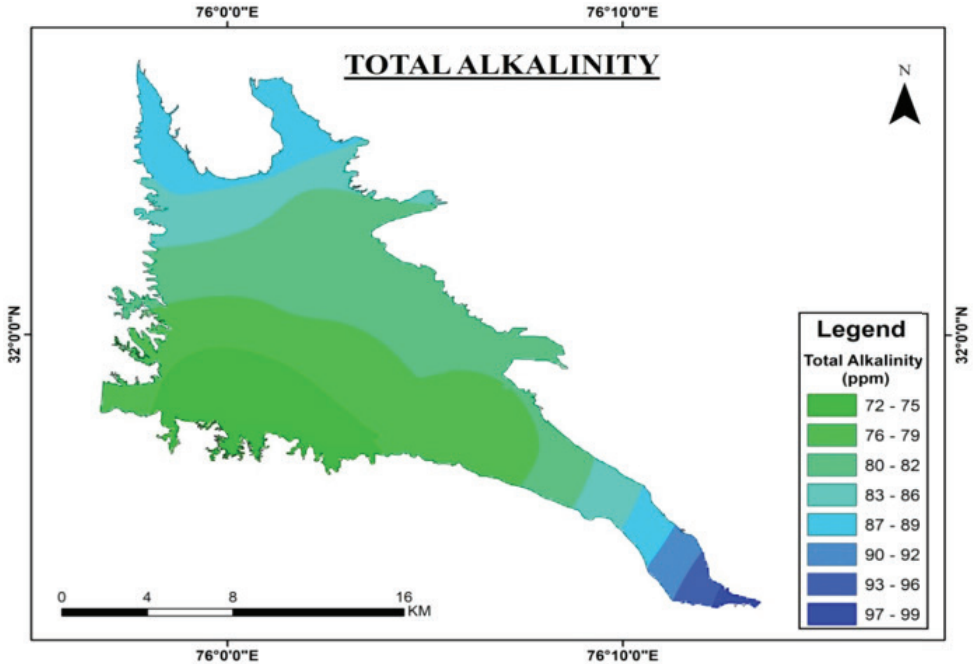


Figure 13 *Spatial variation of average total alkalinity in Pong Reservoir*

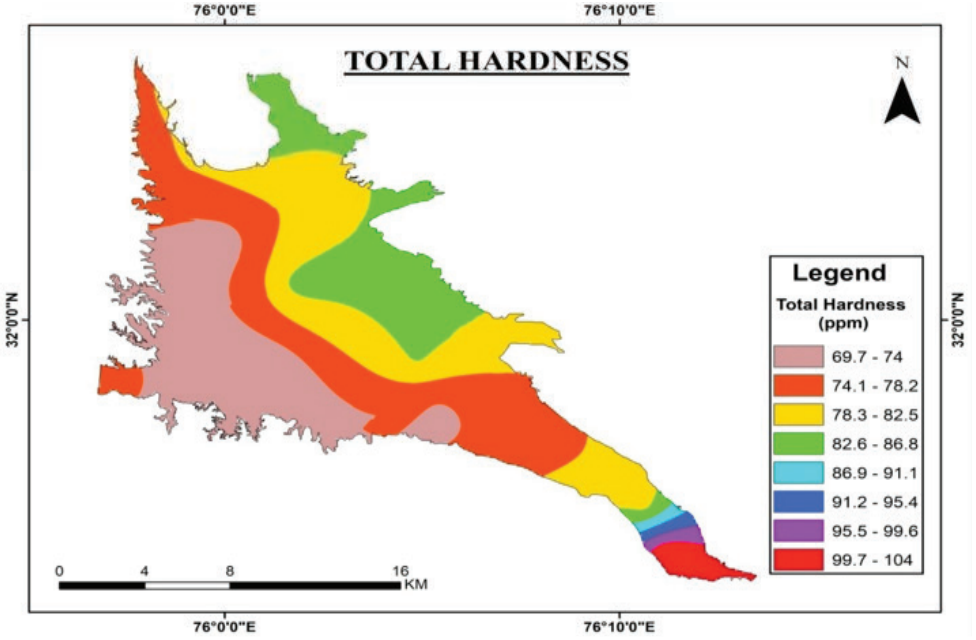


Figure 14 *Spatial variation of average total hardness in Pong Reservoir*

Amongst the dissolved nutrients, nitrate-N and phosphate-P are most important, besides silicate-Si, the very basis of the Bacillariophyceae. The nitrate-N value ranged from 0.005 mg/l to 0.025 mg/l and from 0.008 mg/l to 0.025 mg/l, with a mean value of 0.13 mg/l and 0.015 mg/l in the POM and in winter, respectively. The lentic zone had the lowest nitrate-N content, and the lotic zone had the highest, which is to be expected from the loading point of view for allochthonous inputs. The nitrate-N value indicates that the reservoir is medium-productive. The phosphate-P value ranged from 0.006 mg/l to 0.044 mg/l and from 0.011 to 0.036 mg/l, with a mean value of 0.026 and 0.024 mg/l in the POM and in winter, respectively. The lentic zone had the lowest phosphate-P value, and the lotic zone had the highest value in both these seasons. The phosphate-P values indicate that the reservoir is medium-productive. The mean silicate-Si value was 6.34 mg/l and 4.25 mg/l, with the maximum at 10.58 mg/l and

7.91 mg/l and the minimum at 3.92 mg/l and 2.83 mg/l in the POM and in winter, respectively. The silicate-Si value is maximum in the lotic zone, and it is minimum in the lentic zone during both the seasons.

The mean sulphate-S value was 0.027 mg/l and 0.018 mg/l in the POM and winter sampling periods respectively. The minimum value was in the lentic zone, and the maximum was in the lotic zone. The salinity was maximum in the lotic zone, followed by the intermediate and lotic zones. The mean salinity of the reservoir was 0.05 and 0.04 ppt in the POM and winter, respectively. The chloride content value was highest in the lotic zone, compared with other zones of the reservoir.

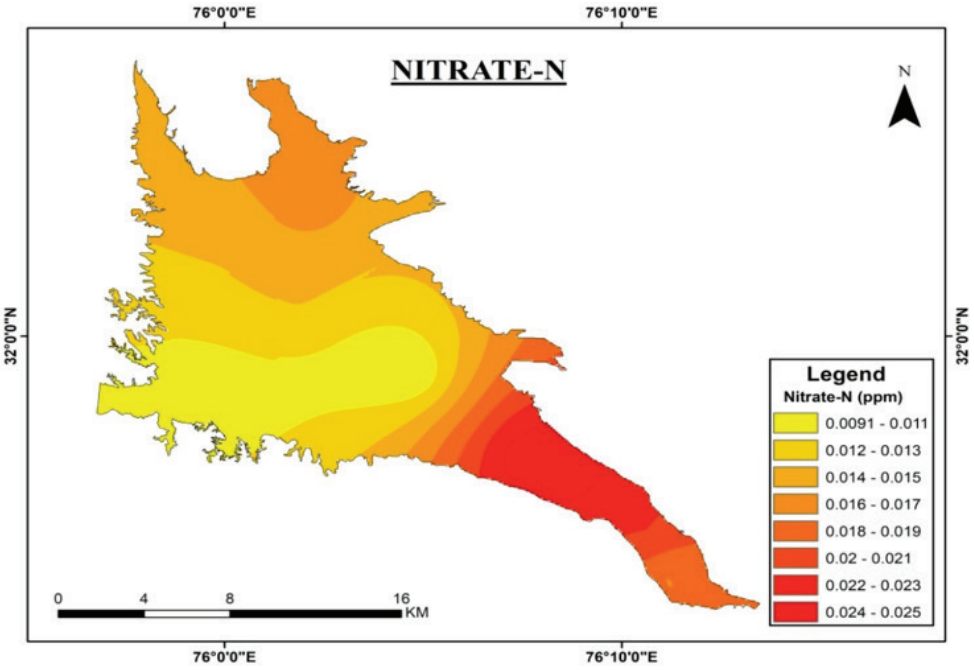


Figure 15 *Spatial variation of the average nitrate-N in Pong Reservoir*

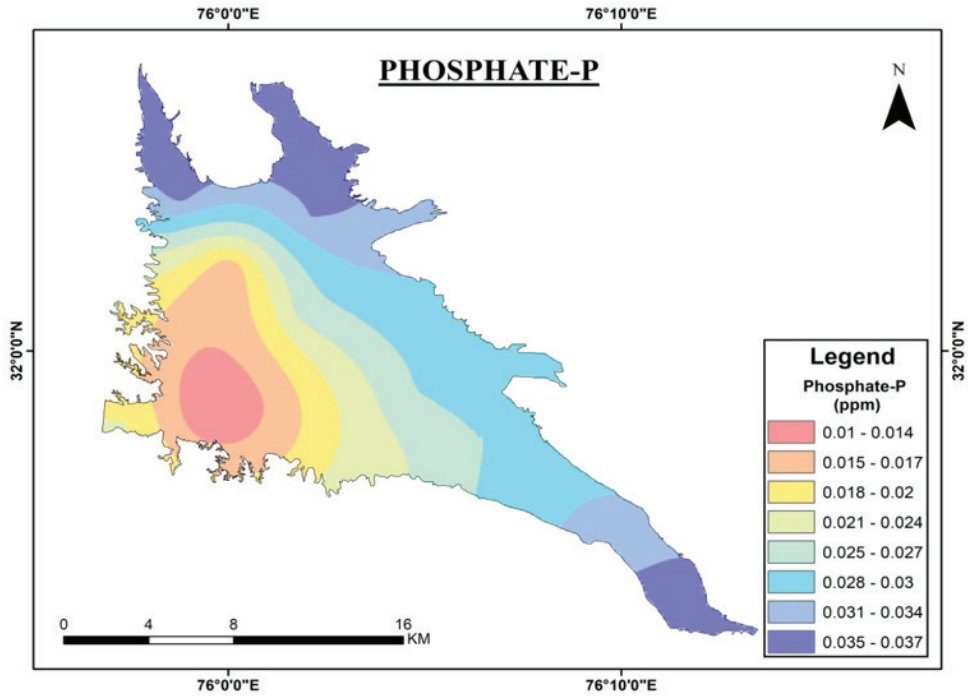


Figure 16 *Spatial variation of the average phosphate-P value in Pong Reservoir*

4.2 HEAVY METAL CONCENTRATION IN WATER

Among the heavy metals studied, the toxic heavy metals are Cr > Cd > Ni > Co > Cu > Pb > Ga > Zn as per their toxicity to aquatic organisms and human beings. On most occasions, the concentrations of toxic heavy metals are very low. The reservoir is free of pollution by toxic heavy metals, but the lotic sector shows signs of toxic pollutants beyond permissible levels, particularly Cr, Pb, Cu, Cd, and Ni. This needs further validation down the food chain in this reservoir for getting a clear picture of the bioaccumulation in the aquatic organisms.

Table 3 *Physico-chemical characteristics of water at Pong Reservoir during the post-monsoon season (a) (POM, October) 2020*

Station	Zone	Air temp.	Water temp.	Depth	Transparency	Turbidity	Specific Conductivity	pH	DO	Total alkalinity	Carbonate	Bicarbonate	Free CO_2	Chloride	Salinity
		(°C)	**(°C)**	**(m)**	**(cm)**	**(NTU)**	**(µS/cm)**		**(mg/l)**	**(mg/l)**	**(mg/l)**	**(mg/l)**	**(mg/l)**	**(mg/l)**	**(mg/l)**
1	Lentic (Dam)	31.1	29.0	56.73	273.0	4.01	170.0	8.68	7.0	76.0	20.0	56.0	Nil	15.99	28.87
2		31.5	29.1	70.40	394.0	2.07	175.0	8.45	5.8	70.0	8.0	62.0	Nil	13.99	25.26
3		31.7	29.2	74.30	310.0	1.37	176.0	8.47	6.2	72.0	12.0	60.0	Nil	14.99	27.07
4	Lentic (Reservoir)	31.8	29.3	30.50	320.0	0.89	201.0	8.46	6.8	84.0	24.0	60.0	Nil	17.99	32.48
5		32.0	29.4	20.70	340.0	0.97	177.0	8.53	6.4	78.0	14.0	64.0	Nil	15.99	28.87
7	Intermediate/ Transitional	29.8	25.4	21.0	190.0	0.98	273.0	8.23	5.2	82.0	Trace	82.0	Nil	20.99	37.90
8		29.9	26.7	22.0	312.0	1.35	182.0	8.52	7.8	76.0	8.0	68.0	Nil	15.99	28.87
10	Lotic	28.9	22.3	6.4	260.0	0.91	346.0	8.45	7.4	94.0	8.8	85.2	Nil	54.99	99.27
11		29.1	22.5	1.5	130.0	1.88	319.0	8.55	8.2	92.0	18.0	74.0	Nil	50.99	92.05
12		29.3	22.2	4.1	152.0	1.27	325.0	8.61	7.8	94.0	24.0	70.0	Nil	50.99	92.05

Table 4 *Physico-chemical characteristics of water at Pong Reservoir during post-monsoon season (b) (POM, October) 2020*

Station	Zone	TS	TDS	TSS	Nitrate-N	Total N	Phosphate-P	Total-P	Silicate-Si	Sulphate	Total hardness	Ca++	Mg++
		(g/l)	**(g/l)**	**(g/l)**	**(mg/l)**	**(mg/l)**	**(mg/l)**	**(mg/l)**	**(mg/l)**	**(mg/l)**	**(mg/l)**	**(mg/l)**	**(mg/l)**
1	Lentic (Dam)	0.0980	0.0728	0.0252	0.0057	0.0066	8.68	0.0852	4.58	0.0147	68.0	18.43	5.25
2		0.1044	0.0960	0.0084	0.0062	0.0075	8.45	0.0942	4.50	0.0149	62.0	20.84	9.89
3		0.1084	0.1008	0.0076	0.0097	0.0110	8.47	0.1233	3.92	0.0147	66.0	19.23	4.29
4	Lentic (Reservoir)	0.1052	0.1032	0.0024	0.0123	0.0133	8.46	0.1860	4.92	0.017	68.0	18.43	5.25
5		0.1196	0.1028	0.0168	0.0136	0.0159	8.53	0.1794	4.75	0.0179	72.0	18.43	6.21
7	Intermediate/ Transitional	0.1287	0.1120	0.0167	0.0105	0.0124	8.23	0.1659	6.0	0.007	88.0	21.64	8.13
8		0.1104	0.1072	0.0032	0.0194	0.0212	8.52	0.1368	6.25	0.0174	74.0	20.04	5.73
10	Lotic	0.1896	0.1604	0.0292	0.0259	0.0269	8.45	0.1546	8.25	0.0252	82.0	26.45	3.80
11		0.150	0.1492	0.0008	0.0128	0.0141	8.55	0.1748	9.66	0.0268	100.0	24.84	9.09
12		0.1548	0.1372	0.0176	0.0163	0.0177	8.61	0.1524	10.58	0.0275	96.0	24.05	8.61

Table 5 *Physico-chemical characteristics of water at Pong Reservoir in the winter (a) (December) of 2020*

Station	Zone	Air temp.	Water temp.	Depth	Transparency	Turbidity	Specific Conductivity	pH	DO	Total alkalinity	Carbonate	Bicarbonate	Free CO_2	Chloride	Salinity
		(°C)	**(°C)**	**(m)**	**(cm)**	**(NTU)**	**(µS/cm)**		**(mg/l)**	**(mg/l)**	**(mg/l)**	**(mg/l)**	**(mg/l)**	**(mg/l)**	**(mg/l)**
1	Lentic (Dam)	11.0	14.5	52.12	280.0	4.92	206.0	7.96	6.8	78.0	Trace	78.0	4.8	14.99	27.07
2		11.2	14.6	64.60	328.0	6.75	209.0	7.82	6.2	74.0	Trace	74.0	2.8	16.99	30.68
3		11.3	14.8	56.99	292.0	5.08	210.0	7.87	7.0	76.0	Trace	76.0	6.0	15.99	28.87
4	Lentic (Reservoir)	11.0	14.1	26.0	290.0	3.28	207.0	7.78	6.8	78.0	Trace	78.0	4.2	13.99	25.26
5		11.3	14.4	17.30	211.0	8.99	211.0	7.85	7.2	82.0	Trace	82.0	3.8	16.99	30.68
6		11.5	14.6	15.24	215.0	7.49	207.0	7.90	6.4	80.0	Trace	80.0	4.4	13.99	25.26
7	Intermediate/ Transitional	11.6	14.8	15.0	290.0	8.12	212.0	7.84	7.0	76.0	Trace	76.0	5.2	14.99	27.07
8		11.7	14.9	17.60	260.0	7.85	209.0	7.91	6.8	75.0	Trace	75.0	3.6	14.99	27.07
9		9.8	14.0	13.0	240.0	6.30	213.0	7.92	6.0	78.0	Trace	78.0	3.8	15.499	27.97
10	Lotic	11.2	14.4	5.70	185.0	6.30	209.0	7.81	6.6	80.0	Trace	80.0	5.2	13.99	25.26
11		11.9	10.5	1.35	175.0	4.04	406.0	8.21	8.2	90.0	Trace	90.0	5.4	60.99	110.10
12		12.2	10.8	2.20	120.0	6.33	405.0	7.87	8.0	104.0	Trace	104.0	5.0	58.99	106.49

Table 6 *Physico-chemical characteristics of water at Pong Reservoir in the winter (b) (December) of 2020*

Station	Zone	TS	TDS	TSS	Nitrate-N	Total N	Phosphate-P	Total-P	Silicate-Si	Sulphate	Total hardness	Ca++	Mg++
		(g/l)	(g/l)	(g/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
1	Lentic (Dam)	0.0492	0.0468	0.0024	0.0149	0.0380	0.0112	0.1951	3.25	0.0159	82.0	21.64	6.69
2		0.1192	0.0940	0.0252	0.0136	0.0225	0.0135	0.0986	3.83	0.0136	78.0	18.43	7.65
3		0.1836	0.1088	0.0748	0.0114	0.0314	0.0179	0.0919	2.83	0.0148	74.0	21.64	4.77
4	Lentic (Reservoir)	0.1136	0.1032	0.0104	0.0141	0.0261	0.0157	0.0538	2.66	0.0129	75.0	23.24	4.05
5		0.1056	0.0860	0.0196	0.0176	0.0203	0.0224	0.0807	5.83	0.0154	86.0	22.44	7.17
6		0.1160	0.1128	0.0032	0.0132	0.0212	0.0246	0.1188	3.92	0.0158	84.0	22.84	6.45
7	Intermediate/ Transitional	0.1940	0.1540	0.0400	0.0075	0.0323	0.0269	0.1457	3.08	0.0147	78.0	22.44	5.25
8		0.1140	0.0916	0.0224	0.0123	0.0239	0.0202	0.1524	3.50	0.0145	72.0	23.24	3.32
9		0.1288	0.0960	0.0328	0.0246	0.0384	0.0292	0.1637	2.91	0.0141	76.0	19.23	6.69
10	Lotic	0.1088	0.0768	0.0320	0.0154	0.0305	0.0314	0.1429	7.42	0.0143	80.0	24.04	4.77
11		0.2304	0.1284	0.1020	0.0207	0.0332	0.0336	0.1390	3.83	0.0329	108.0	28.85	8.60
12		0.2280	0.1508	0.0772	0.0189	0.0261	0.0359	0.1451	7.91	0.0334	106.0	29.65	7.64

Table 7 *Trace elements (including heavy metals) in Pong Reservoir water (values in mg/l)*

Metals	Lentic Zone (Dam)			Lentic Zone (Res)			Intermediate/Transitional Zone			Lotic Zone		
Al	0.0000	1.3924	0.0000	0.0000	0.3803	3.0531	2.2527	4.3968	12.8860	5.7474	11.1072	17.0190
Ba	0.0704	0.1029	0.1314	0.1762	0.2959	0.4009	0.5571	0.6670	0.9263	1.0717	2.2173	3.3768
Ca	39.905	50.686	61.183	72.862	105.203	141.471	171.969	201.476	243.797	270.278	522.053	576.253
Cd	0.0003	0.0008	0.0010	0.0013	0.0024	0.0038	0.0038	0.0065	0.0075	0.0087	0.0090	0.0129
Co	0.0001	0.0000	0.0000	0.0002	0.0002	0.0003	0.0006	0.0009	0.0020	0.0018	0.0020	0.0050
Cr	0.0000	0.0018	0.0054	0.0061	0.0129	0.0215	0.0165	0.0305	0.0412	0.0426	0.0821	0.0875
Cu	0.0019	0.0003	0.0072	0.0074	0.0159	0.0241	0.0301	0.0397	0.0446	0.0461	0.0935	0.1158
Fe	0.0224	0.1631	0.1019	0.1142	0.2875	0.5280	0.6993	0.8726	3.5740	1.1947	2.2182	9.2482
Ga	0.0015	0.0023	0.0055	0.0055	0.0114	0.0179	0.0279	0.0347	0.0479	0.0650	0.1183	0.1815
K	11.385	13.567	17.543	21.519	30.975	41.521	52.486	60.880	75.091	83.632	154.278	192.758
Li	0.0843	0.0973	0.1064	0.1098	0.1577	0.1911	0.2171	0.2409	0.2822	0.2603	0.9403	0.8158
Mg	50.820	82.454	68.193	96.269	127.89	178.65	204.30	236.22	309.412	284.122	590.102	567.560
Ni	0.0006	0.0007	0.0030	0.0027	0.0054	0.0119	0.0077	0.0142	0.0244	0.0320	0.0489	0.0607
Pb	0.0008	0.0012	0.0030	0.0038	0.0078	0.0113	0.0124	0.0174	0.0237	0.0338	0.0645	0.0693
Zn	0.0036	0.0152	0.0126	0.0122	0.0295	0.0394	0.0449	0.0390	0.0762	0.0948	0.1363	0.1590

4.3 SEDIMENT DYNAMICS

Sediment texture (sand, silt and clay contents)

The sediment is predominantly sandy in all the three zones of the reservoir. The sand content of the sediment varied from 46.0% to 72.0% and from 43% to 81% in the POM and in winter, respectively. The maximum sand content was found in the intermediate zone in both seasons. The silt content varied from 22.5% to 45.0% and from 17.0% to 51% in the POM and in winter respectively, with the maximum content being in the lentic and lotic zones. The lowest clay content values of 5.5% and 2.0% were found during the POM and winter respectively in the intermediate zone. The maximum clay content, of 10.5%, was found in the POM in the lotic zone. (Figure 17).

pH

The pH value of the basin sediment was observed to be slightly acidic during the POM, which improved in winter to near neutral and it shifted to moderately alkaline in the reservoir. The maximum pH value of 7.05 and 7.62 was found during the POM and winter respectively in the lotic sector.

Specific conductivity

The specific conductivity of the sediment varied from 0.153 mS/cm to 0.276 mS/cm and from 0.031 mS/cm to 0.314 mS/cm during the POM and winter respectively. The highest values were found in the lotic zone during both the seasons.

Free calcium carbonate

The free calcium carbonate content of the sediment varied from 1.5% to 4.0% and from 1.5% to 7.0% during the POM and winter respectively. The highest value was in the lotic zone while the lowest free calcium carbonate content was in the intermediate sector during both the seasons.

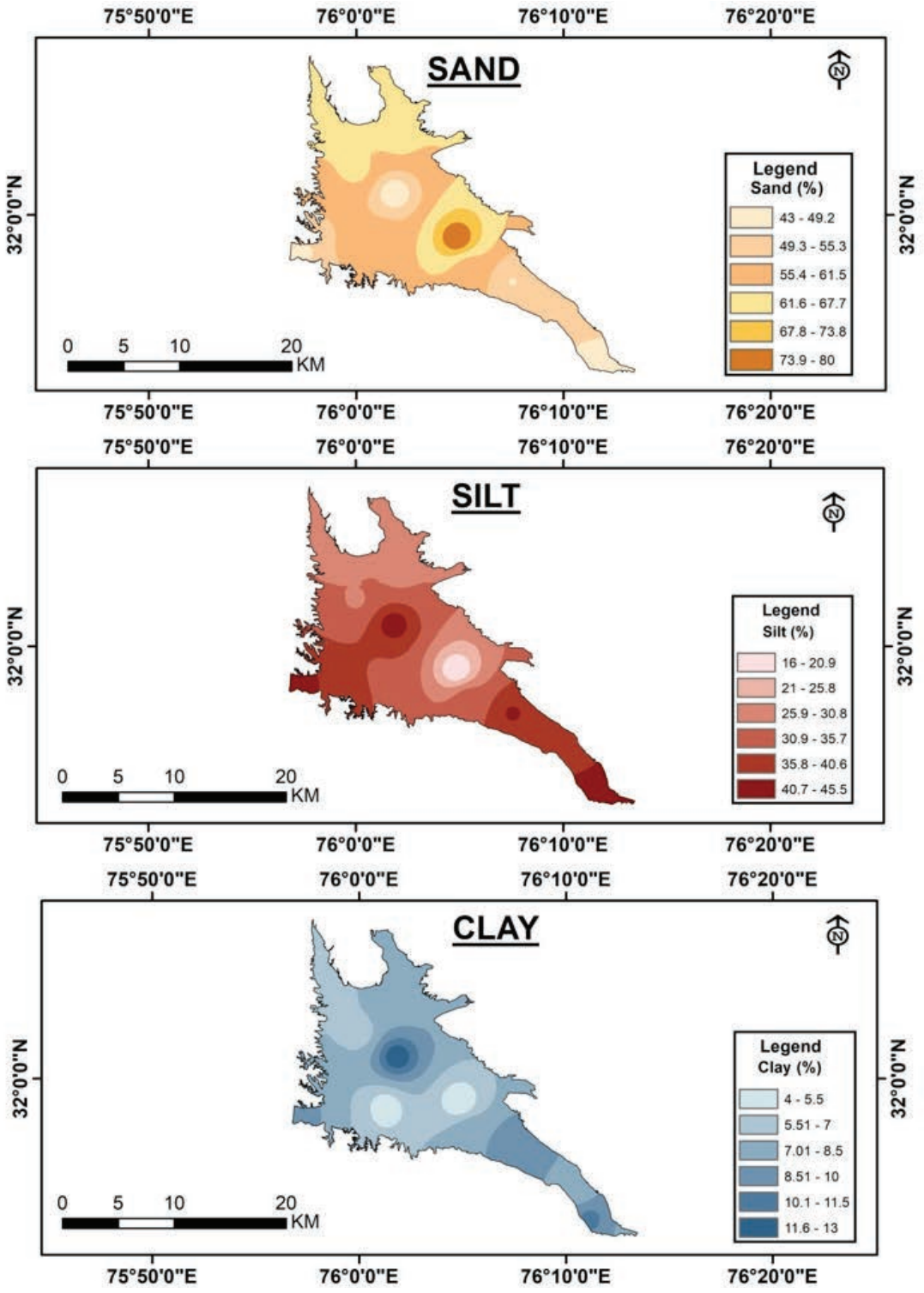


Figure 17 *Spatial variation of the average sediment texture in Pong Reservoir*

Organic carbon

The organic carbon content in the sediment across the three zones ranged from 0.12% to 0.78% and from 0.18% to 0.54% during the POM and winter respectively, with the maximum organic carbon content observed in the lotic zone in both seasons. An increasing trend in organic carbon content is observed from the lentic zone to the lotic zone of the reservoir as allochthonous inputs are being loaded into the reservoir mostly through the lotic zone.

Available nitrogen

The available nitrogen in the sediment ranged from 4.80 mg/100 g soil to 6.72 mg/100 g soil and from 5.04 mg/100 g soil to 14.60 mg/100 g soil during the POM and winter respectively, with the minimum (4.80 mg/100 g soil) in the lotic zone during the POM and (5.04 mg/100 g soil) in the lentic zone during winter. The maximum available Nitrogen (6.72 mg/100 g soil) was observed in the lentic zone during the POM and (14.60 mg/100 g soil) in the lotic zone in winter.

Available phosphorus

The available phosphorus in the reservoir sediment ranged from 0.99 mg/100 g soil to 1.83 mg/100 g soil and from 1.3 mg/100 g soil to 6.2 mg/100 g soil during the POM and in winter, respectively. An increasing trend of the available phosphorus was observed from the lentic zone towards the lotic zone of the reservoir during the POM. This was reversed in winter because of the nutrient either getting used up or locked up as reserve phosphorus in the sediment in the reservoir.

Photo credit: CarrotFilms.GIZ

Table 8 *Physico-chemical characteristics of sediment at Pong Reservoir during the post-monsoon season (POM) and in winter, 2020*

Zone	Season	Sand (%)	Silt (%)	Clay (%)	pH	Sp. Cond. (µS/cm)	Free $CaCO_3$	Organic carbon (%)	Total nitrogen (%)	Available nitrogen (mg/100g soil)	Available P2O5 (mg/100g soil)	C/N
Lentic (Dam)	POM	46.0	45.0	9.0	5.07	0.163	4.0	0.24	0.1624	14.0	0.986	1.477
	Winter	51.0	40.0	9.0	6.57	0.045	3.5	0.42	0.0896	11.76	1.659	4.687
	Winter	56.0	37.0	7.0	6.78	0.031	4.0	0.21	0.0504	16.24	5.829	4.166
	Winter	61.0	35.0	4.0	7.55	0.038	4.5	0.09	0.0392	5.04	6.277	2.295
	Mean	**53.50**	**39.25**	**7.25**	**6.49**	**0.069**	**4.0**	**0.24**	**0.0854**	**11.76**	**3.687**	**3.156**
	SD	**6.45**	**4.34**	**2.36**	**1.03**	**0.062**	**0.40**	**0.13**	**0.0556**	**4.83**	**2.751**	**1.519**
Lentic (Reservoir)	Winter	64.0	30.0	6.0	7.46	0.077	3.75	0.33	0.0448	17.36	4.484	7.366
	Winter	63.0	29.0	8.0	7.19	0.158	3.0	1.71	0.1456	24.08	1.928	11.744
	Winter	43.0	44.0	13.0	7.15	0.101	4.25	0.18	0.0784	17.92	6.053	2.295
	Mean	**56.66**	**34.33**	**9.0**	**7.266**	**0.112**	**3.66**	**0.74**	**0.0896**	**19.78**	**4.155**	**7.135**
	SD	**11.84**	**8.38**	**3.6**	**0.16**	**0.041**	**0.629**	**0.84**	**0.0513**	**3.728**	**2.082**	**4.728**
Intermediate/ transitional	POM	79.0	15.0	6.0	6.58	0.159	2.0	0.18	0.0896	6.72	1.479	2.008
	POM	65.0	30.0	5.0	5.64	0.153	1.0	0.15	0.0952	8.40	1.031	1.575
	Winter	81.0	17.0	2.0	7.01	0.086	2.5	0.30	0.056	11.20	1.434	5.357
	Winter	50.0	38.0	12.0	6.98	0.067	7.0	0.39	0.0616	12.88	1.479	6.331
	Winter	49.0	41.0	10.0	7.02	0.040	1.5	0.15	0.0532	12.32	1.301	2.819
	Mean	**64.80**	**28.20**	**7.0**	**6.64**	**0.101**	**2.80**	**0.23**	**0.0711**	**10.30**	**1.344**	**3.618**
	SD	**15.27**	**11.86**	**4.0**	**0.59**	**0.052**	**2.41**	**0.10**	**0.0197**	**2.64**	**0.189**	**2.108**
Lotic	POM	66.0	27.0	7.0	6.70	0.154	3.5	0.12	0.0728	2.80	1.838	1.648
	POM	44.0	42.0	14.0	7.05	0.208	2.5	0.27	0.0504	5.04	1.165	5.357
	POM	50.0	40.0	10.0	7.00	0.276	3.0	0.78	0.0616	6.16	1.434	12.662
	Winter	44.0	48.0	8.0	7.04	0.269	6.5	0.54	0.0728	14.00	1.748	7.417
	Winter	46.0	47.0	7.0	7.52	0.314	6.0	0.315	0.0952	11.76	1.703	3.308
	Winter	43.0	51.0	6.0	7.62	0.238	5.5	0.36	0.0784	10.64	2.286	4.591
	Mean	**48.83**	**42.5**	**8.66**	**7.15**	**0.2431**	**4.5**	**0.3975**	**0.0718**	**8.4**	**1.69**	**5.830**
	SD	**8.77**	**8.59**	**2.94**	**0.34**	**0.0565**	**1.70**	**0.2315**	**0.0152**	**4.366**	**0.379**	**3.867**

4.4. PRIMARY PRODUCTIVITY

Being a gorge reservoir with steep nature in the lentic and intermediate zones, the reservoir does not provide shelter for macrophyte succession; rather some stray macrophytes are found in the lotic sector. The gross carbon production fluctuated from 200 to 235 mg C/m2/hour vertically up to the euphotic zone, and the net production varied between 102 and 140 mg C/m2/hour. The rate of productivity might increase in summer.

4.5. IMPACT OF CLIMATIC PARAMETERS ON FISH PRODUCTION

The time series data on climatic parameters (including temperature and rainfall) were compared with the fish production in the Pong reservoir. The temperature and rainfall data of Kangra district, of Himachal Pradesh, were collected from the Indian Meteorological Department (IMD), and fish production data of Pong reservoir were collected from the Department of Fisheries, Government of Himachal Pradesh. The impact of rainfall on fish production was assessed by finding the nature of the relationship between the rainfall and fish production using regression analysis. This indicated that rainfall has a mild positive relationship with fish production. On the other hand, the annual mean temperature did not show any significant relationship with the annual fish production. The findings of the present study indicate that rainfall has a positive impact on fish production, but the temperature did not show a proper relationship with the fish production in Pong reservoir.

The correlation matrix indicated that the *T. putitora* catch was negatively impacted by the temperature, but had no impact on IMC catch. On the other hand, the correlation matrix indicated that the rainfall had a positive impact on the catch of IMC, L. calbashu, T. putitora and W. attu but had a negative impact on the C. carpio catch.

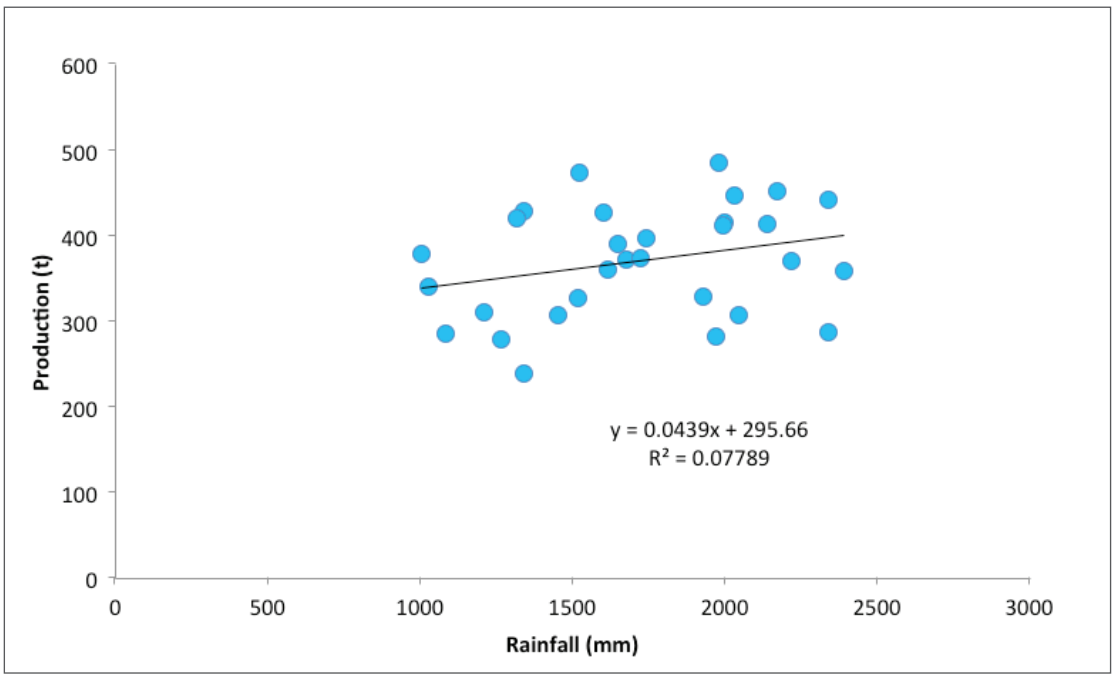


Figure 18 *Relationship between fish production and rainfall for time series data for the period from 1990–91 to 2019–20*

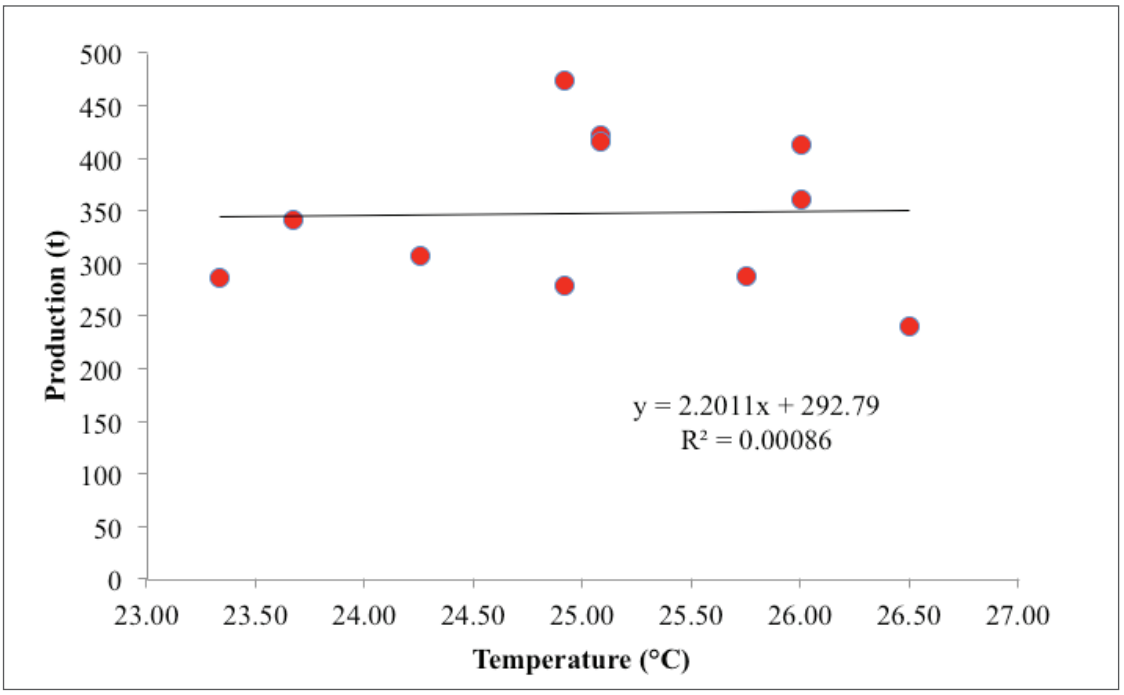


Figure 19 *Relationship between fish production and temperature for time series data for the period from 2009–10 to 2019–2020*

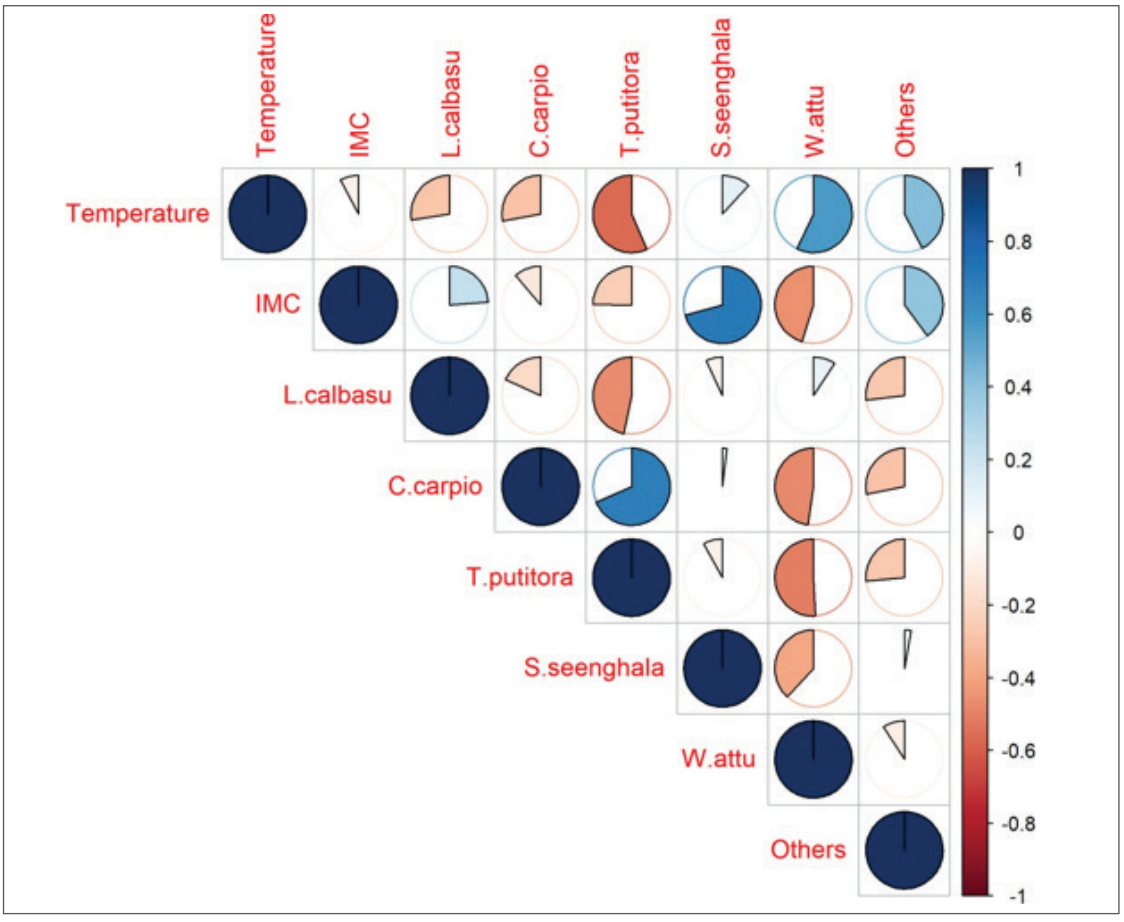


Figure 20 *Correlation matrix showing the relationship between temperature and species-wise fish catch*

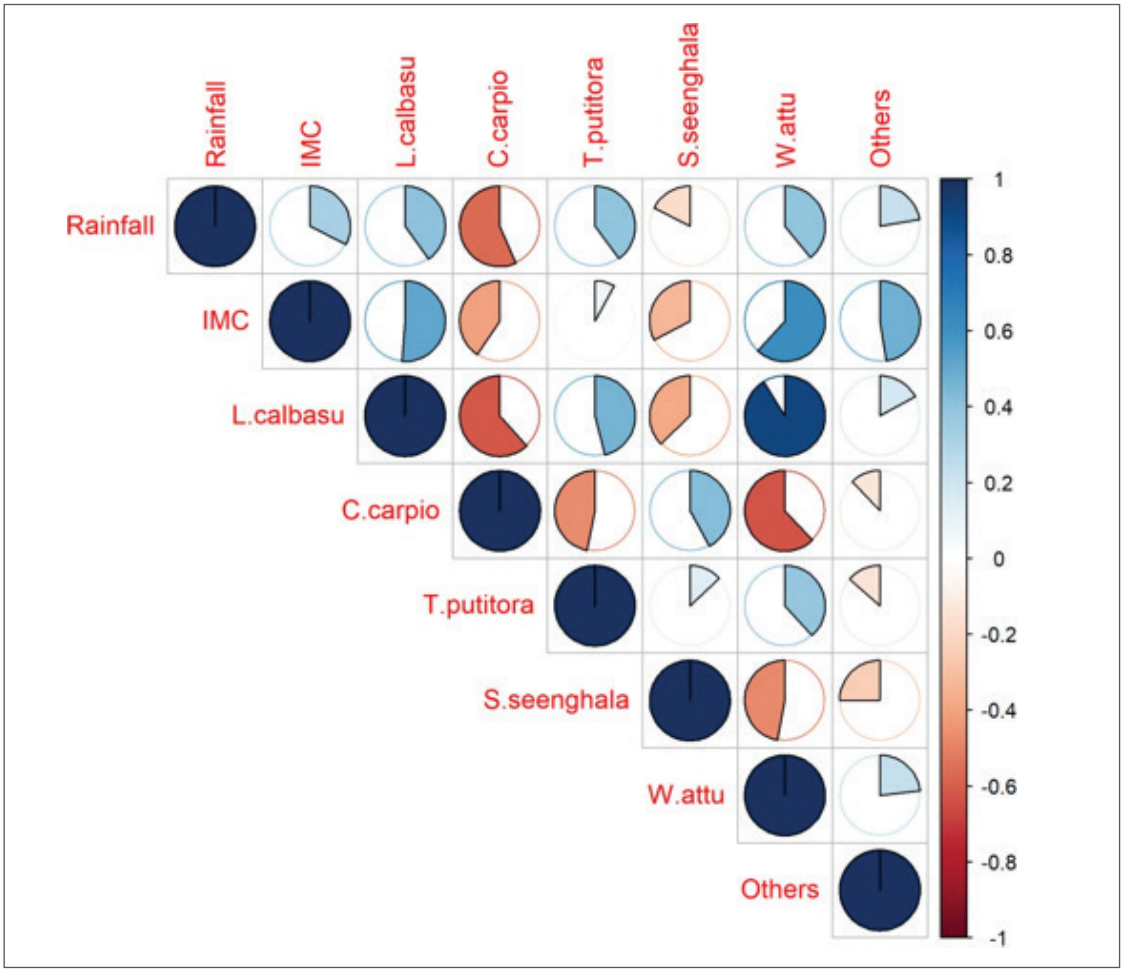


Figure 21 *Correlation matrix showing the relationship between rainfall and species-wise fish catch*

4.6. TROPHIC STATUS

The trophic status of Pong Reservoir was assessed on the basis of the Trophic State Index (TSI) using chlorophyll-a, Secchi depth and total phosphorus. The TSI value based on the chlorophyll-a value (35) indicated an oligotrophic nature while the TSI value based on the Secchi depth (47.6) indicated a mesotrophic nature and the TSI value based on the total phosphorus (75.4) indicated a eutrophic nature. The average Carlson Trophic State Index (52) of the three parameters indicated a meso-eutrophic nature. However, chlorophyll-a is the most reliable TSI among the three parameters. Thus, considering the chlorophyll-a value, Pong Reservoir can be considered to be in an oligotrophic state.

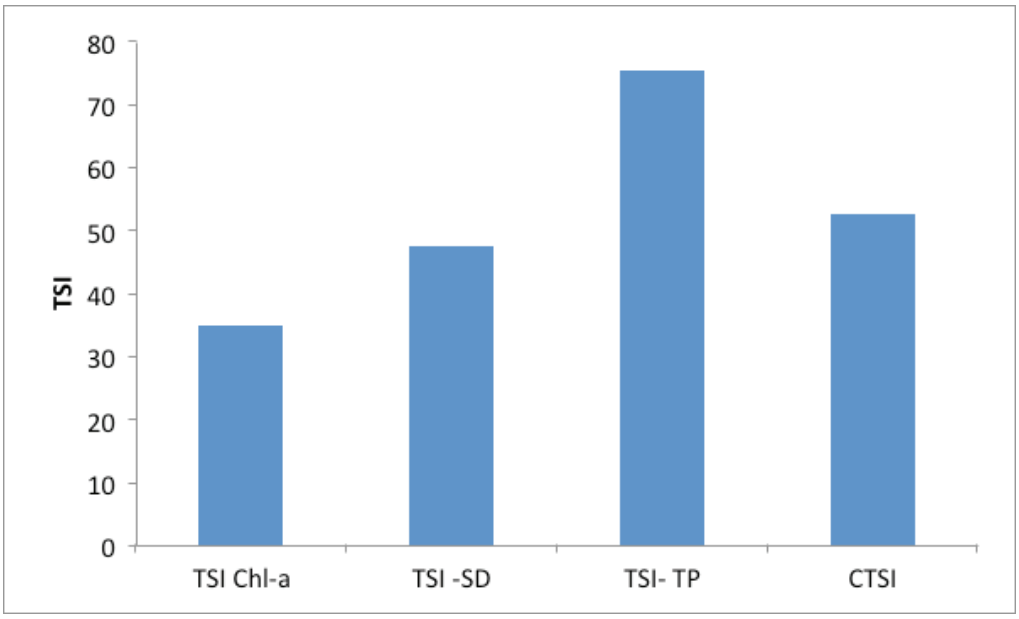


Figure 22 *Trophic State Index based on chlorophyll-a, Secchi depth and total phosphorus*

4.7. ENVIRONMENTAL PARAMETERS AND FISH ABUNDANCE

An analysis was carried out to identify the important environmental parameters influencing fish abundance. Canonical Correspondence Analysis (CCA) indicated that temperature, pH and water depth are the important parameters influencing the abundance of *Sperata seenghala,* which was the most dominant species. Important parameters influencing other fishes are conductivity, hardness, TDS, alkalinity, DO and transparency. The BIOENV (using bioenv) function of Vegan packages of R software was used to select the explanatory parameters for fish production. BIOENV indicated that the overall fish abundance was highly influenced by the combination of water depth, DO and TDS.

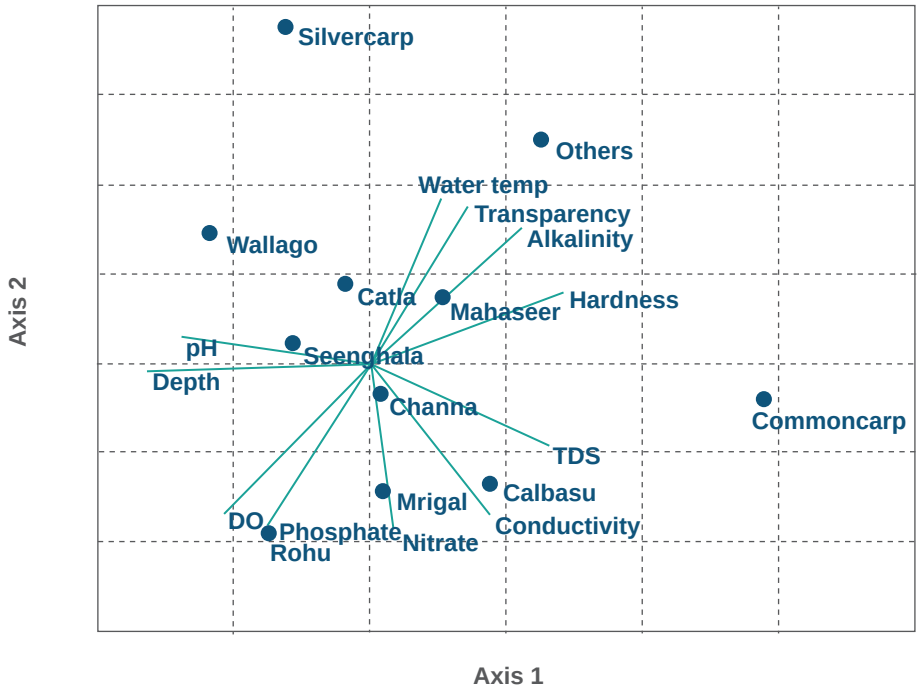


Figure 23 *Identification of important environmental parameters influencing fish abundance using CCA*

Table. 9 *Correlation of environmental parameters with fish production using BIOENV*

Parameter	Correlation
pH	0.8286
Depth Hardness	0.8286
Depth DO TDS	1.0
Depth Conductivity pH DO	0.8857
WaterTemp Depth pH DO TDS	0.9429
WaterTemp Depth Transparency pH Hardness TDS	0.9429
WaterTemp Depth Transparency pH DO Hardness TDS	0.7714
WaterTemp Depth Transparency Conductivity pH Alkalinity Hardness TDS	0.7143
WaterTemp Depth Transparency Conductivity pH DO Alkalinity Nitrate TDS	0.6
WaterTemp Depth Transparency Conductivity pH DO Nitrate Phosphate Hardness TDS	0.6
WaterTemp Depth Transparency Conductivity pH DO Alkalinity Nitrate Phosphate Hardness TDS	0.3714

4.8. FISH DIVERSITY AND ABUNDANCE

During the study period, 20 fish species from seven orders and eight families were observed in the reservoir. The order Cypriniformes (11) contributed the highest number of species, followed by Siluriformes (3), Anabantiformes (2), Perciformes (1), Gobiiformes (1), Beloniformes (1) and Synbranchiformes (1). The lentic zone (reservoir) and lotic zone contributed the highest number of species (16 species each).

The fish diversity was assessed using suitable diversity indices. The analysis indicated that the species richness index was highest in the lotic zone of the reservoir. The evenness index was highest in the lentic (dam) zone of the reservoir. The Shannon diversity index was highest in the lentic zone of the reservoir.

The most abundant fishes among the small indigenous fishes were *Salmophasia phulo, Chanda nama* and *Osteobrama cotio.* Among the commercial fishes, *Sperata seenghala* was the most dominant species. Most of the zones had very similar fish abundance patterns as per MDS; however, the lotic and lentic (dam) zones had closer fish abundance patterns, and the lentic (reservoir) zone and the intermediate zone had even closer patterns.

Table 10 *Fish species abundance patterns in different zones of Pong Reservoir*

Order	Family	Species	Common name	Lotic	Interm ediate	Lentic (Dam)	Lentic (Res)
Cypriniformes	Cyprinidae	*Labeo catla*	Catla	1	0	1	1
		Labeo rohita	Rohu	1	1	1	1
		Cirrhinus mrigala	Mrigal	1	1	2	1
		Labeo calbasu	Calbasu	0	0	1	1
		Cyprinus carpio	Common Carp	1	1	1	0
		Tor putitora	Golden Mahaseer	1	1	2	1
		Hypophthalmichthys molitrix	Silver Carp	1	0	0	0
		Systomus sarana	Olive Barb	3	16	6	13
		Putius sophore	Spotfin Swamp Barb	7	2	8	10

Order	Family	Species	Common name	Lotic	Interm ediate	Lentic (Dam)	Lentic (Res)
Cypriniformes	Cyprinidae	*Salmophasia phulo*	Fine Scale Razorbelly Minnow	12	24	12	19
		Osteobrama cotio	Cotio	10	20	9	21
Siluriformes	Siluridae	*Wallago attu*	Helicopter Catfish	1	0	0	0
		Ompok pabda	Two Stripe Gulper Catfish	2	4	4	5
	Bagridae	*Sperata seeenghala*	Giant river-Catfish	0	1	0	0
Perciformes	Ambassidae	*Chanda nama*	Elongate Glassy Perchlet	18	12	15	18
Gobiifor mes	Gobiidae	*Glossogobius giuris*	Tank Goby	1	2	1	4
Belonifor mes	Belonidae	*Xenentodon cancila*	Freshwater Needle Fish	0	1	1	1
Synbranc hiformes	Mastacemb elidae	*Mastacembelus armatus*	Zig-zag Eel	1	0	0	1
Anabantif ormes	Channidae	*Channa marulius*	Bullseye Snakehead	0	1	0	1
		Channa punctatus	Spotted Snakehead	1	1	0	1

Image 7 *Small indigenous fish catch in Pong R- eservoir*

Plate 8 *Experimental fishing in lentic (dam) zone of Pong Reservoir*

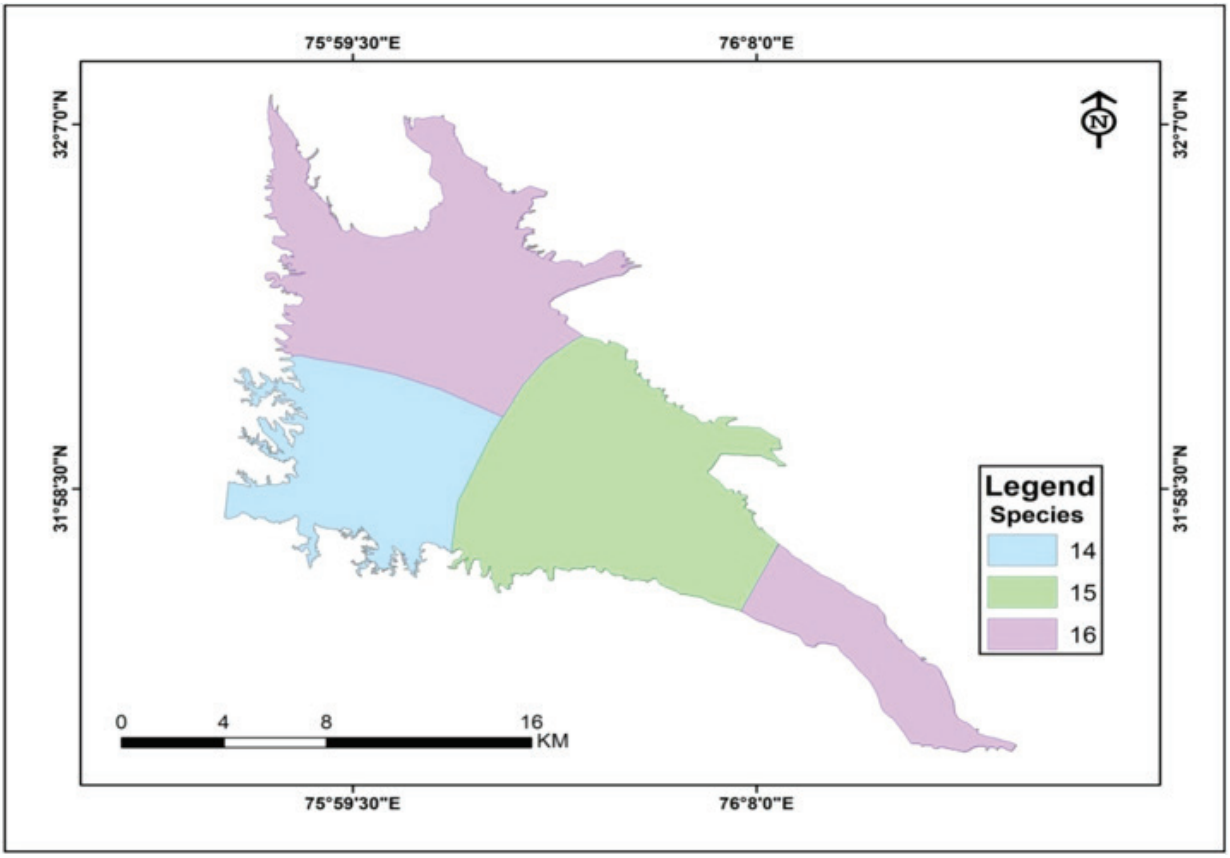


Figure 24 *Number of fish species (in different colours) in the lotic, transitional, lentic (dam), and lentic (reservoir) zones of the reservoir*

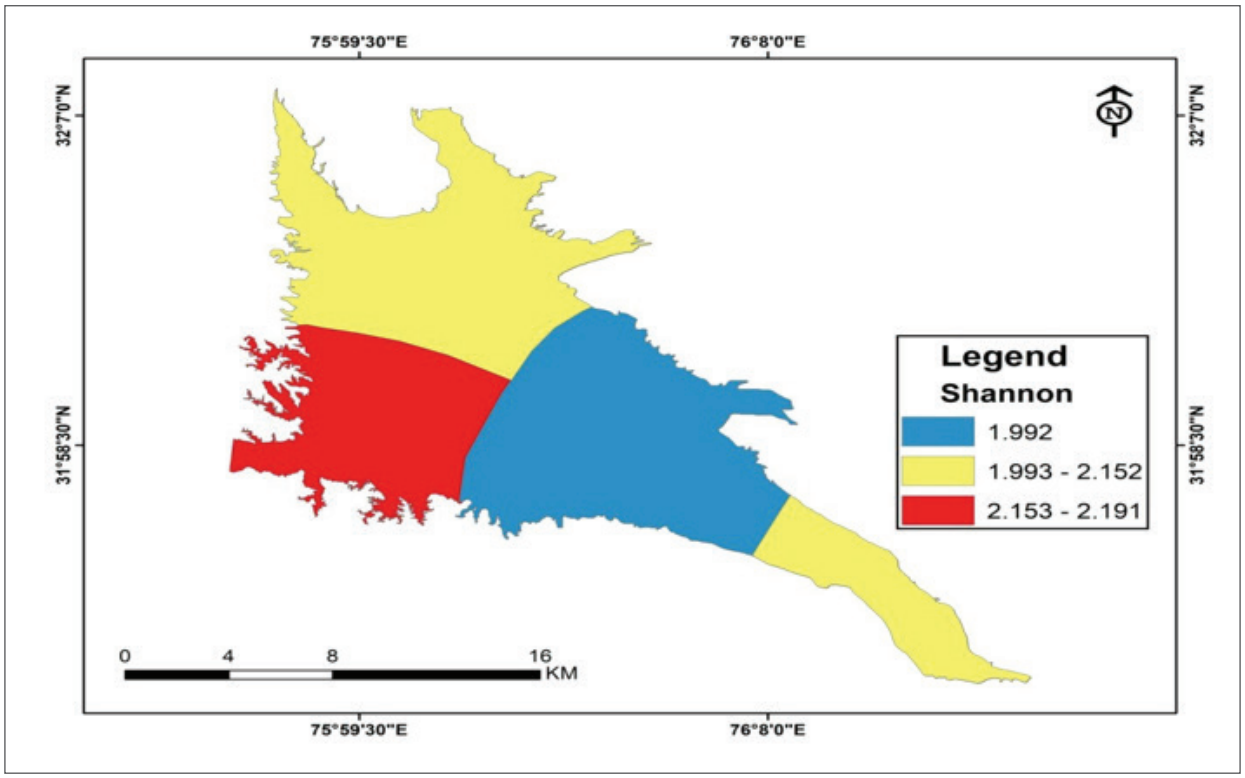


Figure 25 *Fish diversity index (Shannon) of the lotic, transitional, lentic (dam) and lentic (reservoir) zones of Pong Reservoir*

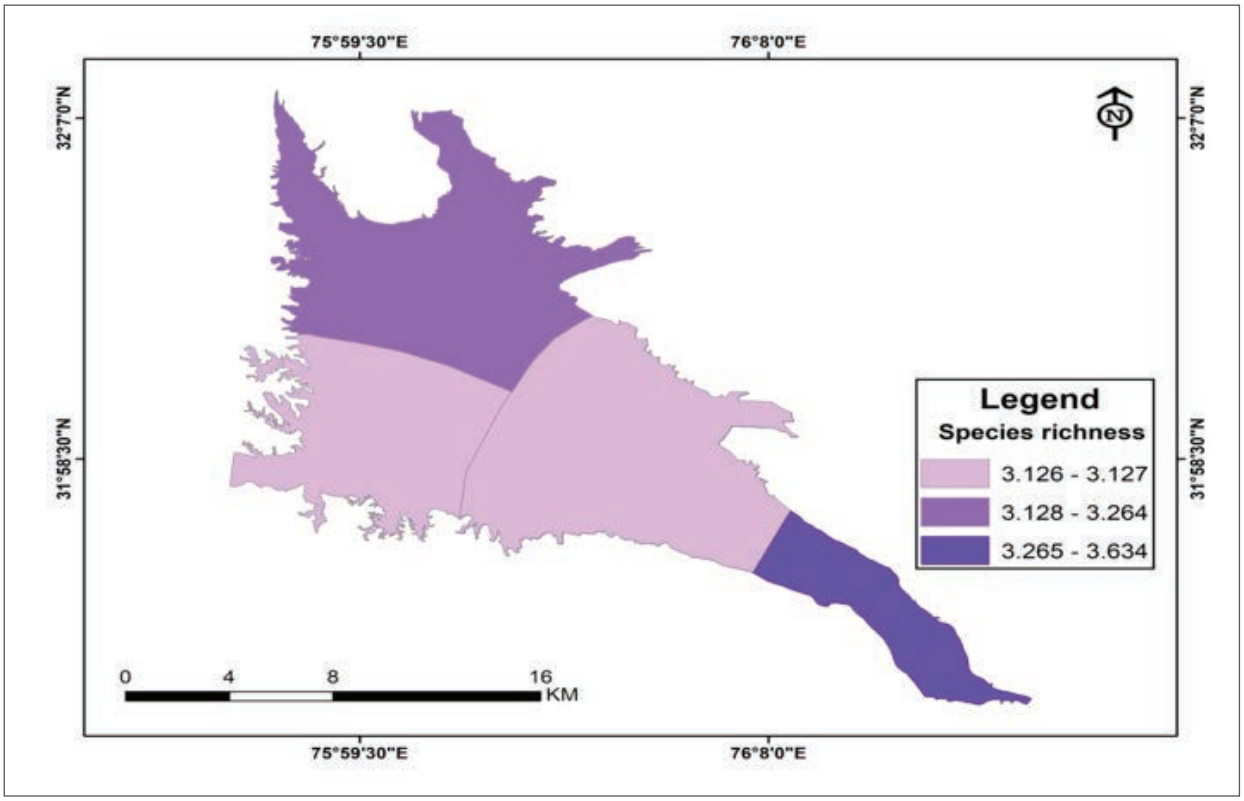


Figure 26 *Fish richness index of the lotic, transitional, lentic (dam) and lentic (reservoir) zones of Pong Reservoir*

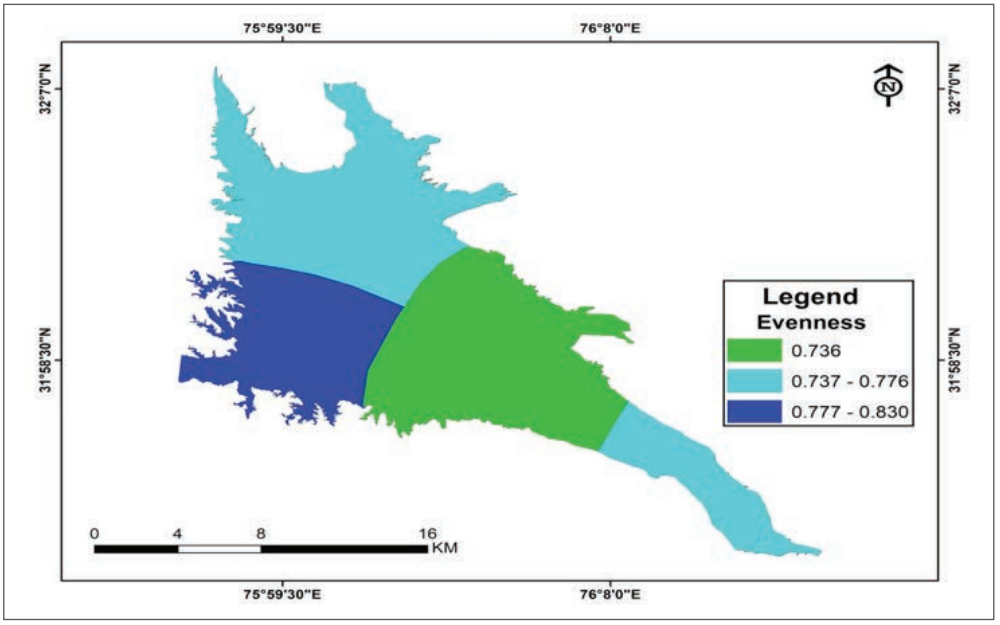


Figure 27 *Fish evenness index of the lotic, transitional, lentic (dam) and lentic (reservoir) zones of Pong Reservoir*

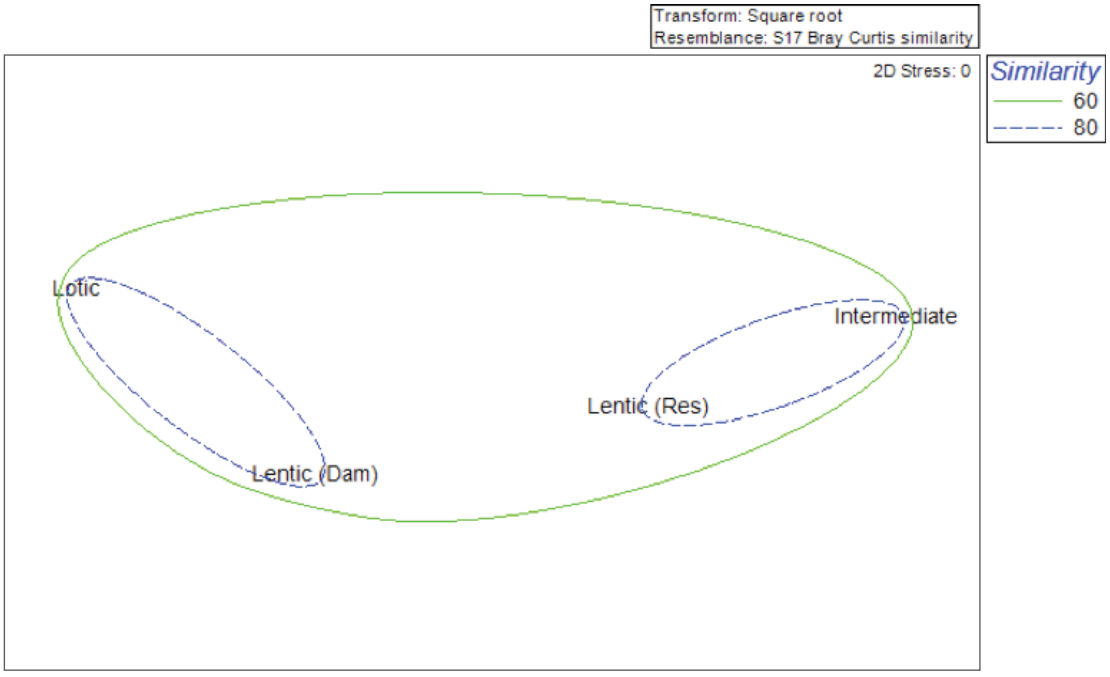


Figure 28 *Fish abundance pattern in lotic, lentic (dam), lentic (reservoir) and transitional zones of Pong Reservoir using MDS*

The decadal trend of fish diversity in Pong Reservoir during 1990–95 (CIFRI, 2007) to 2014 (Jindal et al., 2014), and the present (2020) were assessed. During 1990–95, a total of 34 species were recorded in 7 orders (Osteoglossiformes, Cypriniformes, Siluriformes, Anabantiformes, Perciformes, Gobiiformes and Synbranchiformes) and 11 families (Notopteridae, Cyprinidae, Botiidae, Nemacheilidae, Bagridae, Siluridae, Sisoridae, Channidae, Ambassidae, Gobiidae and Mastacembelidae). In 2014 the number of species were reduced to 28, in 5 orders (Cypriniformes, Siluriformes, Anabantiformes, Synbranchiformes and Beloniformes) and 9 families (Cyprinidae, Botiidae, Nemacheilidae, Bagridae, Siluridae, Sisoridae, Channidae, Mastacembelidae and Belonidae). The number of species were further reduced to 20 during the present study.

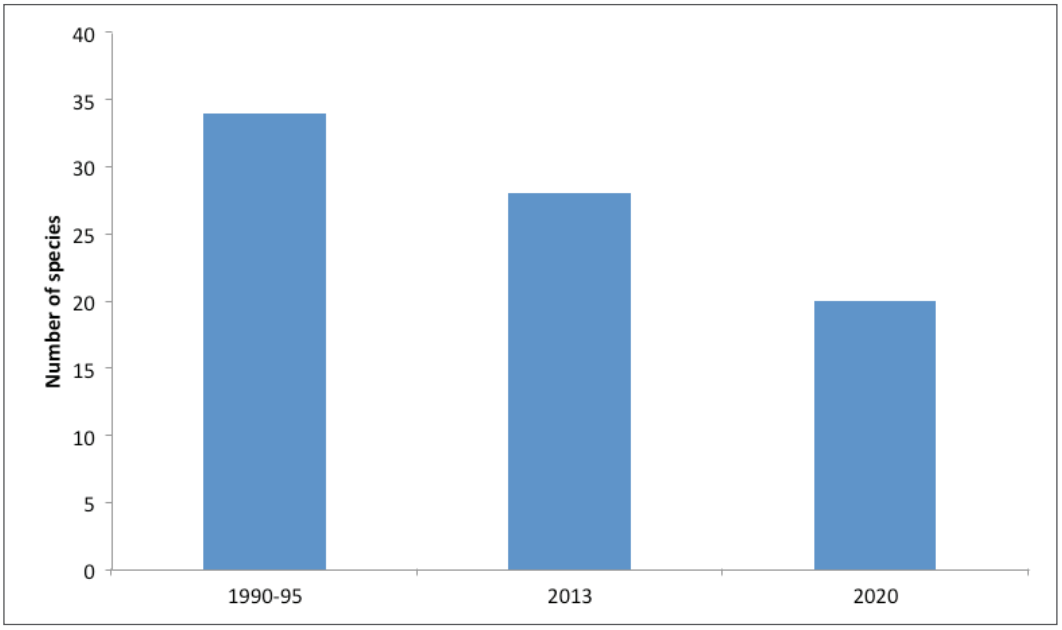


Figure 29 *Decadal trend of fish species richness in Pong Reservoir (1990–95, 2013 and 2020) on the basis of the available data*

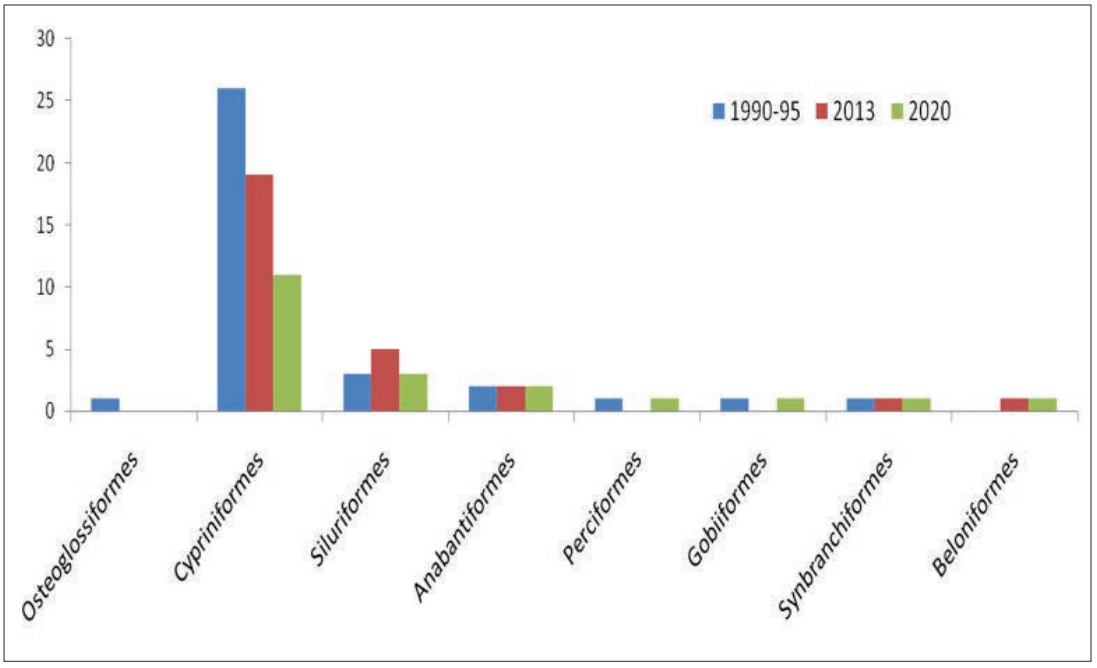


Figure 30 *Decadal trend of fish diversity (order-wise) in Pong Reservoir (1990–95, 2013 and 2020) on the basis of the available data*

4.9. FISH BREEDING GROUNDS

Six actual breeding grounds of IMC, *Sperata seenghala, Tor putitora,* etc. were identified by fisheries officials and fishermen. The breeding grounds are located near the sites where streams and small rivers (locally known as khads) flow into the reservoir. These sites have moderate water flows during the monsoon, which is the critical habitat parameter for the breeding of fish. Apart from the actual breeding grounds, six sites were identified as probable fish breeding places, where streams flow into the reservoir.

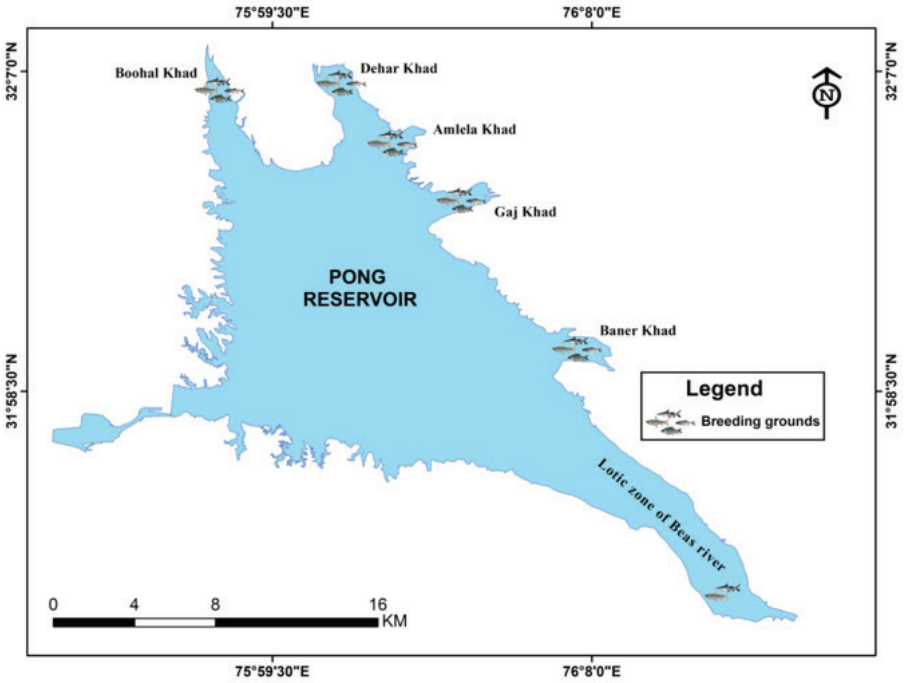


Figure 31 *Breeding ground of fishes in Pong Reservoir*

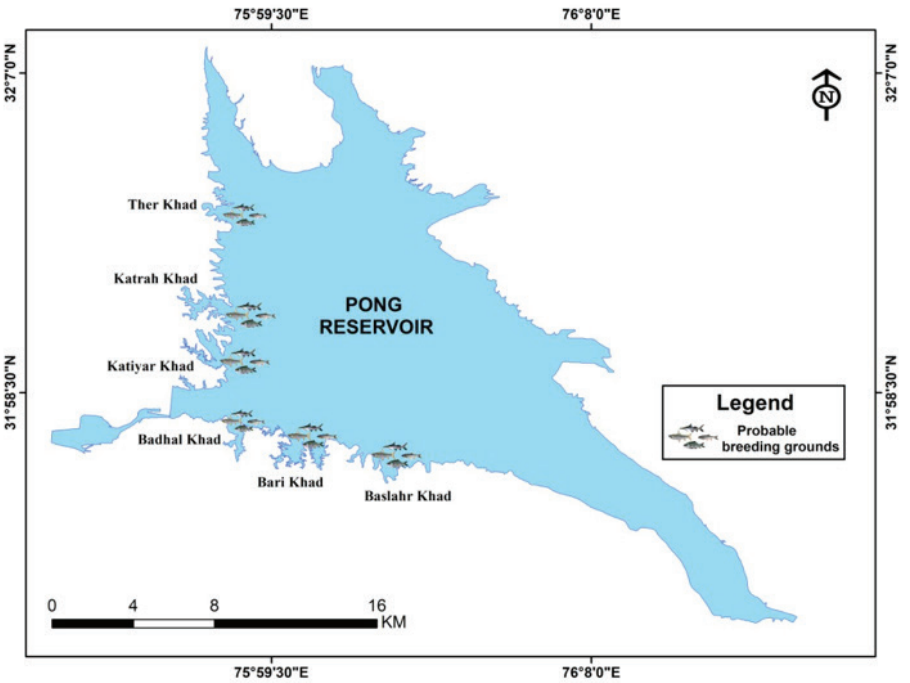


Figure 32 *Probable breeding grounds identified in Pong Reservoir*

4.10. CURRENT STATUS OF COMMERCIAL FISHING

Fishing was done commercially at 15 landing centres by the cooperative societies, covering the entire reservoir. The fish landings were comparatively higher at Dehra, Nagrota Suriyan, Katihar, Haripur and Barnali. The majority of the fish catch was contributed by the catfish *Sperata seenghala* at all the landing centres except Sathana, where *Cyprinus carpio* was the major fish catch.

Table 11 *Fish landing centres along with GPS co-ordinates*

Sl. No.	Landing Centre	District	Latitude (°N)	Longitude (°E)
1	Dehra	Kangra, HP	31.87296	76.22098
2	Haripur	Kangra, HP	32.005509	76.162191
3	Nandpur	Kangra, HP	32.013779	76.115132
4	Nagrota Surian	Kangra, HP	32.054534	76.090811
5	Harsar	Kangra, HP	32.104934	76.037249
6	Jawali	Kangra, HP	32.133565	76.007119
7	Guglara	Kangra, HP	32.088333	75.999476
8	Sihal	Kangra, HP	32.075169	75.960741
9	Dhametha	Kangra, HP	32.042447	75.964673
10	Katiyar	Kangra, HP	31.992372	75.943919
11	Sathana	Kangra, HP	31.967093	75.926582
12	Badnali	Kangra, HP	31.958704	75.961696
13	Seul Khad	Kangra, HP	31.919918	76.0499
14	Dadasiba	Kangra, HP	31.930024	76.090556
15	Jambal	Kangra, HP	31.927092	76.09719

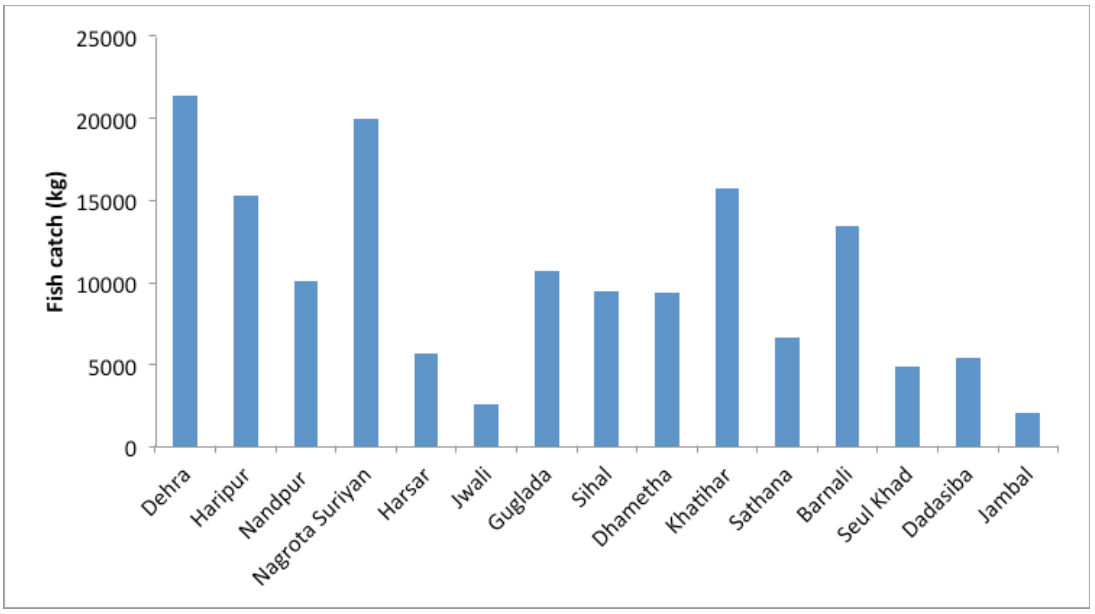


Figure 33 *Landing centre-wise (15 landing centres) fish production pattern in 2020 (Source: DoF, HP)*

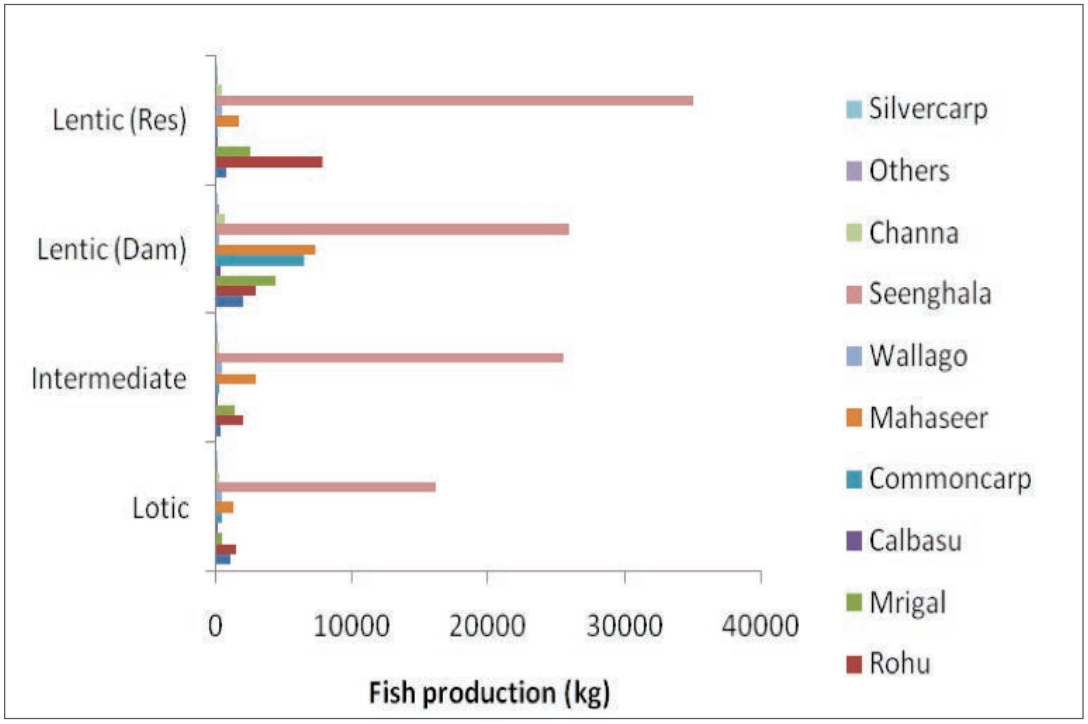


Figure 34 *Species-wise fish catch from different zones of Pong Reservoir in 2020 (Source: DoF, HP)*

The seasonal fish catch pattern was studied to determine the pattern of the fish abundance variation in the reservoir. The fish abundance pattern indicated that *Sperata seenghala* was the species that contributed the most to the fish caught in all the seasons. The abundance of *Sperata seenghala* was higher in most of the zones of the reservoir. IMC also contributed the most to the fish catch next to *Sperata seenghala.* IMC was observed at all the landing centres as well as during all the seasons. *Tor putitora* (Mahaseer) is also one among the species that contributes the most to the fish catch in the reservoir. Mahaseer was observed in all the seasons in each fish landing centre. The other important fish species contributing to the fish catch were *Cyprinus carpio, Wallago attu* and *Labeo calbasu.* The landing centres at Dehra Haripur, Nagrota Suriyan, Kathihar and Barnali had greater fish landings compared with the other fish landing centres. The average size of the fish in the catch ranged from 1 kg to 11.5 kg. Seenghala and Common Carp had the smallest average size, and Catla and Silver Carp had the larger average sizes

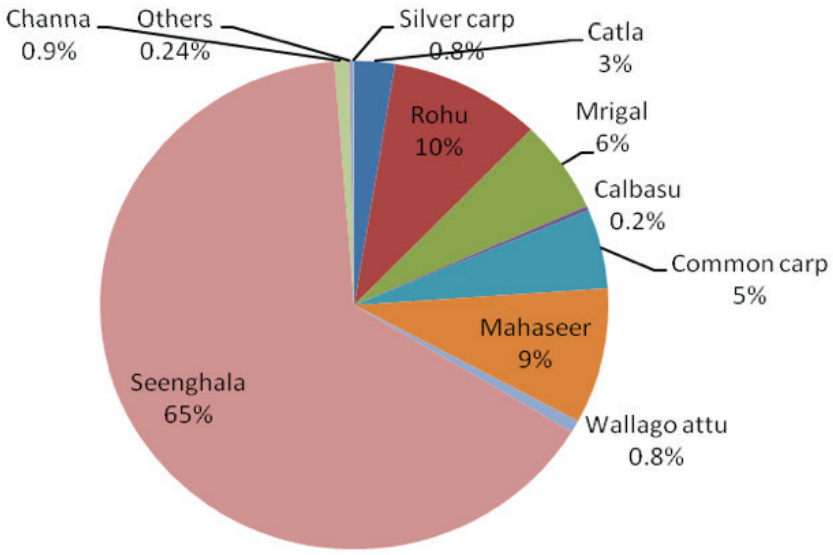


Figure 35 *Species-wise fish catch composition (%) in Pong Reservoir (Source: DoF, HP)*

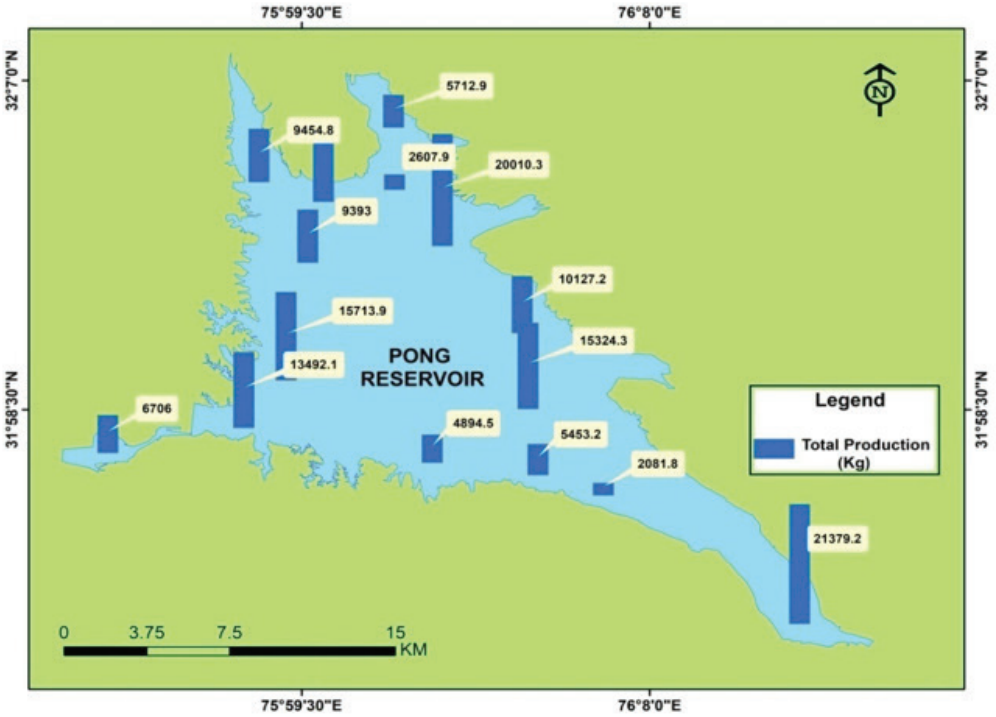


Figure 36 *Fish production (kg) at 15 fishing zones reservoir*

Table 12 *Species-wise average size of fish catch (kg) during 2020*

Species	Average size of fish catch (kg)
Labeo catla	11.5
Labeo rohita	4.4
Cirrhinus mrigala	1.5
Labeo calbasu	1.8
Cyprinus carpio	1
Tor putitora	1.6
Wallago attu	3.2
Sperata seenghala	1
Channa marulius	1.6
Hypophthalmichthys molitrix	7.7

Image 9 *Fish caught at Pong Reservoir*

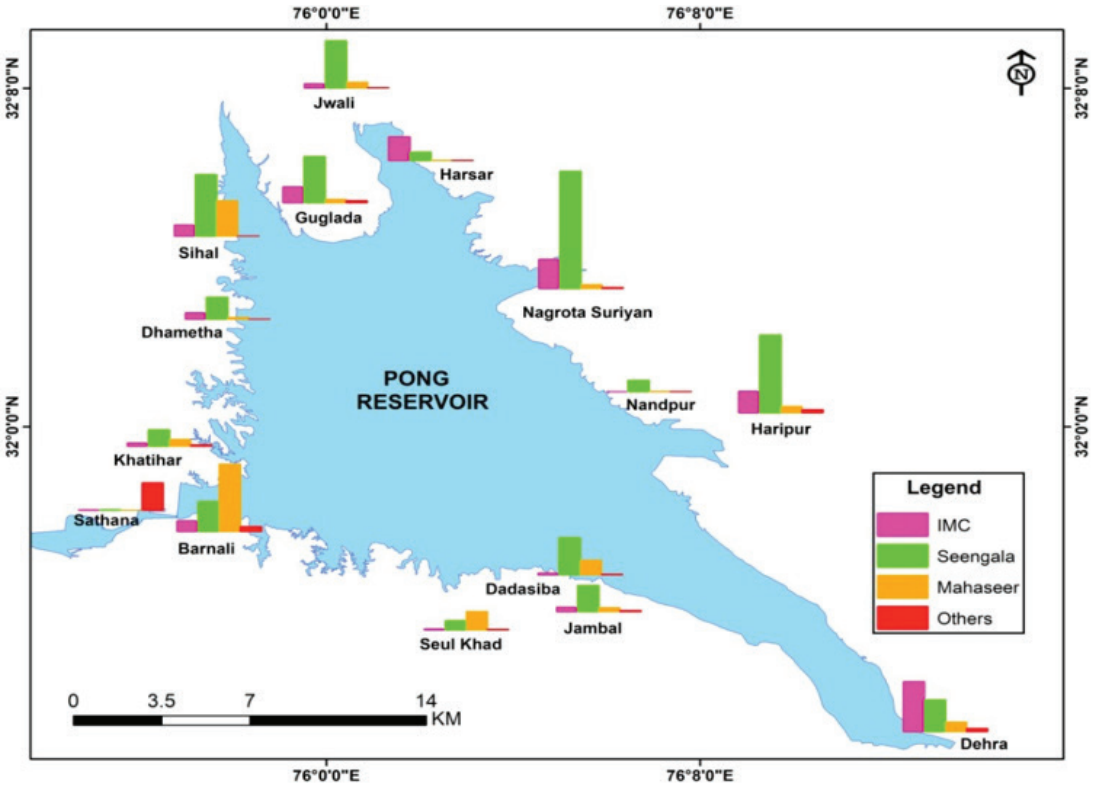


Figure 37 (a) *Fish catch composition (IMC, Seenghala, Mahaseer and others)during the pre-monsoon season*

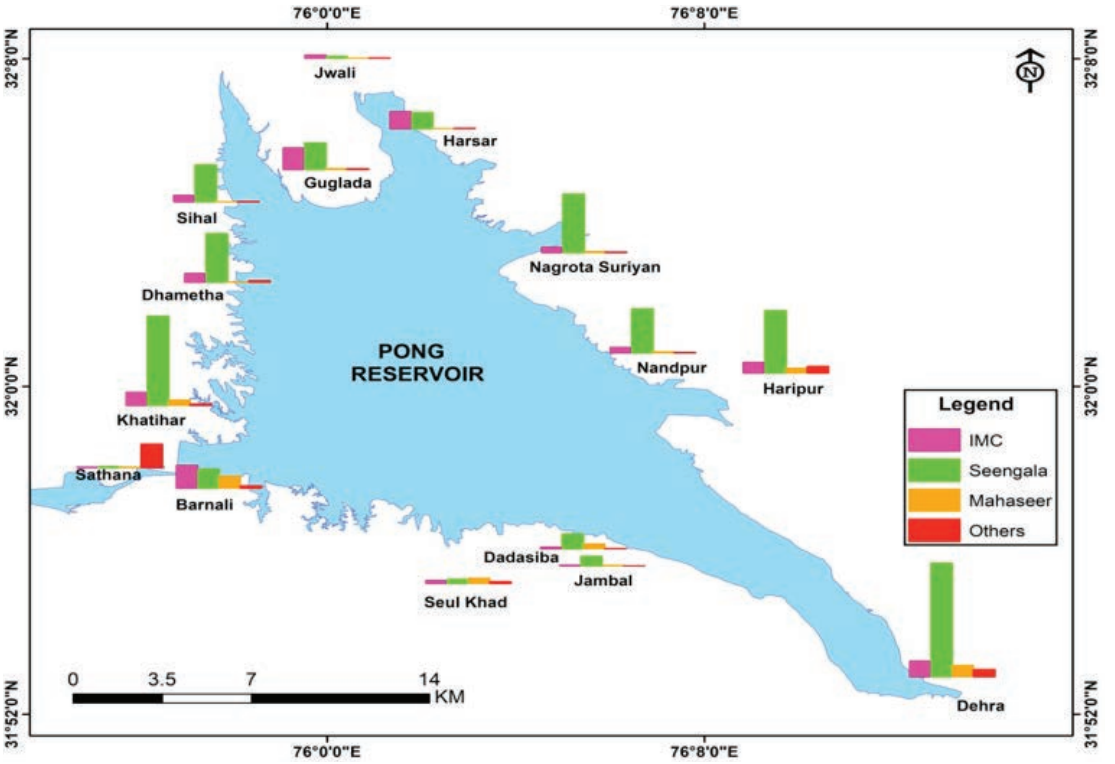


Figure 37 (b) *Fish catch composition (IMC, Seenghala, Mahaseer and others) during the monsoon season*

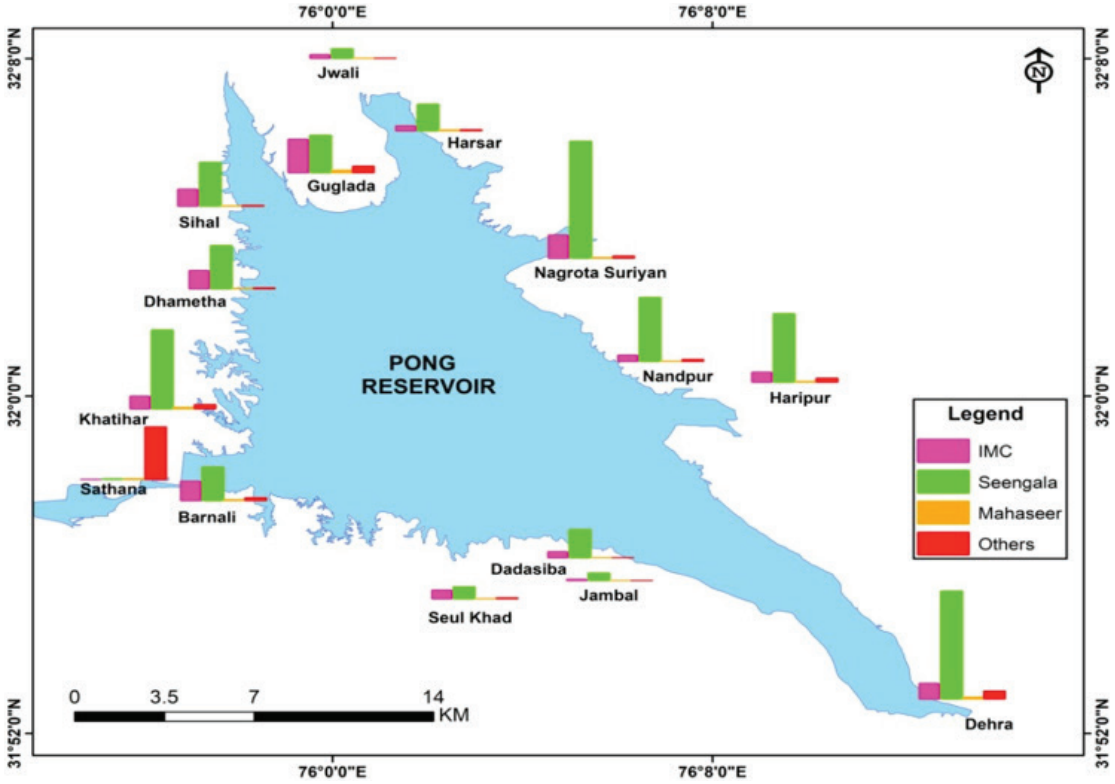
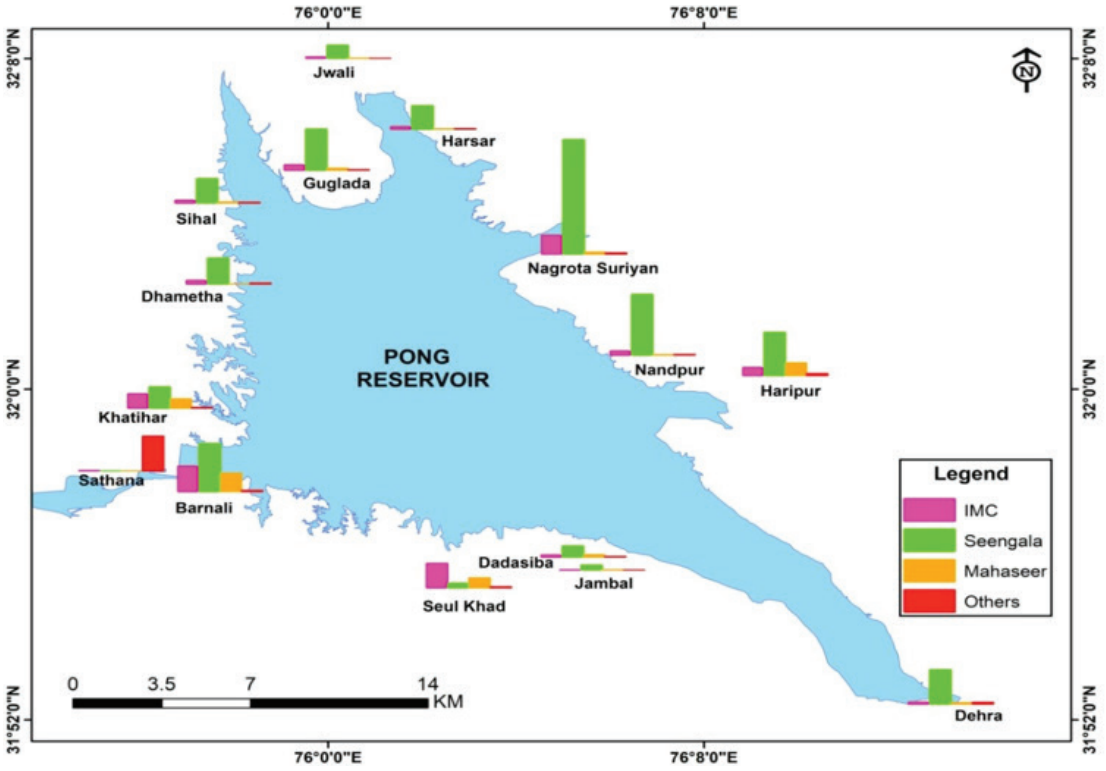


Figure 37 (c) *Fish catch composition (IMC, Seenghala, Mahaseer and others) during the post-monsoon season*



(d)

Figure 37 (d) *Fish catch composition (IMC, Seenghala, Mahaseer and others) in winter*

4.11. FISH PRODUCTION POTENTIAL ESTIMATION

Various models have been used to derive the fish production potential of this ecotope, but mostly the results are not conclusive barring the algal biomass model (Waldichuk, 1958; Rodhe, 1958). The estimated potential fish yield is of the order of 132–156 kg/ha/year (average 140 kg/ha/year) on the basis of the algal biomass model, which is very modest for this ecosystem.

Though the reservoir is a catfish reservoir, building up the stock of IMC also is necessary to utilise the unutilised ecological niches so as to enhance the fisheries in a modest way. The present fish yield is hovering at around 20–24 kg/ha/year, which could be enhanced to at least 50 kg/ha/year if a sound and sustained stocking programme is followed, coupled with other management protocols. The stocking size of IMC fingerlings should not be below 100 mm. Each hectare has to be stocked with 300 fingerlings every year, with Catla, Rohu and Mrigal in the ratio 30:50:20 for the fisheries in this reservoir to be enhanced.

4.12. MAXIMUM SUSTAINABLE YIELD

The maximum sustainable fish yield was assessed using the time series data of the fish yield and the fishing effort data. The fishing effort was calculated on the basis of the number of fishers given licenses to fish in the reservoir each year. Each licensed person was allowed to operate two gill nets in the reservoir any day except during the ban (15 June to 15 August). The Schaefer and Fox model of surplus production was used to estimate the MSY in the reservoir. The estimated value of the MSY according to the Schaefer model was 29 kg/ha/year, and the optimum fishing effort (fMSY) was 67 gill nets per hectare per year. According to the Fox model the MSY was 26 kg/ha/year, and the optimum fishing effort (fMSY) was 60 gill nets per hectare per year.

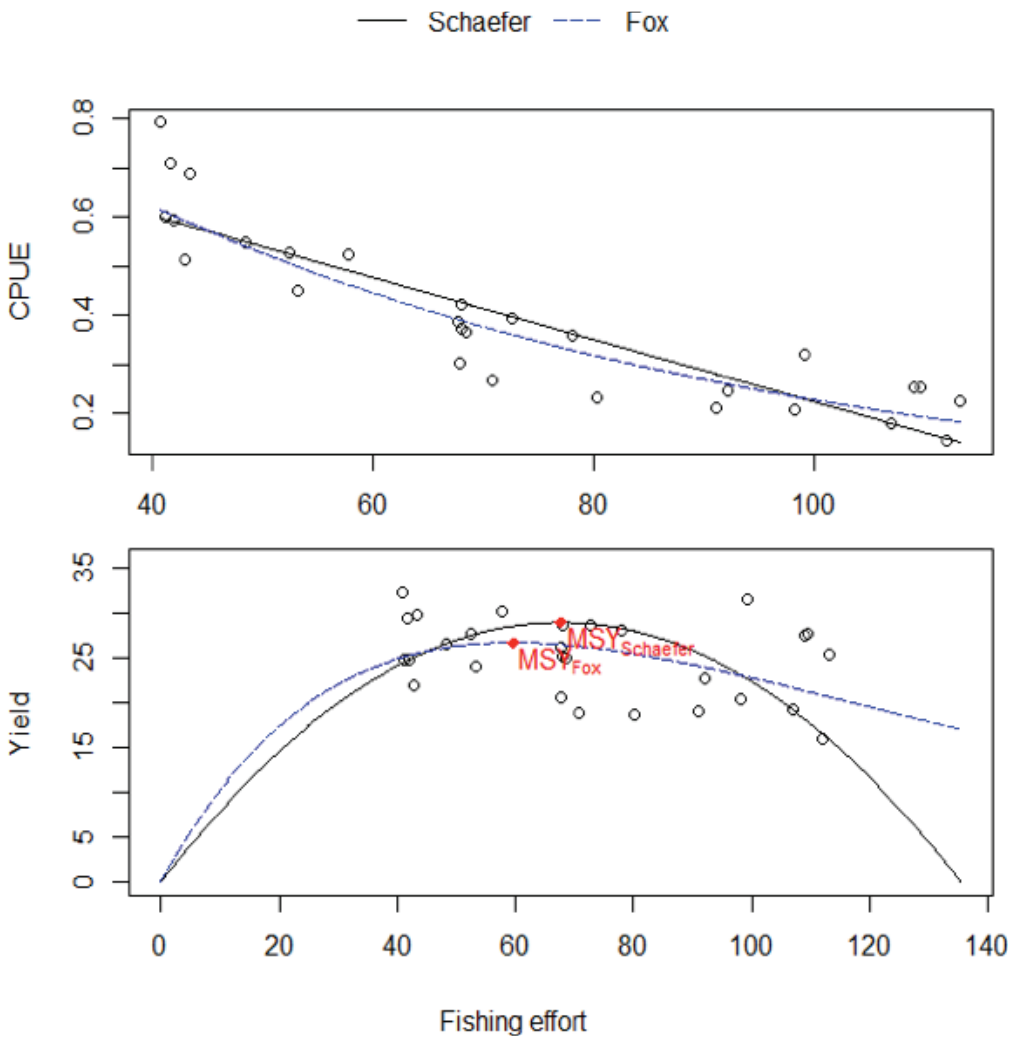


Figure 38 *MSY estimation using the Schaefer model (MSY, 29 kg/ha/year; fMSY, 67 nets/ha/year) and the Fox model (MSY, 26 kg/ha/year; fMSY, 60 nets/ha/year) on the basis of the fish yield and effort data for the years from 1987–88 to 2019–2020*

4.13. CURRENT MODES OF FISHING AND FISHING ZONES

The fisheries in Pong Reservoir are under the control of the Department of Fisheries, HP. Licences were given to the fishermen at each landing centres for fishing in a particular area of the reservoir. Each license holder has the right to operate two gill nets of 80 m length each day. Gill nets are the only fishing gear operated for commercial fishing in Pong Reservoir. Gill nets are operated throughout the reservoir by the fishermen except during the fishing ban (15 June to 15 August). The reservoir is divided into different fishing zones, and there are 15 cooperative societies that carry out fishing using gill nets. Rod and line fishing (angling) is also carried on as a sport fishery in six areas of the reservoir.

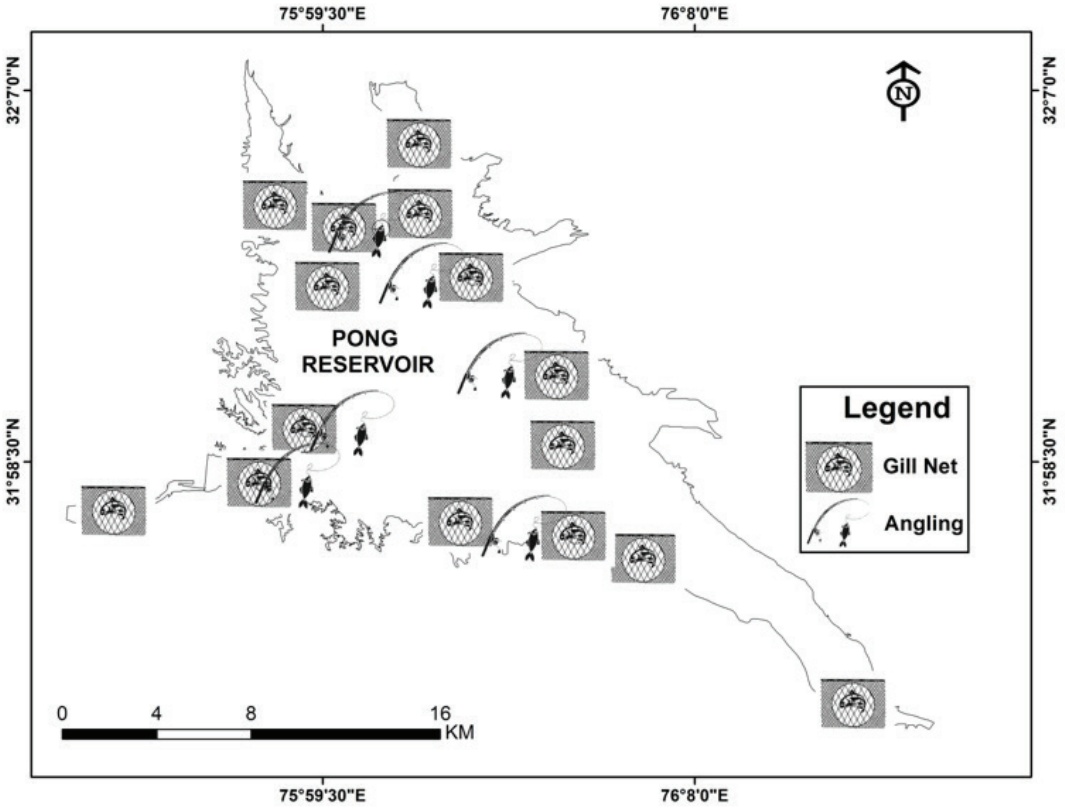


Figure 39 *Fishing gear (gill net and rod and line) operation in different fishing zones of Pong Reservoir*

Image10 *Gill net operated in Pong Reservoir*

5 Socio-economic condition of fishers

Sampling methodology

There are 15 landing centres around the reservoir from where fish are disposed of by fishers: Dehra, Haripur, Nandpur, Nagrota Surian, Harsar, Jawali, Guglara, Sihal, Dhametha, Katiyar, Sathana, Badnali, Seul Khad, Dadasiba and Jambal. Each of the landing centres has its own primary fishermen's cooperative society, with a registered number of members. **The following are the 15 primary fishermen's cooperative societies of the reservoir:**

i. Dehra Primary Fishermen Co-operative Society
ii. Haripur Primary Fishermen Co-operative Society
iii. Nandpur Primary Fishermen Co-operative Society
iv. Nagrota Surian Primary Fishermen Co-operative Society
v. Harsar Primary Fishermen Co-operative Society
vi. Jawali Primary Fishermen Co-operative Society
vii. Guglara Primary Fishermen Co-operative Society
viii. Sihal Primary Fishermen Co-operative Society
ix. Dhametha Primary Fishermen Co-operative Society
x. Katiyar Primary Fishermen Co-operative Society
xi. Sathana Primary Fishermen Co-operative Society
xii. Badnali Primary Fishermen Co-operative Society
xiii. Seul Khad Primary Fishermen Co-operative Society
xiv Dadasiba Primary Fishermen Co-operative Society
xv. Jambal Primary Fishermen Co-operative Society

Image 11 *Data collection at office of fishermen's co-operative society (Katiyar) at Pong Reservoir*

A total of 3991 fishers are registered with the fishermen's cooperative societies for fishing in the reservoir. If any of the members would like to fish in their particular demarcated area in the reservoir, they have to buy a fishing license from the State Department of Fisheries (₹100 for one year). At present, there are 2995 license holders in the reservoir. Landing centres such as Guglara, Sihal and Dhametha have also got female fishing license holders. Among the license holders, only a selected numbers of fishers are actively involved in fishing.

Individual interviews were conducted with active fishers who were chosen randomly from each landing centre. The respondents were first selected according to their status of membership in the cooperative society. The respondents were then categorised according to their fishing license possession and then chosen randomly. Therefore, the respondents were chosen first purposively and then through stratified random sampling.

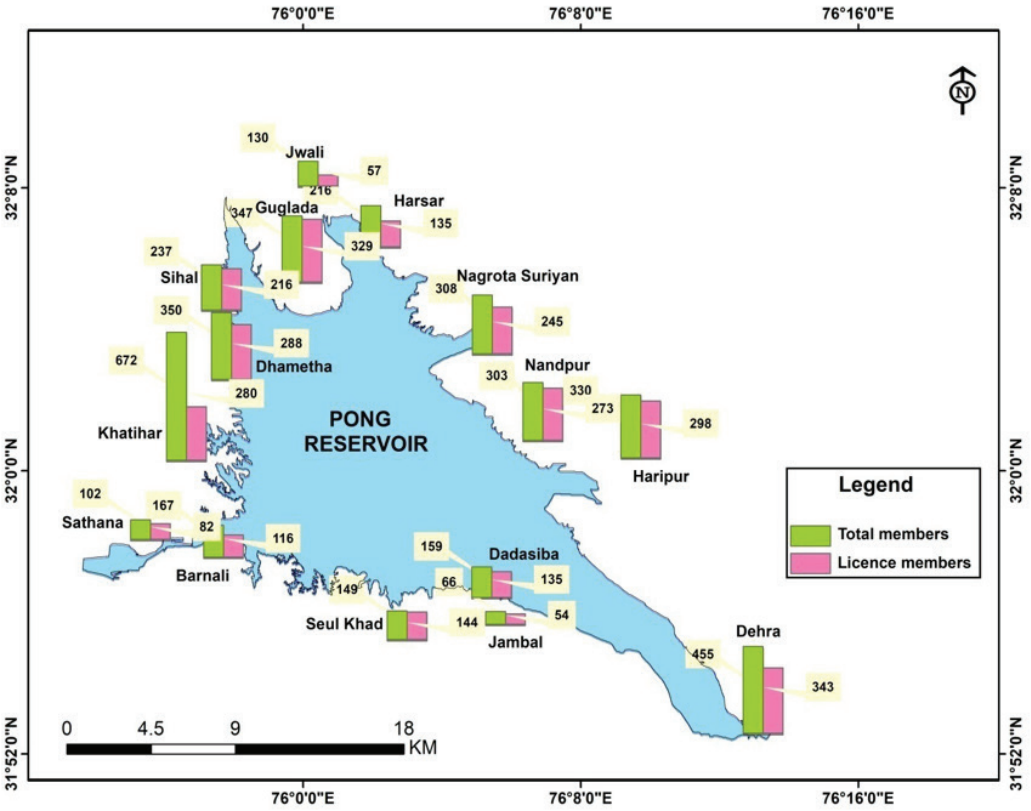


Figure 40 *Total numbers of members of cooperative societies and numbers of members licensed to fish*

Household size

The average family size overall is 4.7, ranging from 2 to 11 members in a household. The highest family size (5.33 family members) is in Guglara, and the lowest (4.2) is in Nagrota Surian.

Age distribution of household heads

The average age of the respondents is 47.02 years, with an overall range of 24–70 years. 25.56% of the household members are children, and 51.5% are female members. The most elderly population of fishers is at the landing centre of Dadasiba, and the youngest population is at Seul Khad.

Education of household head

Overall, the most common level of education attained by the household heads was the secondary level of education, with schooling up to standard VI to standard X (47%), whereas 16% of the heads had received no formal school education. The highest number of people with no formal education was found at the landing centre of Sathana,

whereas there were no illiterate respondents at the landing centres of Dehra and Nagrota Surian. The household heads of Haripur (47%) and Nandpur (47%) were the ones with the highest literacy attainment of higher secondary education (standard XI and standard XII).

Occupation of household head

The primary occupation of all the household heads is fishing. The types of secondary occupation of 94% of the surveyed household heads are labour, agriculture and shopkeeper. 48% of the household heads are engaged as daily wage labourers for their secondary occupation, 41% are engaged in agriculture, 2% are engaged in both agriculture and as labourers, 1% are shopkeepers, and 2% are engaged in other avocations. 73% of the household heads in Nagrota Surian are engaged as daily wage labourers for their secondary occupation. 67% of the household heads each in Jawali and Stahana are engaged as daily wage labourers for their secondary occupation. 67% of the household heads are engaged in agriculture in Khatiyar and Seul Khad for their secondary occupation.

Housing and basic facilities

56% of the respondents live in *pucca* (concrete) houses, and 26% live in *kuchha* houses. The remaining respondents have semi-*pucca* type houses. Harsar, Dadasiba, and Jambal have the highest numbers of concrete (*pucca*) houses, while Khatiyar has the highest number of *kuchha* houses. All the houses use electricity as their source of energy for lighting. For cooking, gas (LPG connection) is commonly used in houses (92%), followed by both gas and wood (5%) and the remaining 3%, use only wood for cooking. All the fishers surveyed, use water from public taps installed in their villages by the government for drinking and daily use. 82% of the houses have properly built concrete facilities for toilets, and the rest do not have hygienic facilities.

Ownership of assets

Amidst the overall respondents 59% possess fridges and 37% television sets. For transportation and commutation, 57% of the respondents possess motorbikes. The ownership of assets by landing centre has been shown separately (Table 5). Television sets are the most common assets possessed by the fishers.

Household income and expenditure

The average monthly household income is ₹6,367. The highest monthly household income is in Seul Khad (₹8827), and the lowest is in Jambal (₹5480). The overall average monthly income from fishing as the primary occupation is ₹5192, and that from the secondary occupation is ₹1175. The fishers of the landing centre at Badnali have the highest income from fishing as the primary occupation (₹7600). The Dehra fishers earn the most from the secondary occupation (₹1573). 11% of the overall respondents have taken loans ranging from ₹10,000 to ₹1,00,000 from formal or informal sources.

The major item of expenditure overall is food (68%), as is expected from families dependent on natural resources such as fisheries for their livelihood. This is followed by expenditure on clothing, education and energy sources for cooking.

Fisheries as livelihood

Catfish, Indian Major Carps, exotic carps, and other minor carps are the most commonly caught species. The harvested fish is first disposed of at the primary fishermen's cooperative societies by auction to local sellers at wholesale rates. These local sellers then channel the fish to retail sellers of other states (Punjab, Jammu and Kashmir and Delhi). The proceeds of the sale is shared by the state government (15% fixed), primary fishermen's cooperative society and fishers. The fish fetch higher prices in winter than in the monsoon and summer. The average share of the cooperative societies is 5% of the sale price and that of the fishers is 80%.

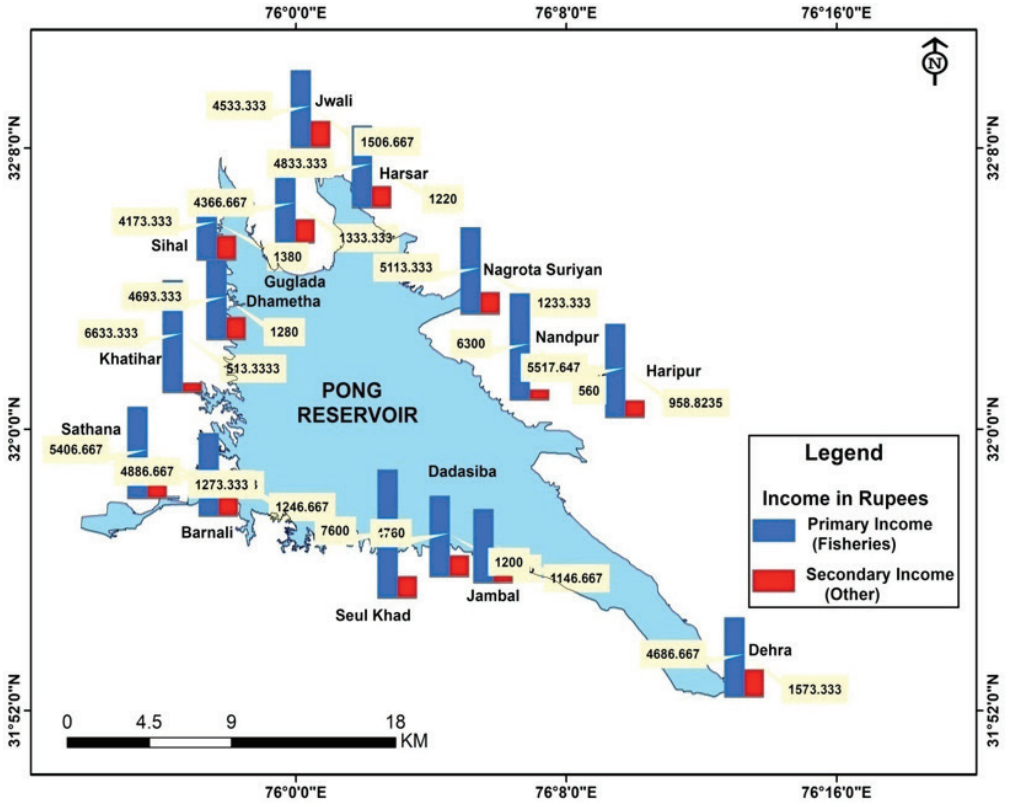


Figure 41 *Income pattern of the fishermen of 15 landing centres*

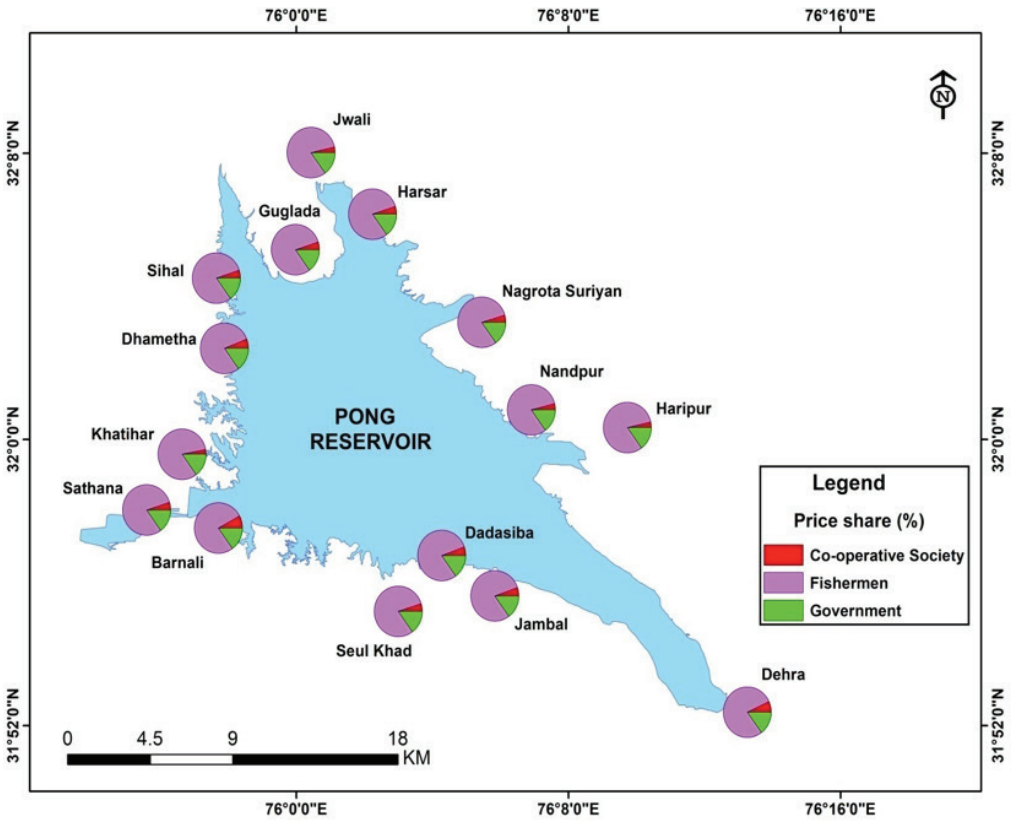


Figure 42 *Sharing pattern of the price of the fish among the cooperative societies, fishermen and the government*

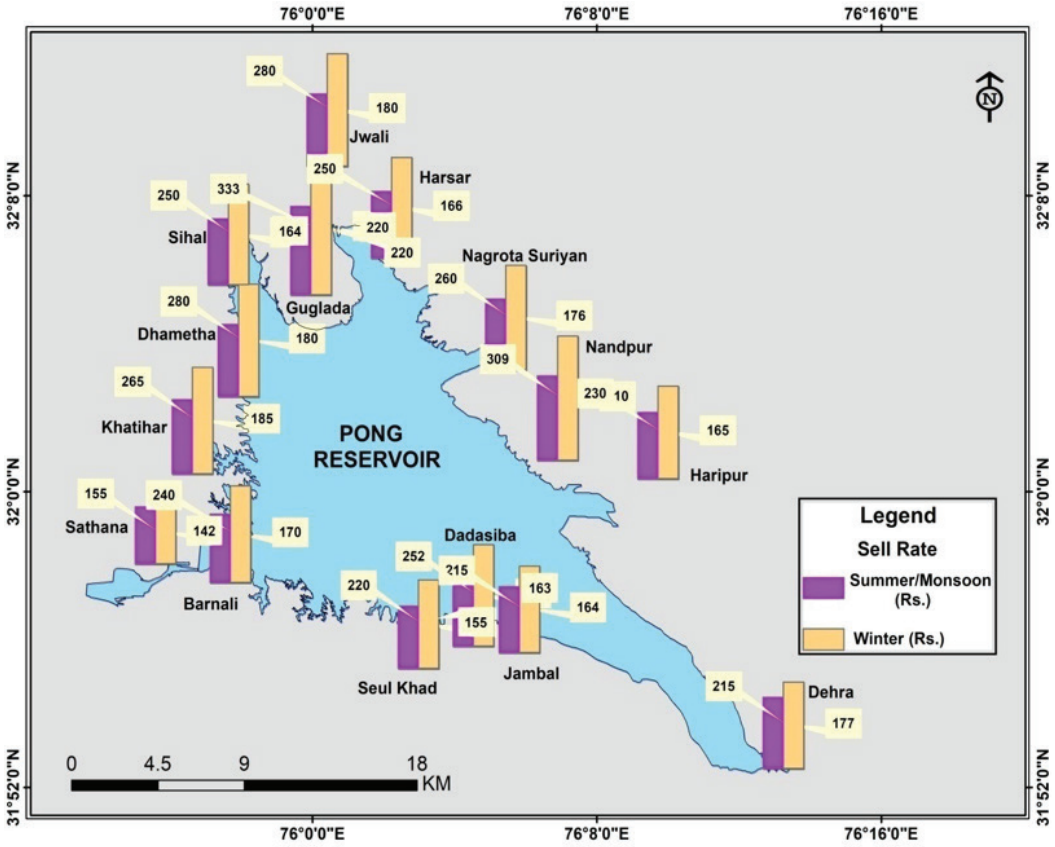


Figure 43 *Price variations in different seasons*

Period of fishing

99.56% of the fishers carry out fishing 10 months in a year. There is a closed season for fishing from 15 June to 15 August, when fishing in the reservoir is banned. It was observed that all the fishers carry our fishing activities almost daily during the fishing season.

Members of household involved in fishing

Overall, fishing was conducted for an average of 6.01 hours per person during the 10 months in the year when fishing is allowed in the reservoir. The participation of female members of the households was observed at the landing centres of Haripur, Nagrota Surian, Harsar, Sihal, and Dadasiba.

Major fishing craft and gear

All the fishers use non-motorised wooden craft for fishing. 96% of the fishers possess only one boat for fishing, 0.4% have two boats (only at the landing centre at Badnali), and the remaining possess no boats of their own. All the fishers mainly use gill nets for fishing. The fishers of the reservoir possess 5990 gill nets in total. Overall, the fishers own three fishing gear per person.

Angling

A total of 352 fishing rods and reels are operated for angling in the reservoir. Angling is carried out at the landing centres of Nandpur, Nagrota Surian, Jawali, Khatiyar, Badnali and Dadasiba.

The results of the study show that the households of the fishers near the reservoir are highly dependent on the fisheries resources of the reservoir for their livelihoods and income. The education levels of most of the household heads were fairly low at some of the landing centres. The average fisher is secondary-literate, having studied at

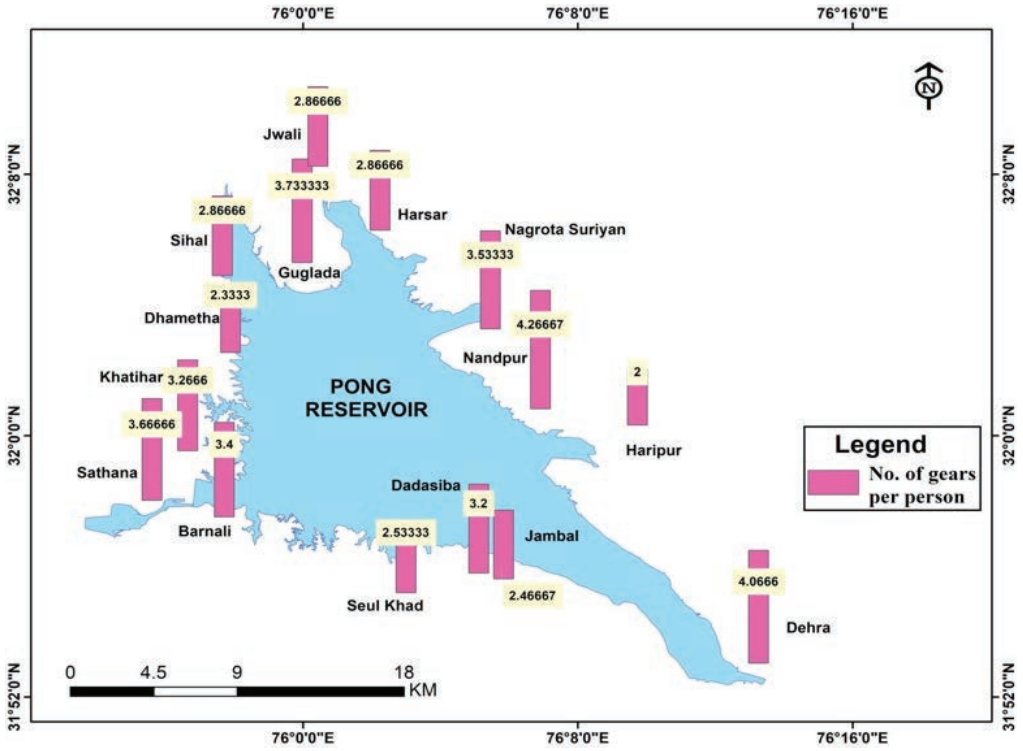


Figure 44 *Number of fishing gear per person at 15 landing centres of Pong Reservoir*

school (standard VI to standard X). Most of the households have fishing as their primary occupation, and working as daily wage labourers and farming as their secondary occupations. Fisheries resources provide a wide range of direct use values for the fishers in the forms of subsistence and commercial value. Overall, the fisheries in the reservoir generated 82% of the household income and were thus the single most available option of livelihood of the fishers. However, the income levels are low at most of the landing centres. Participation of female license holders in the fisheries at the reservoir can be encouraged to promote gender equity.

Table 13 *Status of the 15 fishermen's cooperative societies of the reservoir*

S. No.	Landing Centre	No. of Registered Members in Cooperative Society	Active Fishers among License Holders	No. of Respondents
1	Dehra	455	90	15
2	Haripur	330	80	17
3	Nandpur	303	85	15
4	Nagrota Surian	308	100	15
5	Harsar	216	30	15
6	Jawali	130	30	15
7	Guglara	347	110	15
8	Sihal	237	50	15
9	Dhametha	350	115	15
10	Katiyar	672	100	15
11	Sathana	102	45	15
12	Badnali	167	95	15
13	Seul Khad	149	80	15
14	Dadasiba	159	60	15
15	Jambal	66	40	15

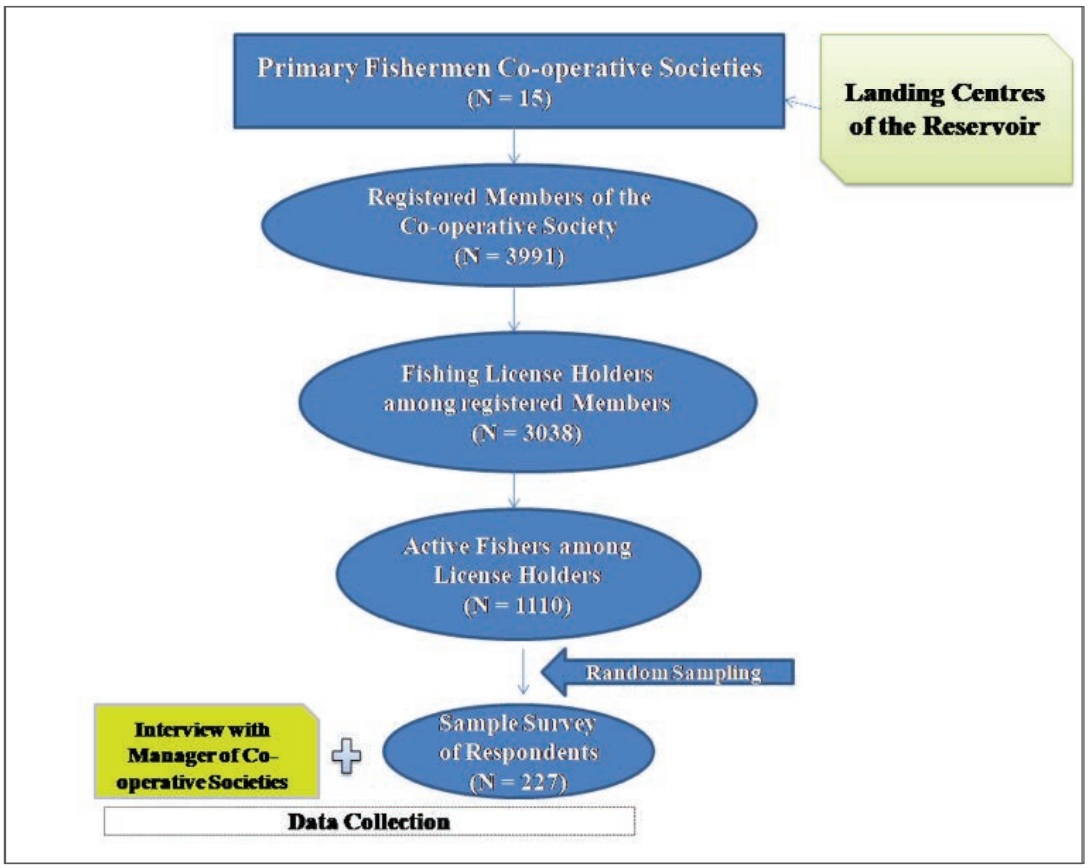


Figure 45 *Sample selection methodology of the survey*

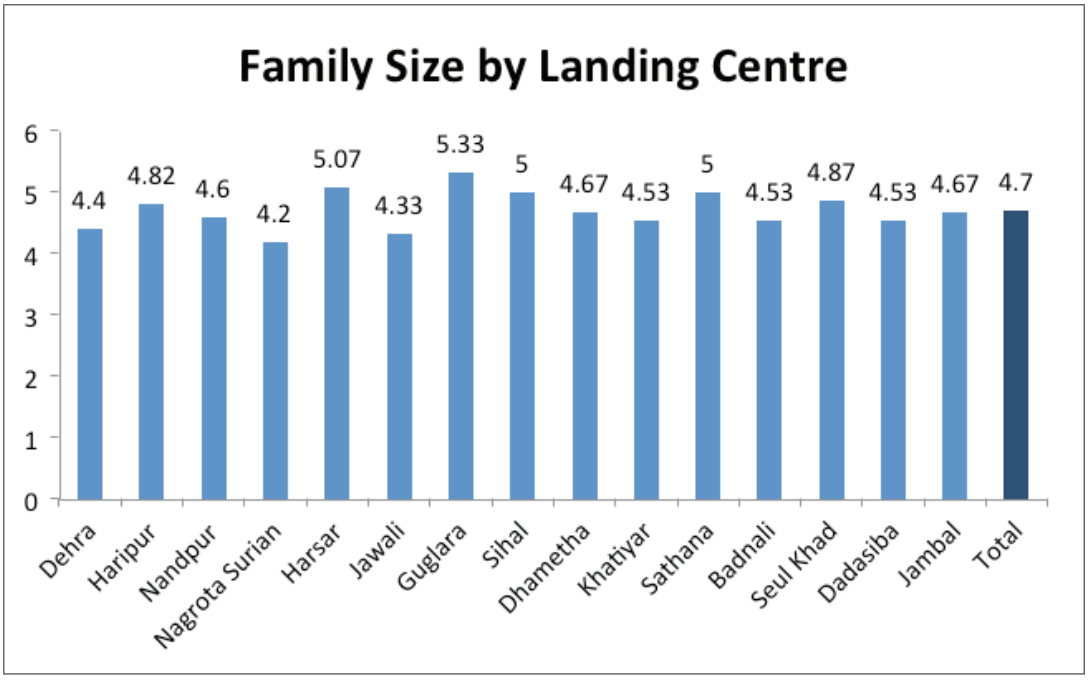


Figure 46 *Average family sizes of fishers*

Table 14 *Age distribution of household heads by landing centre (percentages)*

Age group (years)	Dehra (n = 15)	Haripur (n = 17)	Nandpur (n = 15)	Nagrota Surian (n = 15)	Harsar (n = 15)	Jawali (n = 15)	Guglara (n = 15)	Sihal (n = 15)	Dhametha (n = 15)	Katiyar (n = 15)	Sathana (n = 15)	Badnali (n = 15)	Seul Khad (n = 15)	Dadasiba (n = 15)	Jambal (n = 15)	Total (n=227)
24–30	Nil	Nil	26.67	Nil	Nil	6.67	13.33	Nil	Nil	6.67	Nil	Nil	6.67	Nil	6.67	10.00
31–40	20.00	23.53	33.33	33.33	33.33	46.67	33.33	13.33	20.00	13.33	20.00	33.33	60.00	6.67	20.00	62.00
41–50	33.33	47.06	26.67	26.67	40.00	33.33	26.67	53.33	46.67	26.67	26.67	33.33	26.67	20.00	26.67	75.00
51–60	26.67	23.53	13.33	26.67	20.00	13.33	13.33	13.33	26.67	40.00	26.67	33.33	6.67	46.67	20.00	53.00
61 and above	20.00	5.88	Nil	13.33	6.67	Nil	13.33	20.00	6.67	13.33	26.67	Nil	Nil	26.67	26.67	27.00

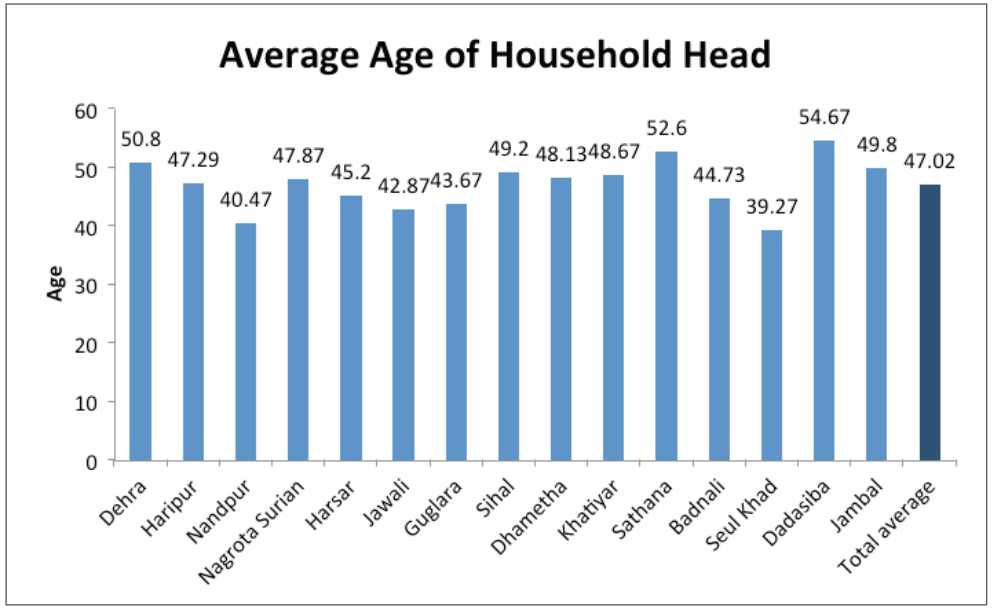


Figure 47 *Average age of the household head by landing centre*

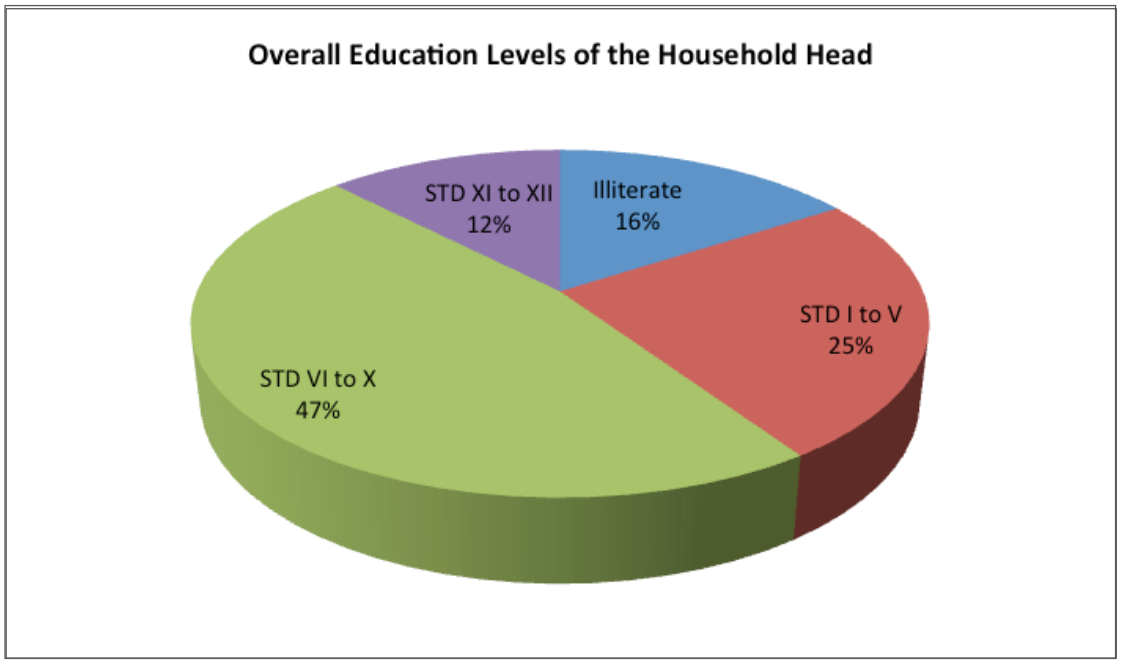


Figure 48 *Overall education level of the household head*

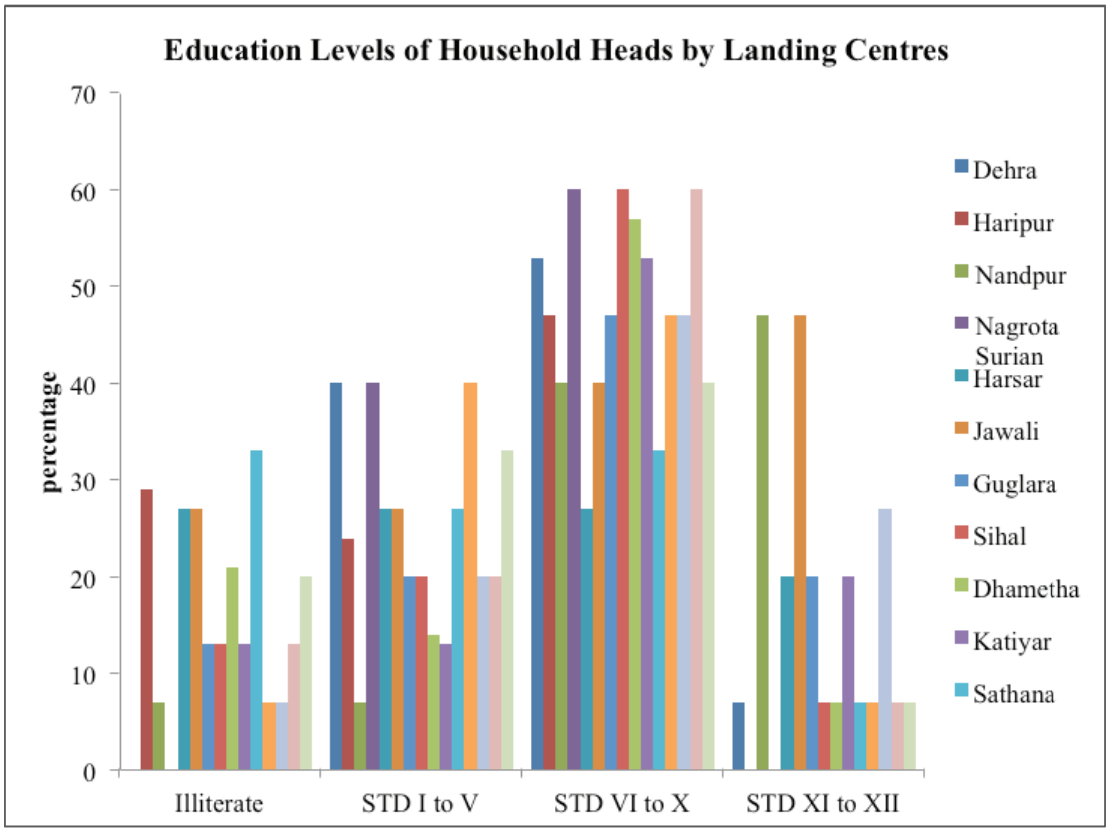


Figure 49 *Education level of the household head by landing centre*

Table 15 *Primary and secondary occupations of the household head by landing centre (%)*

Type of occupation	Dehra (n = 15)		Haripur (n = 17)		Nandpur (n = 15)		Nagrota Surian (n = 15)		Harsar (n = 15)		Jawali (n =15)		Guglara (n = 15)		Sihal (n =15)		Dhametha (n = 15)		Katiyar (n = 15)		Sathana (n = 15)		Badnali (n = 15)		Seul Khad (n = 15)		Dadasiba (n = 15)		Jambal (n = 15)	
	P	**S**	**P**	**S**	**P**	**S**	**P**	**S**	**P**	**S**	**P**	**S**	**P**	**S**	**P**	**S**	**P**	**S**	**P**	**S**	**P**	**S**	**P**	**S**	**P**	**S**	**P**	**S**	**P**	**S**
Fishing	100	--	100	--	100	--	100	--	100	--	100	--	100	--	100	--	100	--	100	--	100	--	100	--	100	--	100	--	100	--
Daily wage labour	--	60	--	35	--	27	--	73	--	53	--	67	--	35	--	47	--	47	--	13	--	67	--	47	--	33	--	60	--	53
Agriculture	--	27	--	53	--	33	--	13	--	40	--	33	--	40	--	47	--	33	--	67	--	33	--	40	--	67	--	40	--	47
Daily wage labour and agriculture	--	--	--	--	--	--	--	--	--	--	--	--	--	27	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Shop keeping	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	7	--	13	--	--	--	--	--	--	--	--	--	--	--	--
Others	--	--	--	--	--	--	--	13	--	7	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

Note:

1. The abbreviations P and S stand for primary and secondary occupations.
2. If the sum of the percentages of the secondary occupation is 100 in any column, the remaining of the surveyed respondents do not have any secondary occupation.

6 Institutional setup and governance

To enforce effective management and formulate a concerted approach to fisheries development in the reservoirs, the Reservoir Development Committee (state level) was set up in 1976. It was decided to bring all fishermen into a cooperative society. Only members of cooperative societies were permitted to operate fishing nets in Pong reservoir. In 1976, three societies with a total membership of 303 fishermen, were registered. By 2015–16, the number of societies increased to 15, with a membership of 3493.

An annual license fee of Rs.100 is levied on each gill net of length 80 m by the Fisheries Department, HP. The department also charges a 15% royalty on the price of the fish caught by each fisherman. Gill nets of mesh size 80–140 mm and rods and lines are the only fishing gear allowed to operate in the reservoir. Fishing bans were imposed during the breeding season (15 June to 15 August). No fishing is allowed during this period.

Selling of fish is done by appointing contractors by open auctioning at the beginning of each year. The fish caught by the fishermen are required to be brought to the fixed landing centres. The representatives of the contractors receive the fish at the fixed landing centres, while a departmental staff member charges the royalty and records the quantity of the catch by species. The contractors make weekly payments to the societies besides keeping a lump sum or fixed deposit that is to be confiscated in the eventuality of any default. The societies make the payment to the fishermen after deducting a marginal commission (5.0% to 7.0%), which varies between societies and is fixed each year at the general meeting of the societies. To avoid conflicts between the societies regarding the area of operation, the reservoir is demarcated on the basis of area and productivity of the water bodies, which are apportioned for each society. Fishermen who are members of the cooperative societies are issued annual licenses through the cooperative societies by the respective Fisheries Officers of the landing centres at the beginning of each year.

Presently there are 15 fishermen's cooperative societies functioning in the reservoir. The fisheries department initiated a training course for fishermen for operating gear in the deeper waters. Besides providing direct employment to over 2300 fishermen, the fishing activities provide indirect jobs to over 1000 families engaged in helping the fishermen, carrying/transporting fish, packing fish, weaving, mending gear, marketing, etc. The fishermen in Pong are mostly full-time fishermen. On average, every fisherman has one boat, usually with dimensions 5.0 m × 1.0 m × 0.7 m. The fishermen normally use gill nets with a mesh size varying from 80 mm to 140 mm. The minimum allowable mesh size for economically important species is fixed by the department.

The Fisheries Department, HP has initiated a number of welfare schemes for the benefit of fishermen. The department arranges procurement of certain equipment to meet the needs of the users. A personal accident insurance scheme has been initiated free of cost for each fisherman. Fishing is a hazardous job, and there is every risk of life during heavy rains and storms. Keeping this in view, all active fishermen working in the reservoirs/riverine sector have been insured for Rs. 2,00,000/- in case of death or permanent total disability. In case of partial permanent disability, a fisherman is insured for Rs. 1,00,000/- and a cover of Rs. 10,000/- towards hospitalization expenses. The insurance premium is being shared by the Government of India & the Government of Himachal Pradesh in 50:50 ratio. A Risk Fund Scheme has also been initiated under which fishermen are compensated to the tune of 33% for losses such as blowing and sinking of boats or nets. Further, during the period of closed season (15, June – 15, August), a subsistence allowance of Rs. 1800 is paid under a Relief Scheme. For this, the fishermen have to make a contribution on equal installments of Rs. 60 each for ten consecutive months of the fishing season.

Image 12 *Meeting with officials of ADF office, Department of Fisheries, Pong Dam, HP*

7 Spatial and temporal trends for fisheries within Pong Reservoir

7.1. TRENDS OF FISH PRODUCTION/YIELD

The decadal pattern of fish yield showed a decreasing trend. During the years 1976– 1987 and 1987–1998 the fish yield were 30 kg/ha/year. But the fish yield decreased to 24.5 kg/ha/year during 1998–2009 and further decreased to 23.19 kg/ha/year during 2009–2020. The species-wise fish production pattern of the last three decades (1991–2000, 2001– 2010 and 2011–2020) was analysed. The catches of *T. putitora, L. catla, L. rohita, L. calbasu* and *W. attu* showed decreasing trends. However, the catches of *C. mrigala and C. carpio* showed increasing trends. The increasing trend of the catch of *C. mrigala* indicates the positive impact of stocking. However, the increasing trend of the fish production of *C. carpio* might be due to the availability of a suitable habitat for proper growth and the prevalence of auto-breeding of the species in the reservoir. Though *L. catla and L. rohita* were stocked in the reservoir, the production showed a decreasing trend in the last three decades, which might be due to the irregular stocking and small size of the stocking material. The *T. putitora* catch showed a decreasing trend during the last three decades, which might be due to the impact of climate change on the general biology of the fish. This species needs a particular temperature, a particular water flow and other special conditions for its growth, breeding activity and larval development for its population to increase. The population of *W. attu* also showed a decreasing trend during the last three decades, which might be due to the reproductive failure of the species as it needs a proper habitat for building nests for laying eggs. The *Sperata seenghala* production was increasing from the beginning of 1990 till 2010; after which it started declining till 2013. However the *Sperata seenghala* production increased again for a few years (2014 and 2015), but later the production again declined.

To rejuvenate the production of species, the breeding ground and suitable habitat should be demarcated and protected. The fishing ban during the breeding season and the mesh size regulation should be strictly followed. The stocking programme would be more effective if large-size fish seeds are stocked. The fishing regulations should be strictly maintained and monitored by the HP Fisheries Department with the involvement of the local fishermen's cooperative societies.

Image13 *Fish landing at Pong Reservoir*

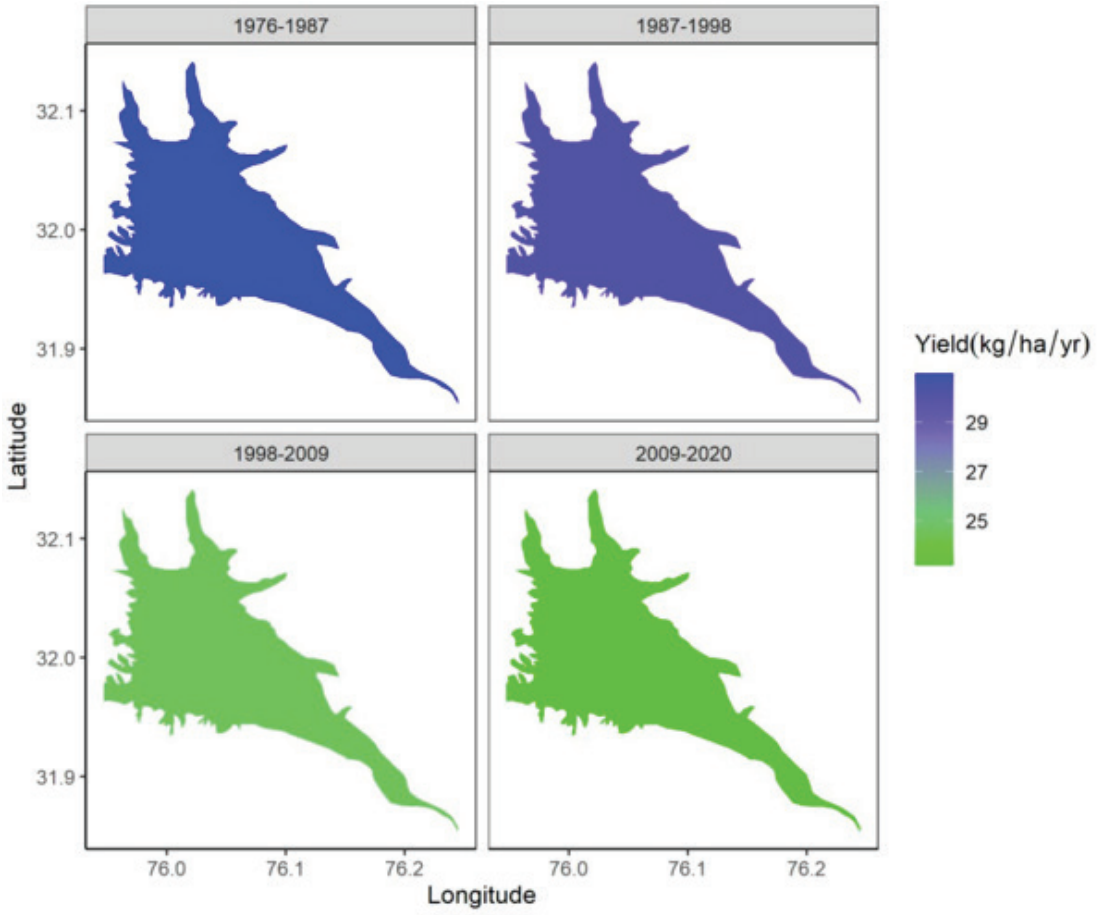


Figure 50 *Decadal trend of fish yield (kg/ha/yr)*

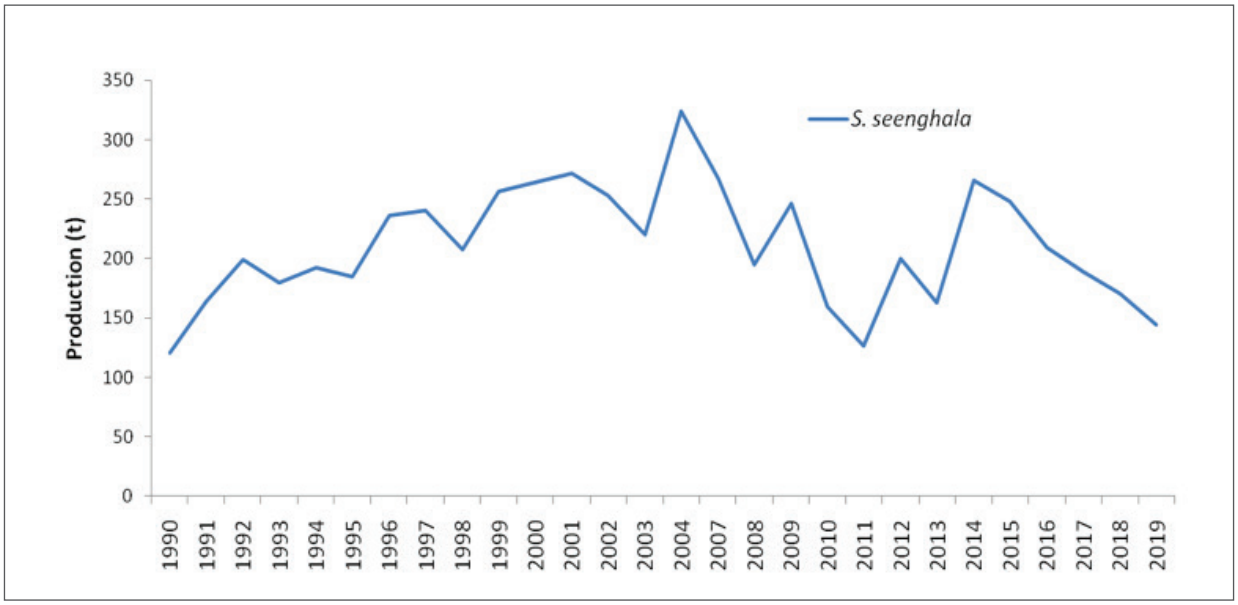


Figure 51 *Decadal trend of fish production of S. seenghala*

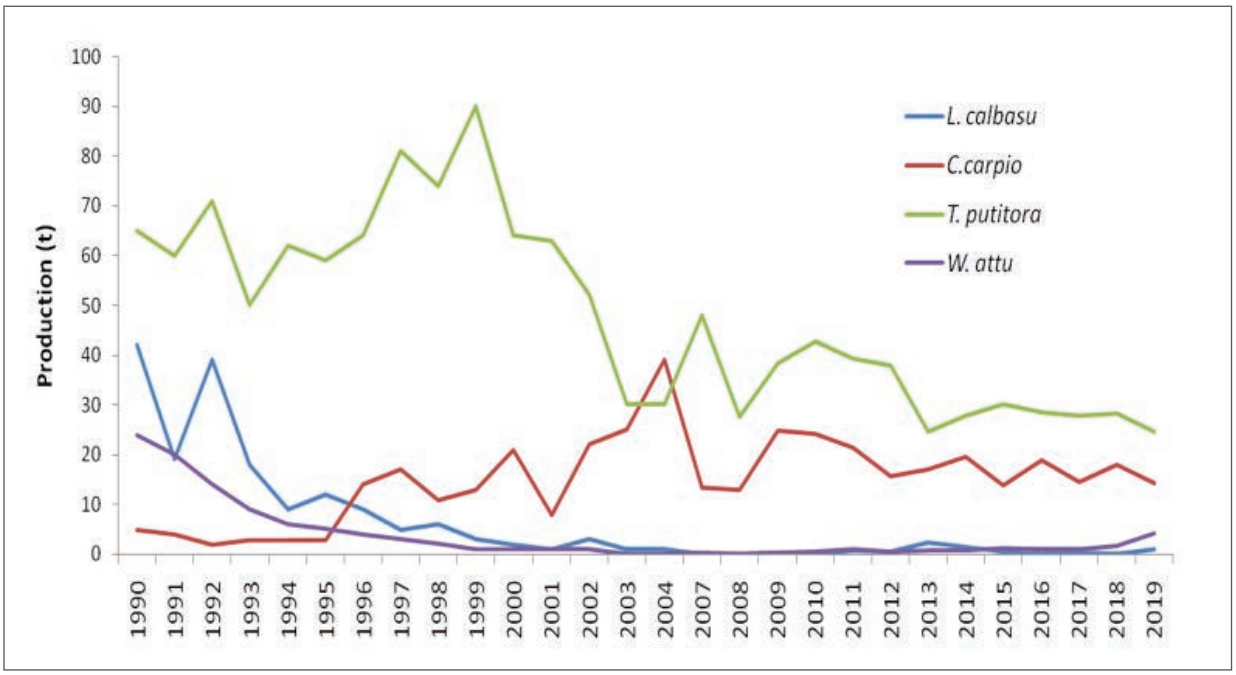


Figure 52 *Decadal trend of fish production of Calbasu, Common Carp, Mahaseer and Walago (Source: DoF, HP)*

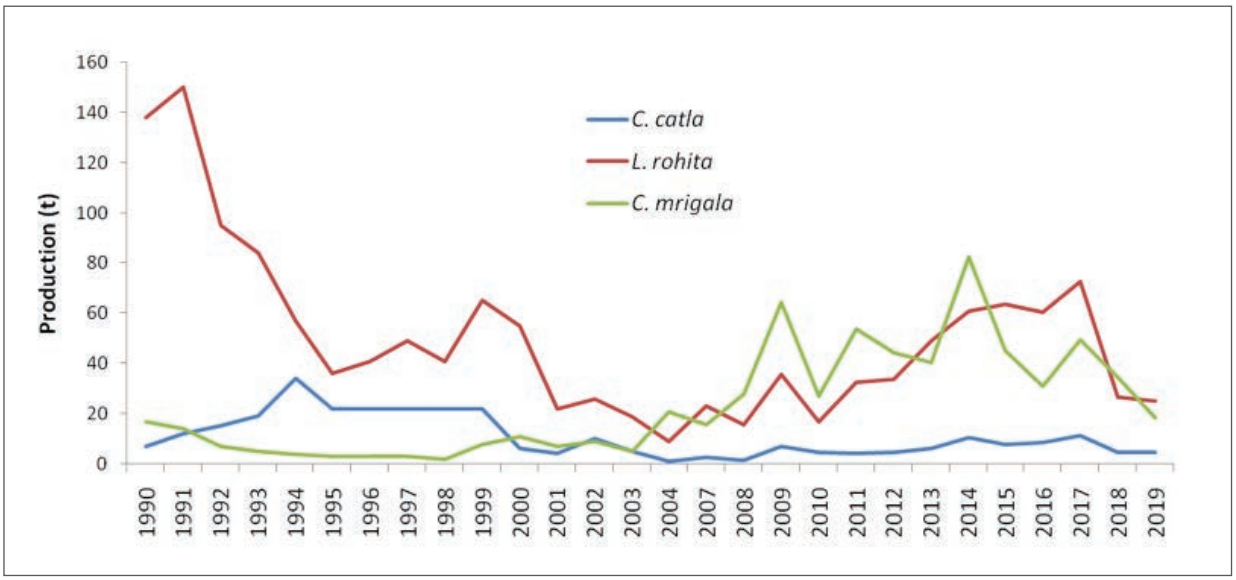


Figure 53 *Decadal trend of fish production of IMC (Catla, Rohu, Mrigal) (Source: DoF, HP)*

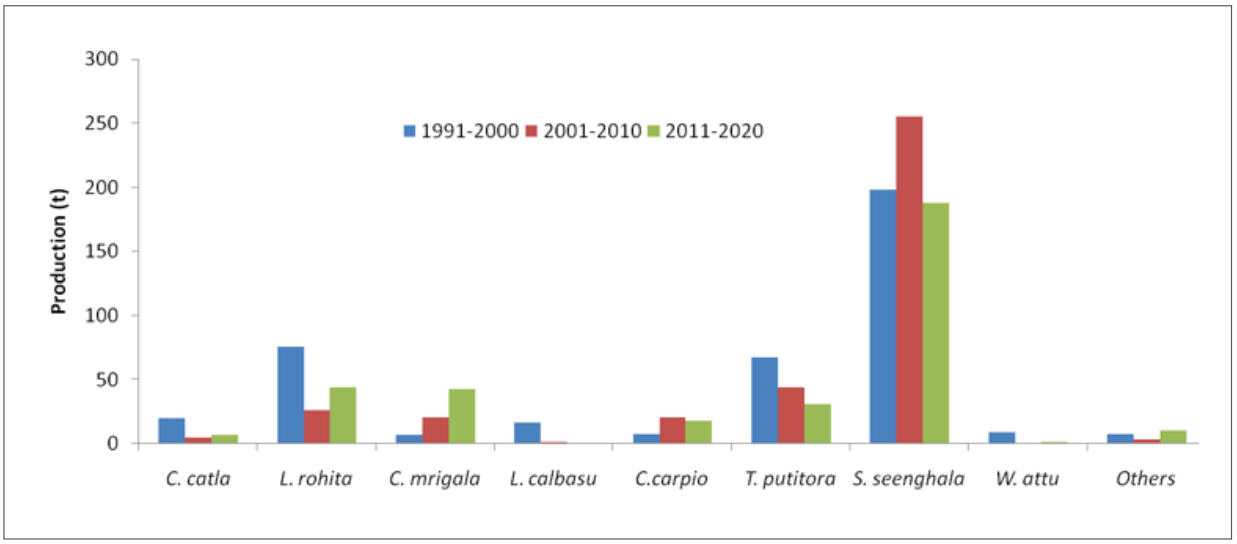


Figure 54 *Species-wise decadal trend of fish production in Pong Reservoir*

The fish catch data of landing centres in different zones of the reservoir indicated that the fish catch is much higher in the lentic (dam) and lentic (reservoir) zones compared with the other zones. The lentic (dam) and lentic (reservoir) zones have relatively consistent and higher water volume compared with the other zones of the reservoir. The lotic and intermediate zones were highly disturbed by the fluctuations of the water volume and water spread area. The lentic (dam) and lentic (reservoir) zones have more inflowing streams *(khads) as* compared to other zones. Water volume and number of inflowing streams are considered to be important factors in the fish production of the reservoir. These factors need to be considered when issuing fishing licenses for the different landing centres of the reservoir.

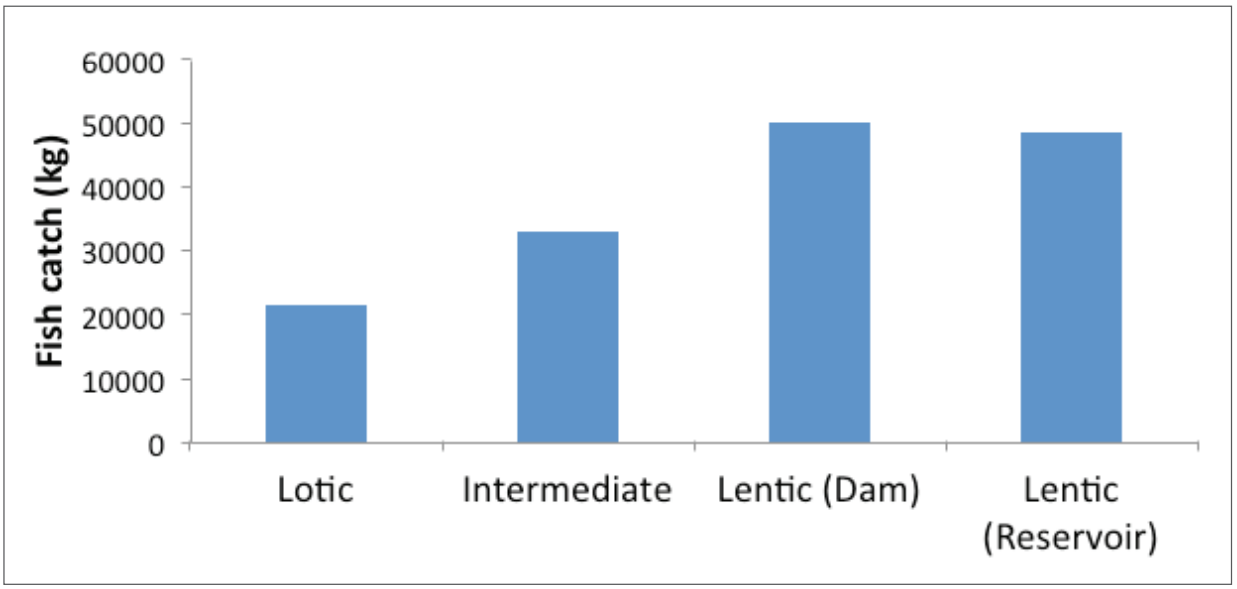


Figure 55 *Fish production pattern in different zones of Pong Reservoir*

7.2. TRENDS OF FISH STOCKING AND IMPACT OF STOCKING

IMC was stocked regularly in Pong Reservoir every year. The three-decade pattern of fish stocking indicated an increase in average stocking density (50/ha/year, 138/ha/year and 367/ha/year during 1990–2000, 2000–2010 and 2010–2020, respectively). The impact of stocking on fish production was assessed by determining the nature of the relationship between stocking and fish production using regression analysis. The analysis was carried out for the last three decades (1990–2000, 2000–2010 and 2010–2020). The relationship was positive for all three decades, and a strong relationship was observed for the decade 2010–2020, but the relation was weak for the decades 1990–2000 and 2000–2010. The findings clearly indicated that stocking has a positive impact on production.

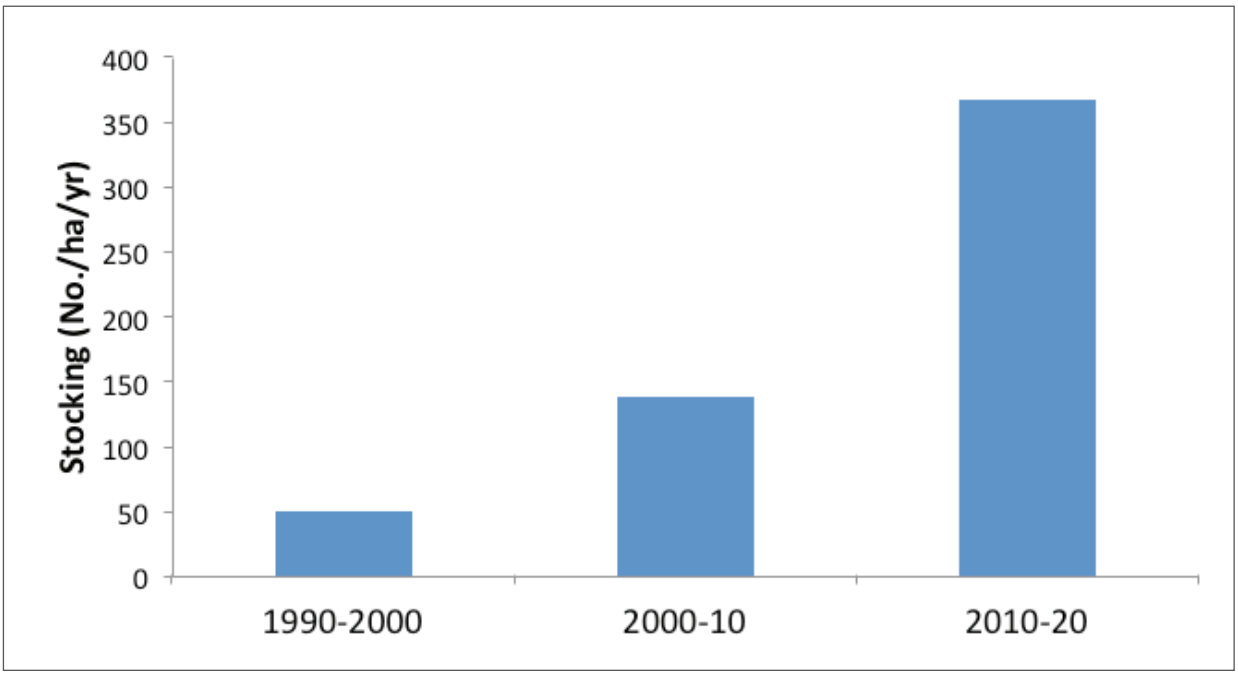


Figure 56 *Average annual fish stocking density (nos./ha/year) in the last three decades in Pong Reservoir*

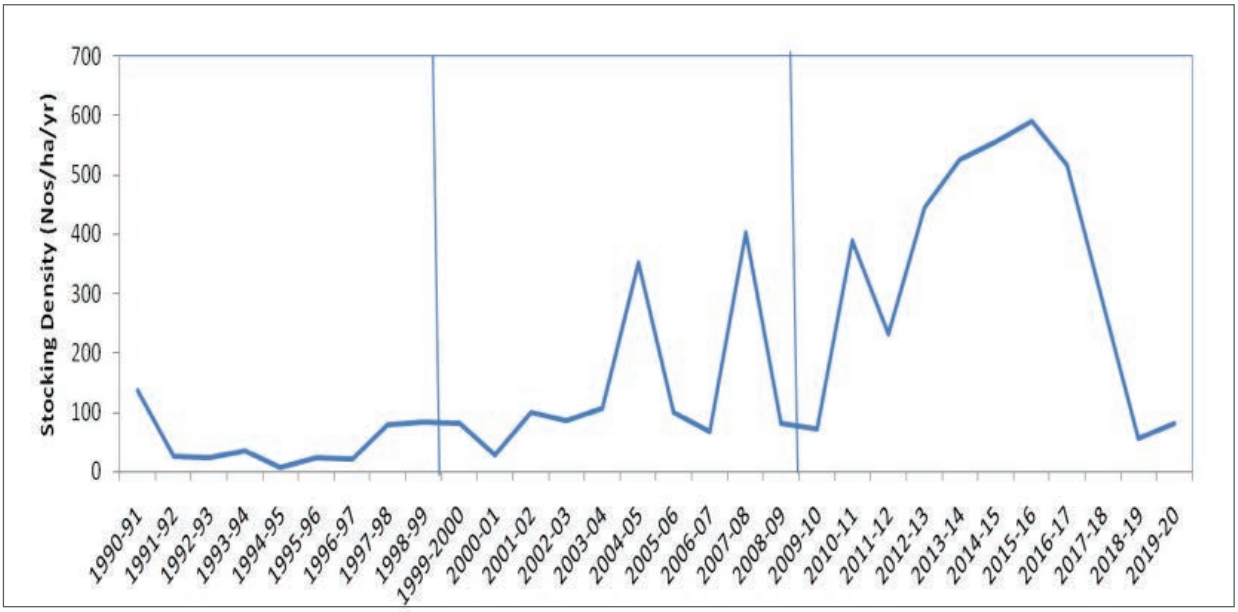


Figure 57 *The trend of fish stocking density (nos/ha/year) the last three decades*

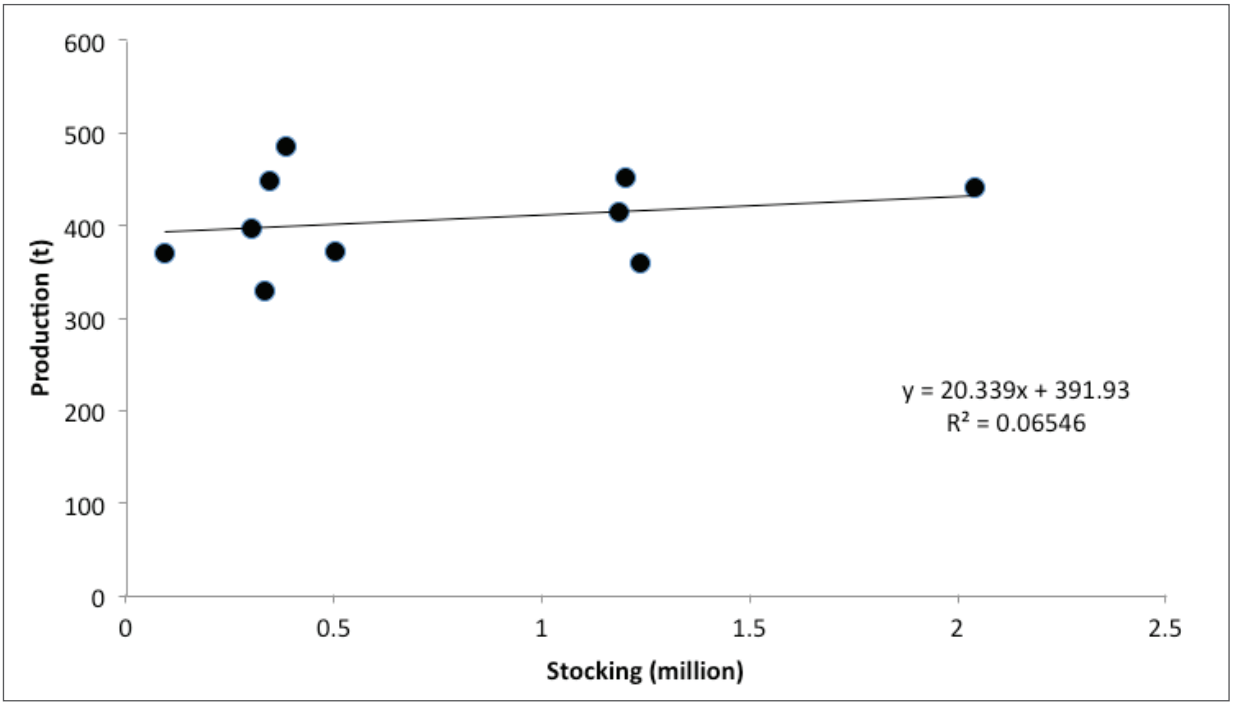


Figure 58 *Relationship between stocking and fish production (1990–1991 to 1999–2000)*

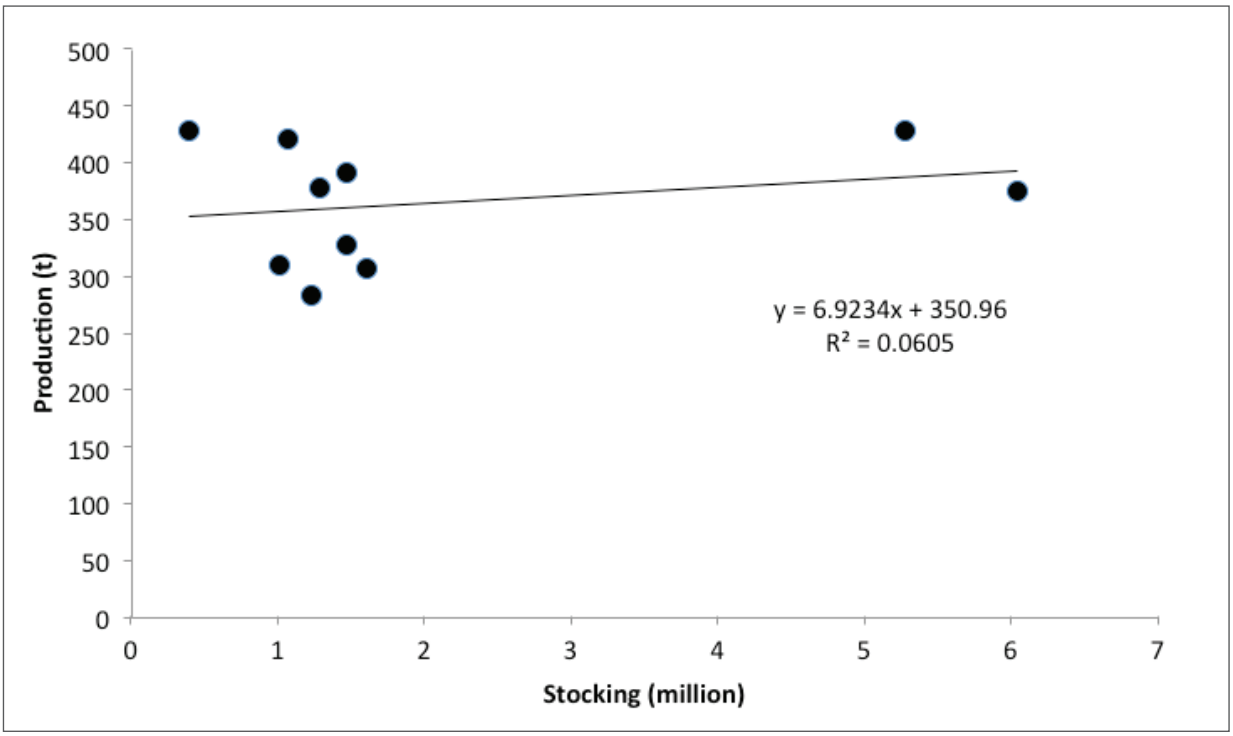


Figure 59 *Relationship between stocking and fish production (2000–2001 to 2009–2010)*

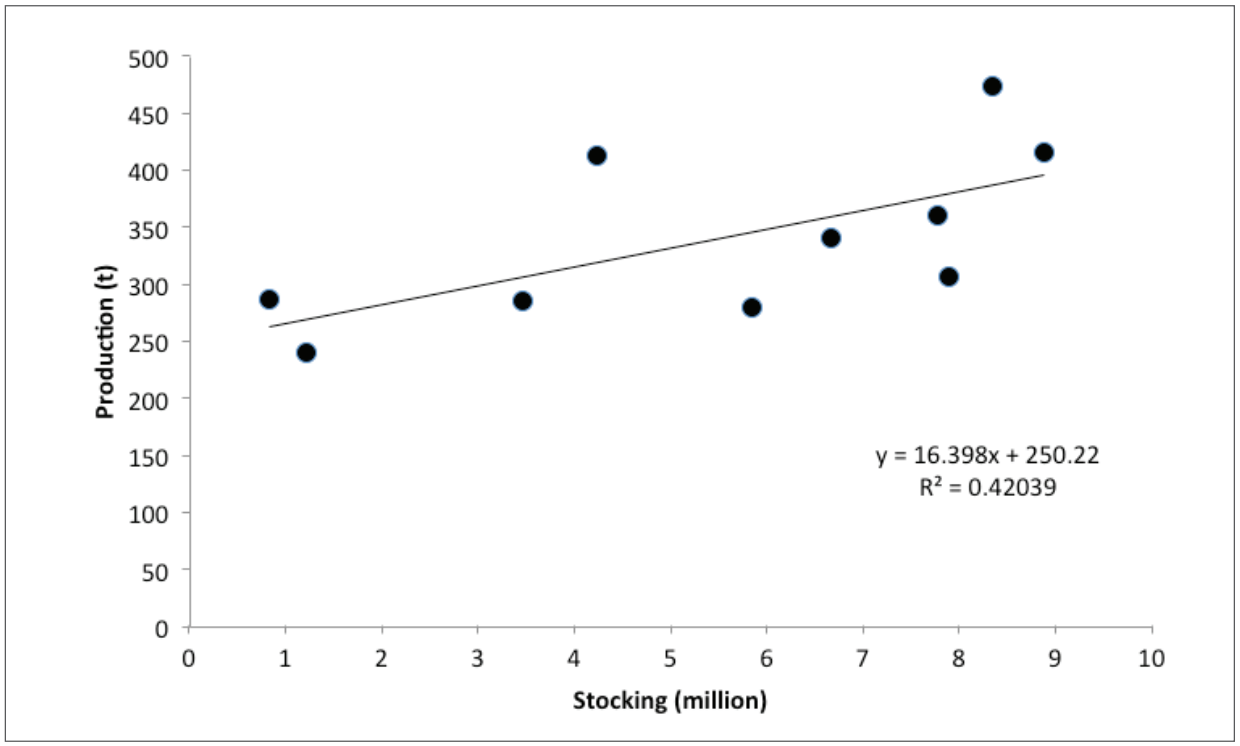


Figure 60 *Relationship between stocking a nd fish production (2010–2011 to 2019–2020)*

8 Impact of migratory birds on fish production

Pong Dam provides an excellent habitat for foraging, breeding and roosting of birds. Flocks of birds usually migrate to the dam from Tibet, Mongolia and Russia. Records reveal that the population of migratory birds has increased in the wetland, indicating that the birds are finding ideal conditions in winter. Waterfowl (Family Anatidae) usually spend some stages of their life cycle at the wetland. Some species of bird are dependent on seeds, fruits, flowers, etc., while others consume insects, snails, fishes, etc. The Pong Reservoir has emerged as a major habitat for migratory birds other than resident birds. The abundant aquatic vegetation of the lake and mixed perennial and deciduous pine forests on the hillsides provide food and shelter for the migratory birds. The habitat requirements are species-specific, and the birds prefer to nest and forage at certain heights and in certain structures of the vegetation. The influx of birds can be seen at the northern part of the Pong Reservoir at places such as Nagrota Suriyan, Budladha and Sansarpur.

Bar-Headed Geese and Pintails form the majority of the waterfowl seen at the wetland. In general, the migratory birds start arriving at the wetland around mid-October and remain there up to the last week of March. The peak time of migratory birds is the last week of December and all of January. The food and feeding habits revealed that out of 324 species of bird identified, 167 species prefer small fishes as their main diet and 91 species are migratory in nature. Six species seen at Pong Reservoir are classified as Vulnerable in the IUCN Red List, six species are Endangered, 16 species are Near Threatened, and the remaining 296 species are Least Concern.

The time series data on the migratory bird abundance from 1988 to 2016 clearly indicate that the number of migratory birds at Pong Reservoir has been increasing. The number of migratory birds was very low during the 1990s, but the number has been increasing significantly since 1997. The impact of the birds on the fish production was studied. The impact was assessed by analysing the relationship between the time series data of the migratory birds and fish production using regression analysis. The birds had a negative relationship with the fish production.
A list of birds found in Pong Reservoir and their feeding habits is provided in Annexure V.

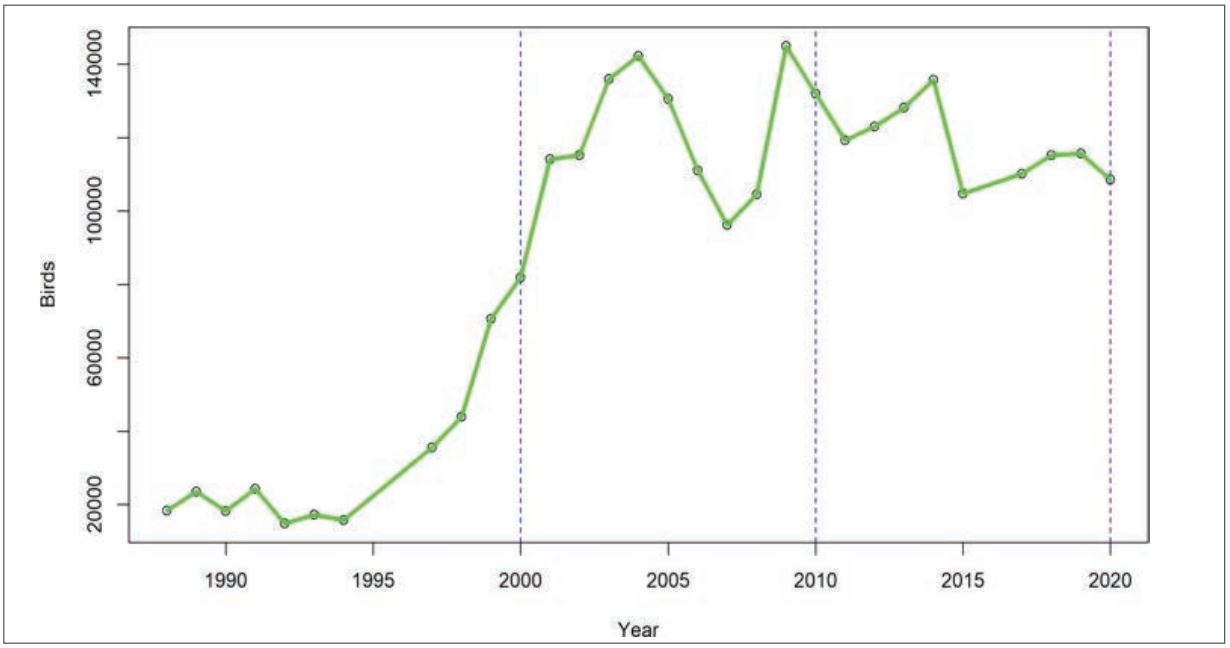


Figure 61 *Figure depicting trends of abundance of migratory birds at Pong Reservoir*

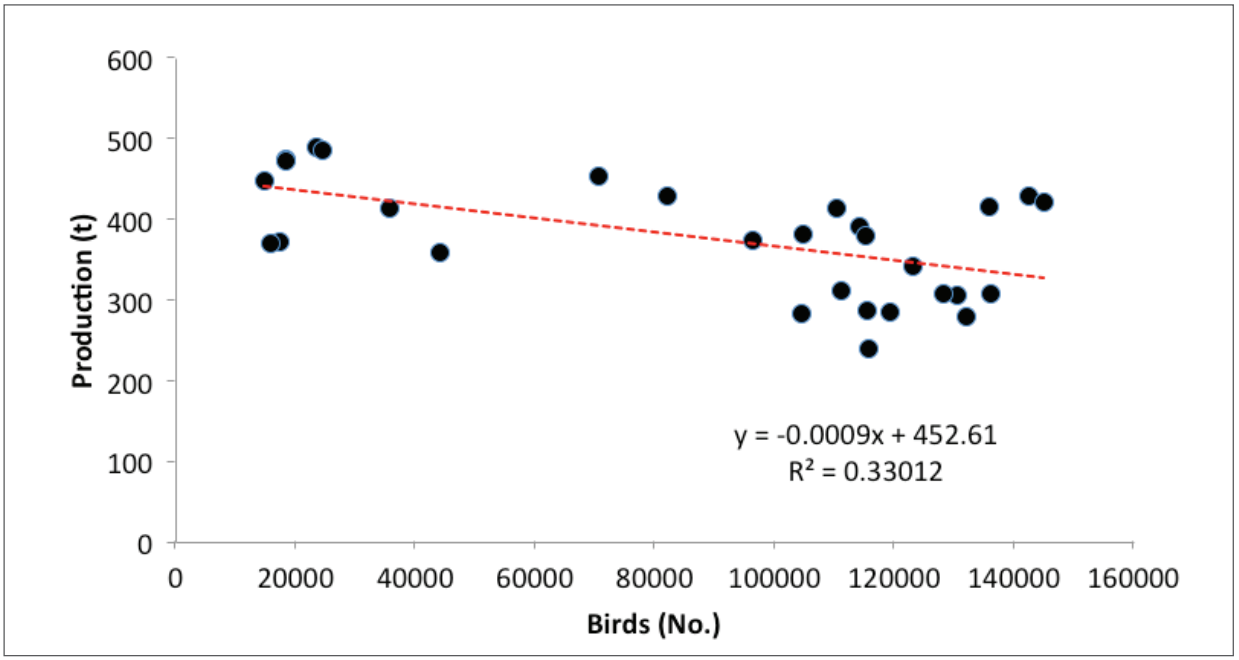


Figure 62 *Relationship of fish production with migratory bird abundance at Pong Reservoir*

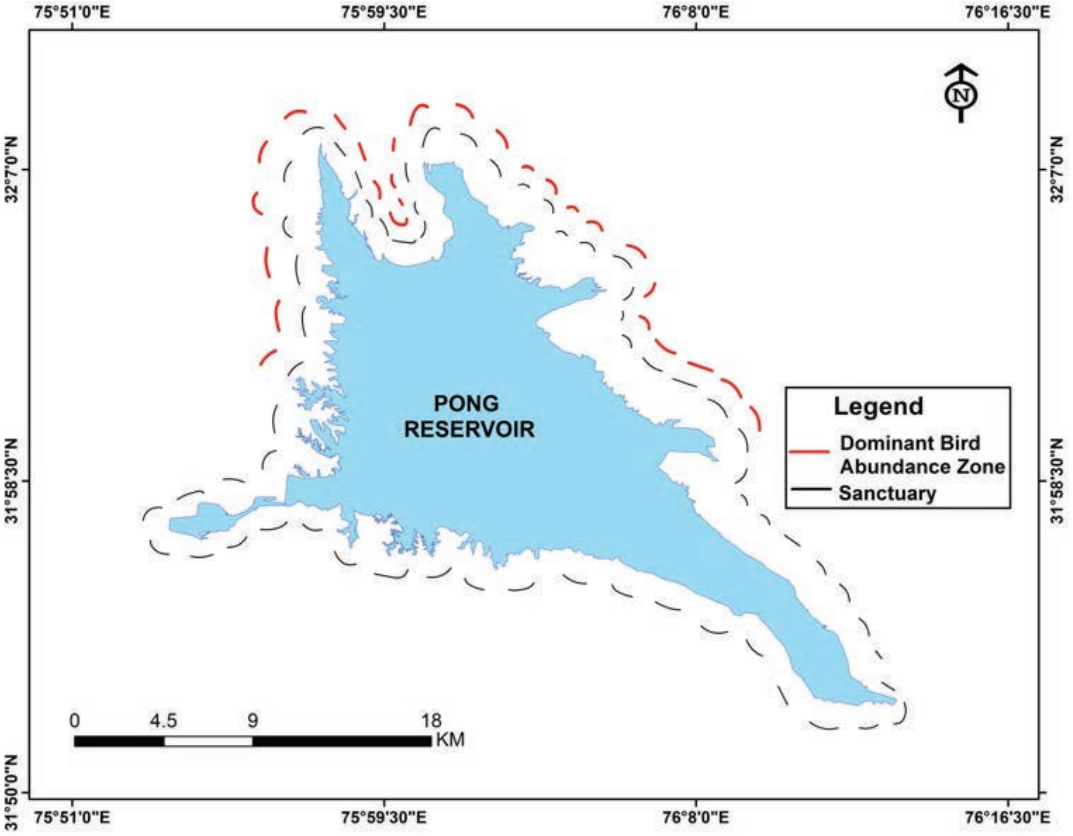


Figure 63 *Sanctuary area and the zone of bird abundance zone at Pong Reservoir*

Image14 *Migratory birds at Pong Reservoir*

9 Plankton Dynamics

Plankton samples were collected from the lentic (dam and reservoir), intermediate and lotic sectors during 9–10 AM at Pong Reservoir. The samples were preserved in 4% formalin and brought to the laboratory for analysis. A total of 45 planktonic genera were encountered at this reservoir, belonging to nine phyla, of which four (Bacillariophyceae, Chlorophyceae, Zygnematophyceae and Cyanophyceae) were phytoplankton phyla and the other five were zooplankton phyla (Copepoda, Cladocera, Rotifera, Protozoa and Insecta).

Image 15 *Collection of plankton using plankton net at Pong Reservoir*

9.1 PHYTOPLANKTON

The phytoplanktonic abundance ranged from 1092.48 units/l to 2780 units/l. The planktonic abundance was highest in the intermediate zone, which is a stable sector between the lentic and riverine sectors, while the abundance was lowest in the lotic sector, possibly due to the moderate low-temperature water current entering the reservoir ecosystem from the river Beas.

The study revealed that Bacillariophyceae dominated in the lentic zone (1122.5 units/l), followed by the intermediate zone (998.5 units/l) and the lotic sector (480.82 units/l). The dominant genus was *Nitzschia* sp. (102.95units/l), recorded in all the sampling sectors, followed by *Aulacoseira* sp. (85.22 units/l), *Navicula* sp. (76.13 units/l) and *Frustulia* sp. (19.09 units/l).

Chlorophyceae dominated in the intermediate zone (503.75 units/l), followed by the lentic zone (440.15 units/l), and the lowest density was in the lotic sector (227.47 units/l). The dominant genus was *Cosmarium* sp. (79.54 units/l), followed by *Pediastrum* sp. (46.13 units/l) and *Closterium* sp. (39.54 units/l), and the genus with the lowest density

across the sectors was Cladophors sp. (6.36 units/l). The abundance of Cyanophyceae was greatest in the intermediate zone (863.75 units/l), followed by the lentic zone (797.08 u/l), and the abundance was lowest in the lotic sector (197.49 units/l). The most dominant genus recorded was *Microcystis* sp. (356.81 units/l), followed by *Nostoc* sp. (61.13 units/l) and *Oscillatoria* sp. (35.90 units/l), and the least dominant species was *Gomphosphaeria* sp. (6.59 units/l).

The abundance of Zygnematophyceae was greatest in the lentic zone (488.75 units/l), followed by the intermediate zone (420 units/l) and the lotic zone (255 units/l). The dominant genus was *Spirogyra* sp. (49.54 units/l), followed by *Mougeotia* sp. (43.40 units/l) and *Staurastrum* sp. (41.13 units/l). The abundance of Trebouxiophyceae was greatest in the intermediate zone (142 units/l), followed by the lotic zone (75 units/l) and the lentic zone (60 units/l). The abundance of Dinophyceae was greatest in the intermediate zone, 62units/l, followed by the lentic and lotic zones (30 units/l). The abundance of Euglenophyceae was greatest in the intermediate zone (85 units/l), followed by the lentic zone (40 units/l), and the lowest abundance was in the lotic zone (31 units/l).

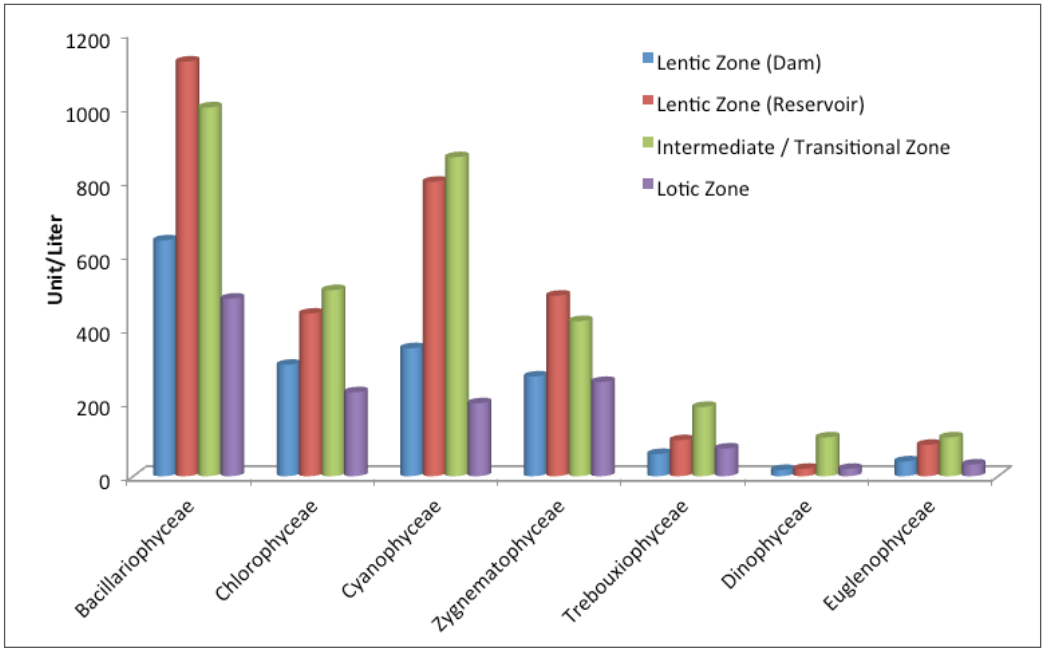


Figure 64 *Abundance of phytoplanktonic phyla in different sampling zones*

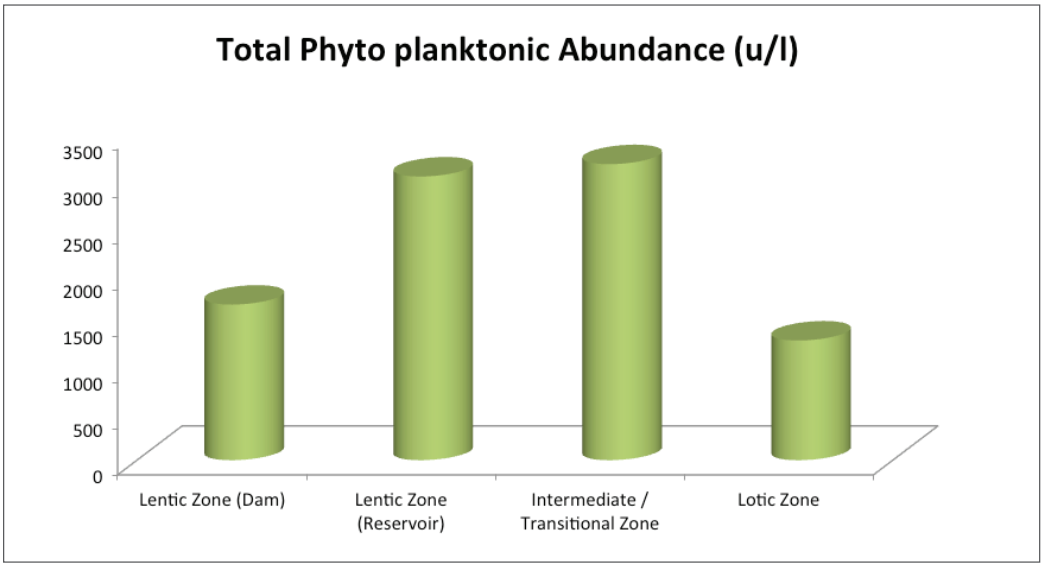


Figure 65 *Total phytoplankton abundance in different zones of Pong Reservoir*

9.2 ZOOPLANKTON

The abundance of zooplankton ranged from 174.97 units/l to 364.98 units/l. The abundance of zooplankton was highest in the lentic zone and lowest in the lotic zone of the reservoir. Six genera from the Cladocera were reported. The sector with greatest abundance of Cladocera species was the lentic zone (186.65 units/l), followed by the intermediate zone (144.15 units/l) and the lotic zone (96.65 units/l). Three genera from the Copepoda were reported. The abundance of the Copepoda species was greatest in the lentic zone (114.58 units/l), followed by the intermediate zone (110 units/l), and the least abundance was in the lotic zone (62.49 units/l). Only one genus from the protozoan group was reported. The protozoan abundance was greatest in the lentic zone (65 units/l), followed by the intermediate zone (55 units/l), and it was least in the lotic zone (10 units/l). Different insect larvae were encountered across the reservoir in the different sectors. The study revealed that the highest zooplanktonic abundance was in the lentic sector due to the stable water conditions and lowest in the lotic zone because of the movement of the of the entry of riverine water into the reservoir ecosystem here.

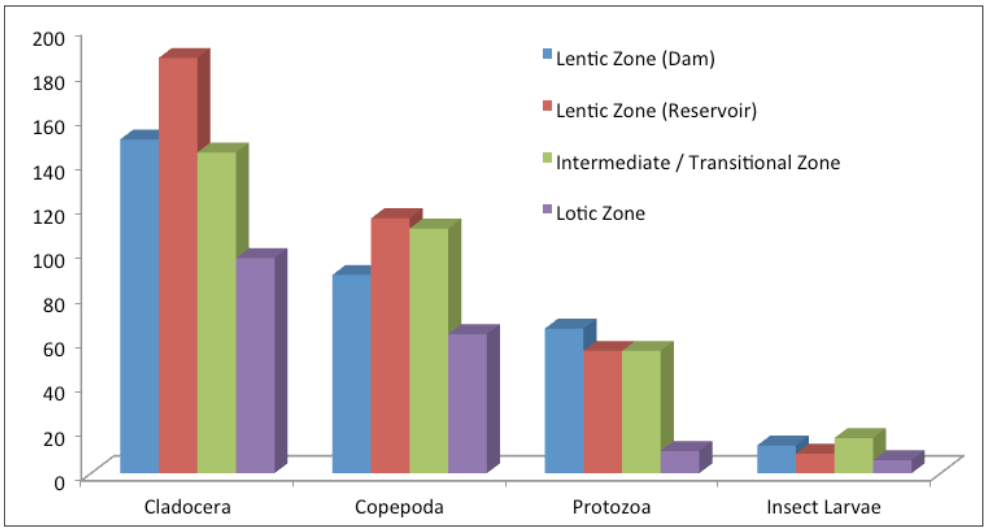


Figure 66 *Group-wise zooplanktonic distribution across different zones of Pong Reservoir*

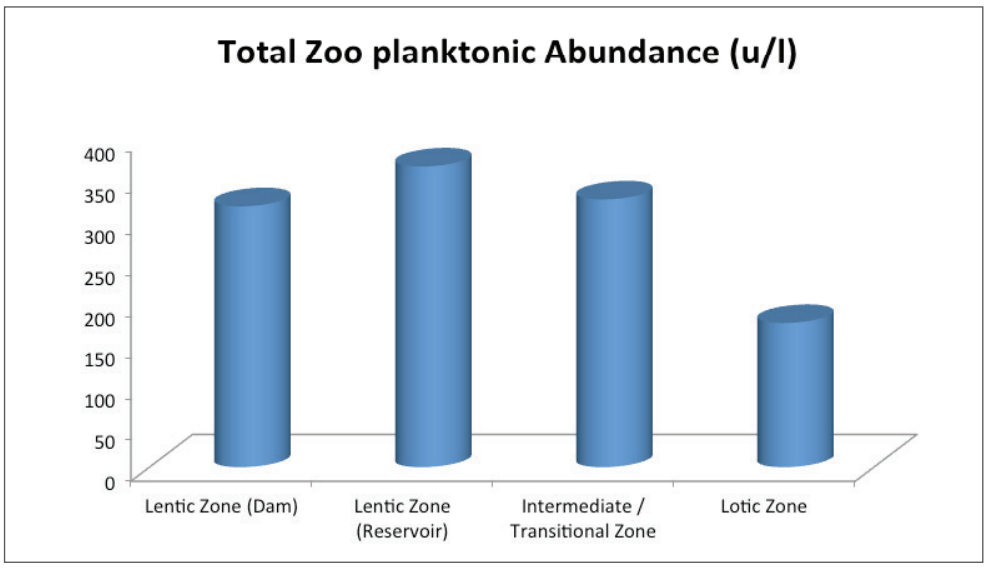


Figure 67 *Abundance of total zooplankcton in the different zones of the reservoir*

10 Macro-invertebrate diversity

Macroinvertebrates are valuable indicators of the health of aquatic and terrestrial ecosystems. During the survey, benthos samples were collected using a grab, and the samples were sieved through a metallic gauge and transferred to vials for sorting and separation of individual organisms from the debris and stones. The faunal elements were fixed in 4% formalin for further investigations in the laboratory. The samples collected were analysed, and 17 different species were recorded. During the present study oligochaetes, dipterans, molluscs (Viviparidae, Bithyniidae, Lymnaeidae, Thiaridae, Planorbidae, Ariophantidae, Sphaeriidae, Naididae) and insects (Chironomus, stone flies, water beetles, etc.) were found among the fauna of the reservoir. Two species of the family Viviparidae, *Filopaludina bengalensis* and *Bellamya dissimilis,* were recorded. The family Bithyniidae was represented by *Gabbia orcula. Physella acuta,* of the family Physiidae, was also recorded. *L.acuminata, R.auricularia* and *R.luteola,* in the family Lymnaeidae, were recorded. *M.tuberculata* (family Thiaridae) was recorded. *Gyraulus convexiusculus* and *Indoplanor bisexustus* (family Planorbidae) and *Ariophanta interrupta* and *Macrochlamys indica* (family Ariophantidae) were recorded. *Pisidium sp.* and *Sphaerium sp.,* family Sphaeridae, was recorded. *Limnodrilus hoffmeisteri* and one unidentified species in the family Naididae were recorded. The abundance of the family Viviparidae was greatest in the transitional zone. The family Lymnaeidae had a uniform distribution, whereas bivalves and Clitellata were scattered. The abundance of dipteran larvae (chironomids) was greatest in the lotic region.

Image16 *Collection of benthos*

Table16 *Abundance of macro-invertebrate species in different zones of Pong reservoir*

Species	Family	Lentic (Dam)	Lentic (Res)	Intermediate /Transitional	Lotic
Filopaludina bengalensis	Viviparidae	+++	++	+++	+
Bellamya dissimilis	Viviparidae	+++	++	+	-
Gabbia orcula	Bithyniidae	++	+	-	+
Physella acuta	Physiidae	++	+	++	+
Lymnaea acuminata	Lymnaeidae	++	+++	+	-
Radix auricularia	Lymnaeidae	+	-	+++	+++
Radix luteola	Lymnaeidae	+	-	++	-
Melanoides tuberculata	Thiaridae	++	+	-	-
Gyraulus convexiusculus	Planorbidae	++	++	+	+
Indoplanorbis exustus	Planorbidae	+	+	-	-
Ariophanta interrupta	Ariophantidae	+	-	-	-
Macrochlamys indica	Ariophantidae	+	+	-	-
Pisidium sp.	Sphaeriidae	-	-	+	+
Sphaerium sp.	SphaeriidaeN	-	-	-	+
Limnodrilus hoffmeisteri	aididae	-	-	-	+++
Unidentified species	Naididae	-	-	-	+
Chironomus larvae (dipteran)	Chironomidae	-	++	-	+++

(+++, most abundant; ++, abundant; +, rare; -, absent)

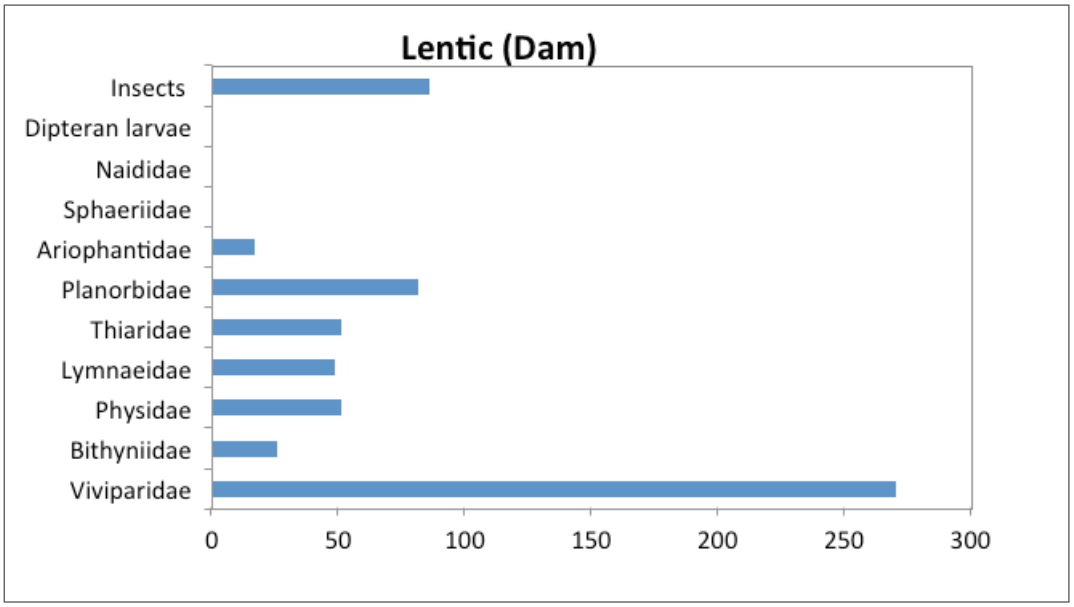


Figure 68 (a) *The abundance of the macroinvertebrate group (nos./m2) at lentic zone (dam)*

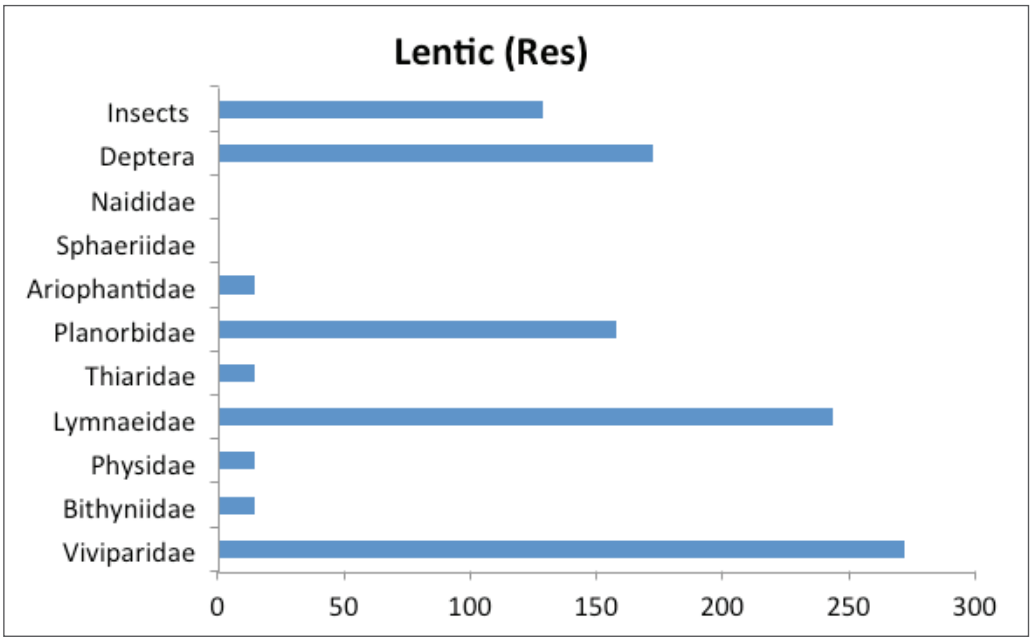


Figure 68 (b) *The abundance of the macroinvertebrate group (nos./m2) at lentic zone (reservoir)*

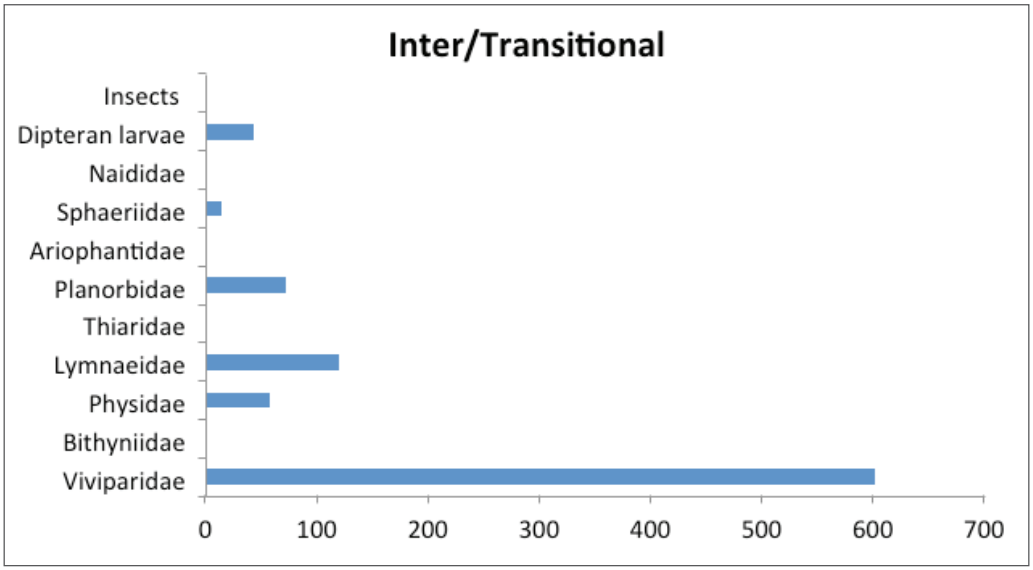


Figure 68 (c) *The abundance of the macroinvertebrate group (nos./m2) at intermediate zone*

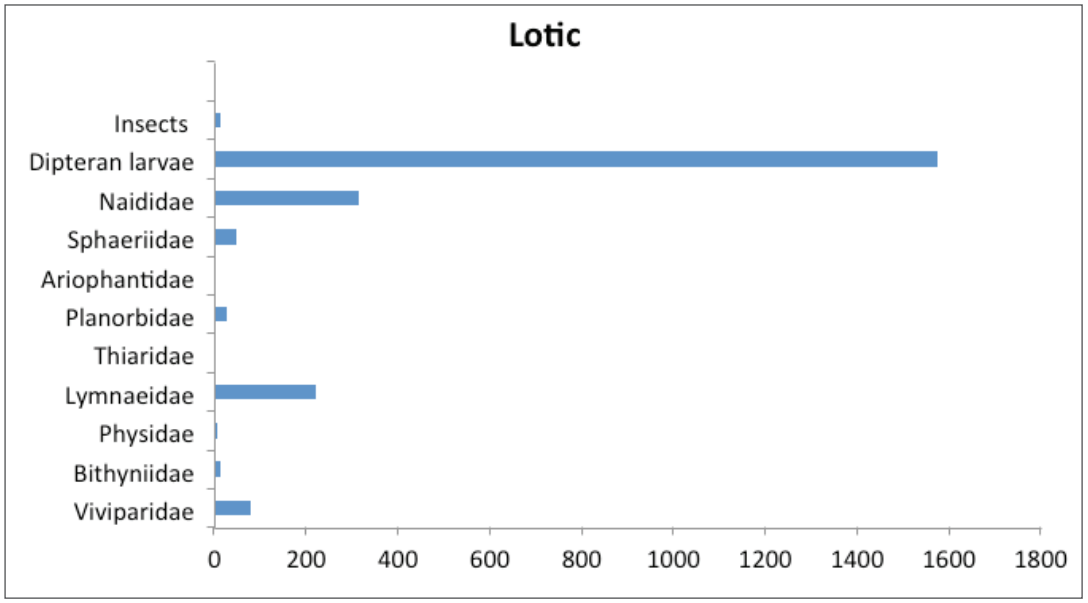


Figure 68 (d) *The abundance of the macroinvertebrate group (nos./m2) at lotic zone*

11 Threats to sustainable fisheries

Migratory birds

The number of migratory birds in Pong Reservoir is increasing year by year. Many juvenile fishes may be getting consumed by the birds, leading to a reduction in the fish population in Pong Reservoir. The relationship of the abundance of the migratory birds with the fish production also indicated a negative impact of migratory birds on fish production.

Presence of large predatory fishes

The presence of large predatory catfishes *(Wallago attu) i*s one of the most important threats from the fisheries' points of view in Pong Reservoir. Fish stocking is done regularly in Pong Reservoir for enhancing carp production. Large catfishes *(Wallago attu)* consume small fish vigorously, including the stocked fish in the reservoir, which can significantly impact the production of carps in the reservoir.

Erratic climatic variations

Climatic parameters such as temperature and rainfall are very important for the breeding, growth and survival of fishes in inland water bodies. The erratic climatic variations in Pong Reservoir can be considered potential threats for sustainable fish extraction in Pong Reservoir.

Inconsistent stocking

The stocking of fish in Pong Reservoir was inconsistent, which has impacted the fish production in the reservoir.

12 Suitable resource extraction models and guidelines to ensure sustainable resource extraction

12.1 GUIDELINES FOR SUSTAINABLE EXTRACTION OF FISH

Stocking policy

- Large-sized fish seed (>100 mm) is recommended for stocking in Pong Reservoir. Advanced fingerlings are recommended for reducing predation mortality due to large catfishes *(Sperata seenghala and Wallago attu)*. Large-sized fish seed is also recommended to reduce predation loss due to aquatic birds.
- Stocking density: Stocking 300 fishes/ha/year is recommended for enhancing the fish production in Pong Reservoir. A species combination of Rohu, Catla and Mrigal in the ratio 50:30:20 is recommended.
- Time for stocking: The stocking of fish should not be overlap with the season of abundance of migratory birds as the birds prey on small fishes.
- The bays and coves of the reservoir could be judiciously utilised for in situ raising of IMC fingerlings in floating pens,a CIFRI technology that has shown promising results in the Indirasagar and Mansarovar reservoirs of Madhya Pradesh.
- Stocking greater numbers of fish seed is recommended not only to increase the fish production but also to reduce the GHG emissions as most of the carps are phytoplankton feeders.

Harvesting policy

- Closed seasons should be observed on the basis of the breeding seasons of some of the important fish species such as the Mahaseer as the Mahaseer population has declined by around 50% in the last two decades.
- Multifilament gill nets are recommended instead of monofilament gill nets for fishing in the reservoir. The mesh size should be >80 mm to catch fish weighing more than 1 kg.
- The recommended fishing effort in Pong Reservoir is 67 gill nets per hectare or 1 million gill nets in a year, as per the Schaefer model.
- Once fish are harvested in the early morning hours, the nets should be brought to the shore for cleaning, mending and drying so that they can be used again in the evening. This would increase the catchability of the net with more fish. But here the nets are left in the reservoir after collecting gilled fishes which leads to smell from nets and lesser catchability.
- As the reservoir is dominated by catfish (especially *Sperata seengahla*), the use of small-meshed disco nets/monofilament nets should be strictly prohibited to allow the small indigenous fish to thrive as food fishes for the predatory catfish.

CONSERVATION

- The populations of most of the commercially important fishes, including the Mahaseer *(T. putitora),* have declined drastically in the last three decades. A protected area or aquatic sanctuary needs to be developed to protect the potential breeding ground of important species such as the Mahaseer, Seenghala and IMC.

ECOTOURISM

- Sport fishing needs to be promoted as important sport fishes such as the Seenghala and Mahaseer are the main fishes of Pong Reservoir. Value added fish product, especially the Seenghala, can be initiated to attract tourists from all over the country and abroad

Support

- Opportunities to develop the fisheries in the reservoir through PMMSY, RKVY, Blue Revolution schemes and other development schemes for fishers extended by the DoF, HP. The production and productivity of the reservoir will be developed; livelihood opportunities for the fishers thriving in this ecosystem will be enhanced.
- Establishment of ice-plants on either side of the reservoir, fish-selling kiosks (at least four or five kiosks at different landing centres across the reservoir), easy fish transportation avenues and processing plants should be given priority for proper disposal of fishes harvested from this reservoir. As suggested by the Tourism Development Department, ready-to-eat fish items should be made available at the tourist spots around the reservoir.
- Renovation/construction of the respective FCS office-cum-storehouses should be carried out to imbibe the activites of the FCS members in a more relevant manner.

12.2 ZONATION OF RESERVOIR FOR SUSTAINABLE EXTRACTION OF FISH RESOURCES

Zonation of the reservoir is necessary for optimum exploitation of the fish resources of vast reservoir. During the present investigation and earlier records of ICAR-CIFRI, it was observed that the greatest amount of fish is harvested from the lentic zone (dam and reservoir), followed by intermediate zone. Therefore, the priority fishing zones are required to be demarcated into four potential zones i.e. 1) lentic (dam), 2) lentic (reservoir), 3) transitional and 4) lotic. It was noticed that the fish resources of the deeper portions of the reservoir (both in the lentic zone and in the intermediate zone), have not been properly explored, which might be because the fishers do not have proper gear to employ in these deep parts or because they lack the craft needed to venture into such areas to harvest the larger-sized fish of the reservoir.

On the basis of the planktonic abundance, the presence of breeding grounds, species diversity and morphology (presence of streams and depth profile), the lentic zone (reservoir) was found to have the greatest potential for the fisheries. The number of licenses needs to be fixed proportionately on the basis of these findings. Accordingly, the 15 landing centres need to be allocated to different zones. With the lentic zone (reservoir) having the most potential, five landing centres (Nagrota Suriyan, Harsar, Jwali, Guglada and Sihal) may be allocated to this zone. The lentic zone (dam) also has potential for fishing because of the presence of several *khads* (streams) and thus five landing centres (Dhametha, Khatihar, Sathana, Barnali and Seul Khad) may be allocated to this zone. Being the zone where the lotic and lentic zones meet, the transitional zone is also productive in nature. These four landing centres (Haripur, Nandpur, Dadasiba and Jambal) may be allotted to this zone. Since the lotic zone is small in extent and the area and depth are highly variable in the different seasons, only one landing centre need be allocated to this zone.

The reservoir is divided into four zones, i.e., the riverine or lotic zone, the transitional or intermediate zone, the lentic (dam) zone and the lentic (reservoir) zone.

Lotic or riverine zone:

This zone has the properties of the river. The water area and the depth fluctuate greatly from season to season. The zone can be demarcated for breeding zones of the indigenous species. The zone is colder than the other zones of the reservoir, and the flow of the water makes the zone a suitable habitat for many indigenous fish species. Thus, the riverine zone can be demarcated for conservation of fish diversity.

Intermediate or transitional zone:

The transitional zone of the reservoir has the property of both the lotic and lentic zones. Transitional zones are generally considered to have the habitat preferred by many freshwater species. Transitional zones are considered to be more productive zones among the zones of a reservoir. Thus, this zone can be designated for production of fish.

Lentic (dam) zone:

This zone is the deepest part of the reservoir, and the water spread area is less fluctuating. This zone can be prioritised for fish production.

Lentic (reservoir) zone:

This zone is also the lentic part of the reservoir. However, the zone is much shallower than the lentic (dam) zone of the reservoir. Many small rivers and streams (locally known as *khads*) flow into the reservoir in this zone. As the depth is low and there are many inflowing streams in this zone, it can be prioritised as the breeding ground of fishes.

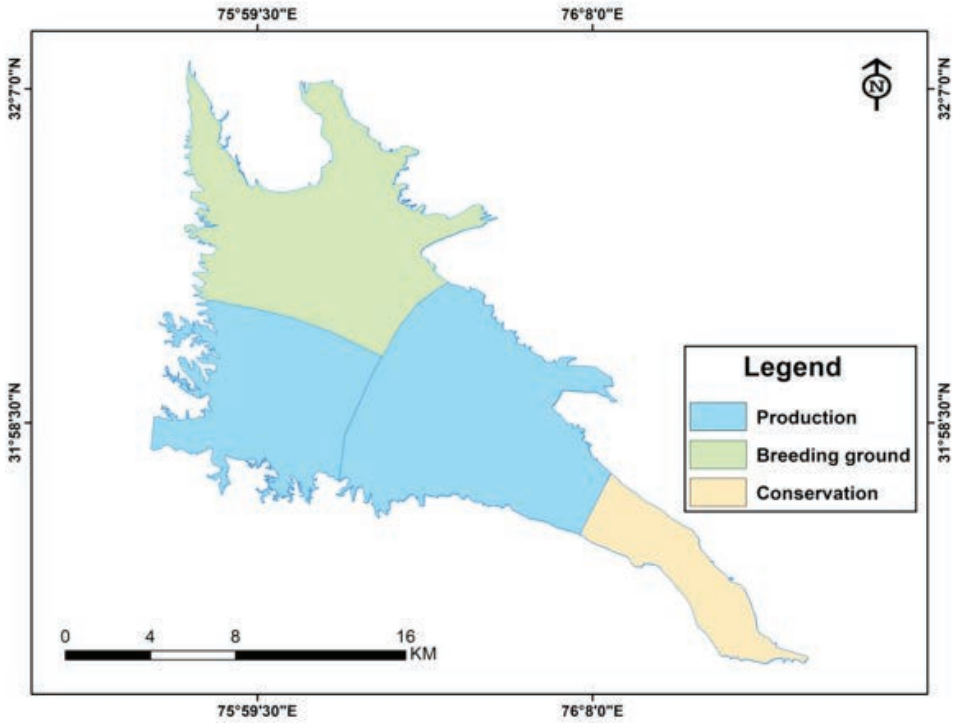


Figure 69 *Priorities in different zones of the reservoir*

12.3 RELATIONSHIP BETWEEN FISHERIES, ECO-TOURISM AND WETLAND USE BY WATER BIRDS

Nowadays, due attention is being given to the promotion of eco-tourism/aqua-tourism in inland open waters, especially reservoirs and wetlands, because of their unique landscapes, their natural beauty and the richness of the flora and fauna associated with them. Many reservoirs remain unexplored for development of eco-tourism. This is a sector with considerable for not only generating revenues for the government exchequer but also providing ample opportunities for entrepreneurship, like with many facets if properly managed, designed and shaped - the hotels, holiday homes, the kiosks for easy to have food items, the migratory birds viewing places, the jungle resorts with due safety aspects, the boating facilities, diving opportunities, transport lines, local tourist places of interests for sightseeing, the jungle retrieves besides venturing other such opportunities. The spectacular migratory birds will be of great interest to the tourists visiting Pong reservoir. The fisheries sector in Pong can be popularised greatly if ecotourism is developed jointly with other departments (tourism and wildlife).

Many tourists are attracted to Pong Reservoir because of its migratory birds and natural beauty. Sport fishing is also an important attractant for tourists at lakes and reservoirs. Boating and sport fishing (hook and rod) were initiated in Pong Reservoir as tourism activities. The Fisheries Department officials and fishermen feel that the fishing activity

and fish production have not been impacted by the tourism. However, the regression analysis of the time series data of fish production and migratory birds indicates that the increasing trend of the migratory birds has had a negative impact on the fish production.

As many birds are fish eaters, fish should not be stocked in sites that will potentially be utilised by migratory birds and the stocking time should not overlap with the period when migratory birds visit the reservoir. As rods and lines are selective gear and catch only large-sized fish, angling may be recommended in the reservoir. However, angling should not be recommended in the potential breeding zones and breeding seasons.

The DoF at Pong should be much more proactive so that there are many more kiosks for selling live fish ready-to-eat fish items are popularised amongst the tourists at the reservoir. The bird migration sites should be identified and protected.

Close coordination and networking are to be developed in bridging the gaps, if any, amongst the stakeholders. The Wildlife Department, Police, DoF, Tourism Department, the Department of Water Supply, the Irrigation Department, other such line departments and the local administration are to develop this sector in a holistic manner towards generating more revenues and livelihood opportunities for the stakeholders of this area without hampering the fish production and the rich biodiversity of the reservoir ecosystem.

Gill nets are the only nets operated in Pong Reservoir. Gill nets are set out in the evening till early morning in all the four zones of the reservoir. The ecotourism in Pong Reservoir takes the form of recreational boating, boating for birdwatching or for angling using rods and lines. Angling is mostly done in the lentic zone (dam) and lentic zone (reservoir) of the reservoir. Boating services for birdwatching and sports are also operated mostly in the lentic zone (dam) and lentic zone (reservoir). Angling uses selective gear that targets only specimens of the selected species of a particular size. According to the perceptions of the Fisheries Department officials, HP, angling does not have an adverse impact on commercial fish catch. The boating service for bird watching and sports is operated during the daytime, which does not disturb the gill net operations. However, angling is not recommended during the breeding season, i.e., the monsoon.

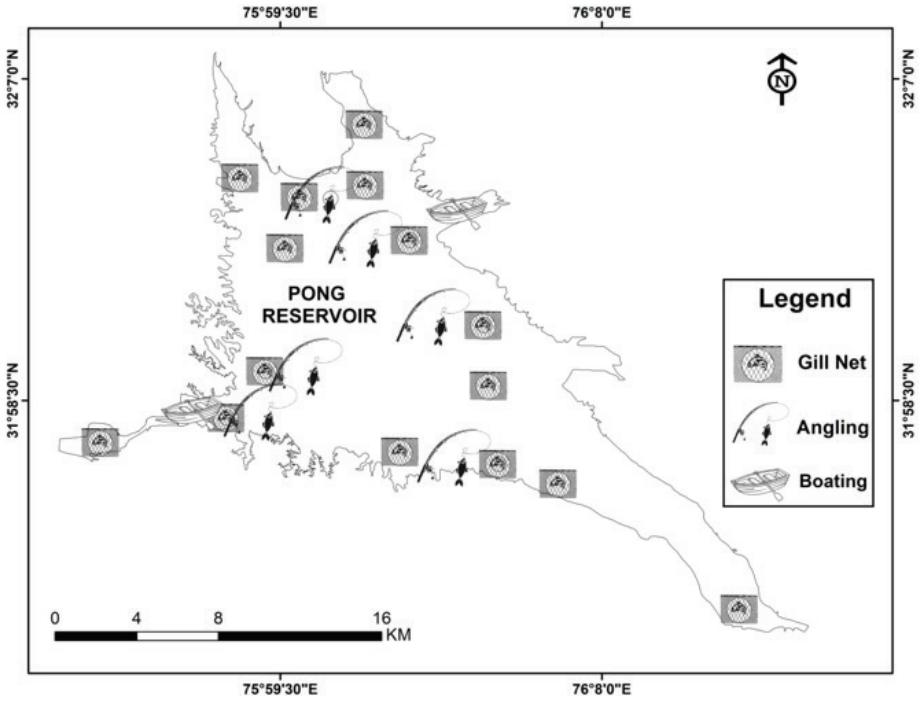


Figure 70 *Sites of gill net fishing, angling and boating*

12.4 GUIDELINES TO MINIMISE STAKEHOLDER CONFLICT

The purpose of Pong Reservoir is water storage for irrigation and hydroelectric power generation. However, the fisheries also play an important role in Pong Reservoir. As the reservoir harbours a rich biodiversity, it was declared a wildlife sanctuary and a Ramsar site. Due to its beautiful nature, the reservoir attracts many tourists for birdwatching and water sports. Certain guidelines are necessary to avoid conflicts between the stakeholders of Pong reservoir.

- The hydroelectric generation activity should not be disturbed by the fishing and tourism activities.
- Boating for birdwatching and water sports should be done during the daytime to avoid hampering with the fishing activity, which is mostly conducted from the evening till the next morning.
- The fishing activity should not disturb the migratory birds of Pong and its surroundings.
- Extreme fluctuations of the water levels, which may disturb the fish habitat in the reservoir, should be avoided. Proper habitat is very important for fish breeding and fish growth in open waters.
- Boating, water sports and angling activities should not pollute the environment, and the fish habitat should not be disturbed as far as possible.
- Fishing regulations, including closed seasons, mesh size regulations, protection of migratory birds and other regulations should be monitored with the involvement of all the stakeholders of Pong reservoir, including the local fishermen's cooperative societies.
- The channel of marketing the fish from the reservoir should be managed properly so that the fishermen get the maximum share to improve their livelihoods.

12.5 MULTI-STAKEHOLDER WORKSHOP ON SUSTAINABLE MANAGEMENT OF FISHERIES IN PONG RESERVOIR

ICAR-Central Inland Fisheries Research Institute (CIFRI), in association with Deutsche Gesellschaft für InternationaleZusammenarbeit (GIZ) GmbH, organised a stakeholder meeting on 19 February 2021 in the virtual mode for sustainable management of the fisheries in Pong Reservoir. The main objective of the meeting was to involve all the stakeholders of Pong Reservoir in formulating a policy for sustainable fish resource extraction from the reservoir. Dr. B.K. Das, Director, ICAR-CIFRI, and PI of the project, when inaugurating the meet, invited all the stakeholders to participate in holistic development of the fisheries and overall resource extraction of this reservoir and pointed out that the involvement of the Fisheries Dept., Wildlife Dept., Tourism Dept., anglers and FCS members of the 15 cooperative societies functioning in this reservoir are necessary. Dr. Das presented the findings of this study to the stakeholders and the draft recommendations for sustainable extraction of fish resources of Pong reservoir. Mr. Kunal Bharat, from GIZ, gave his comments and suggestions for improving the draft recommendation. Mr. Satpal Mehta, Director-cum-Warden of Fisheries, HP also addressed the meeting and gave his valuable comments and suggestions on various issues for the development of Pong reservoir. During interactions, Director of Fisheries, HP raised the issue that though 300 fingerlings per hectare per year are being stocked in the reservoir, this is not being reflected in the overall production. In his response, Dr. Das, said that as Pong is a catfish reservoir, stocking of advanced fingerlings (50–100 g) is necessary to overcome the pray–predator relationship. Dr. Das said that the desired stocking material could be produced in *situ* using CIFRI technologies (enclosure pens or floating cages) in the bays and coves in the reservoir. Explaining the development of eco-tourism facilities and the impact of migratory birds in the overall production of this fragile ecosystem, Dr. Das assured the stakeholders that their valuable inputs would be included in the final draft. He also commented on the use of gill nets of the right mesh size with multifilament

nets, saying that this was mostly not followed in the reservoir, saying that this should be viewed seriously. Officials of the Department of Fisheries, HP engaged duties at Pong Reservoir actively participated in the meeting, providing need-based inputs. Representatives of the 15 fishermen's cooperative societies took part actively and were involved in the discussion, sharing their experiences. During the meeting, important issues such as the impact of tourism on the fish production, the impact of migratory birds on the fish production and the stocking and harvesting policy were thoroughly discussed. All the suggestions and inputs were noted for incorporation in this report.

The meeting was coordinated by Dr. U. K. Sarkar, HoD, RWF Division, Dr. A. K. Das, PS & In-charge, Training & Extension Unit, and Dr. Lianthuamluaia, Scientist, the GIZ team and ICAR- CIFRI

Image 17 *Stakeholder meeting for developing the Pong Reservoir fisheries*

Photo credit: CarrotFilms.GIZ

ANNEXURE-I

Fish species recorded at pong reservoir during the study period

Sperata seenghala

Tor putitora

Cirrhinus mrigala

Labeo rohita

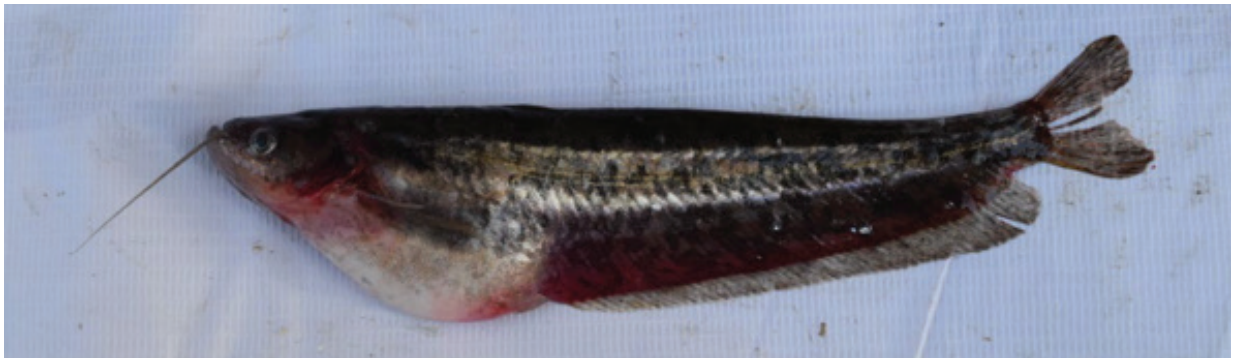
Labeo catla

Labeo calbasu

Cyprinus carpio

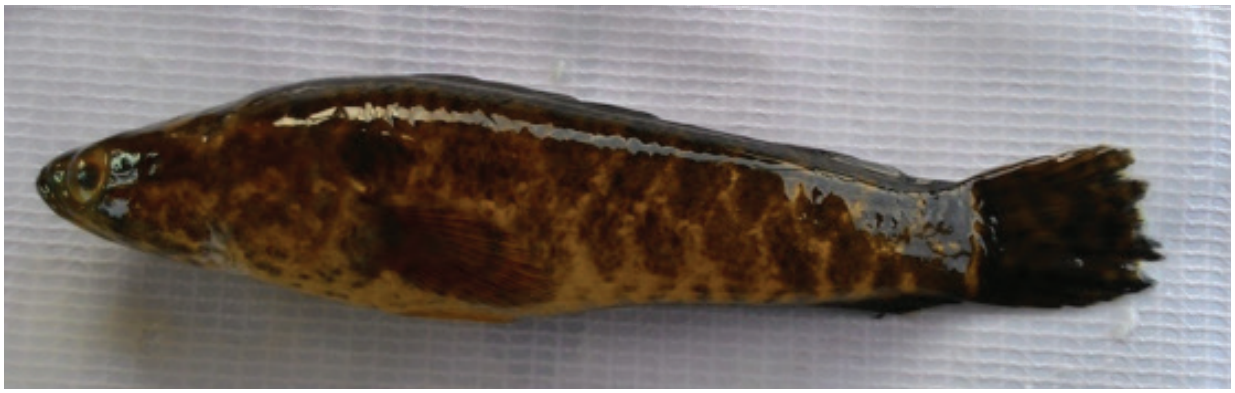
Hypophthalmichthys molitrix

Wallago attu



Ompok pabda

Channa marulius



Channa panctatus

Mastacembelus armatus

Xenentodon cancila

Systomus sarana

Puntius sophore

Osteobrama cotio

Chanda nama

Salmophasia phulo

Glossogobius giuris

ANNEXURE-II

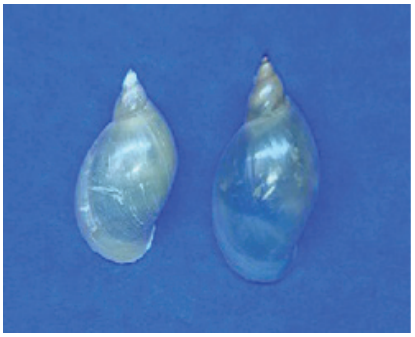
Macro-invertebrate organisms recorded during the study period

Filopaludina bengalensis

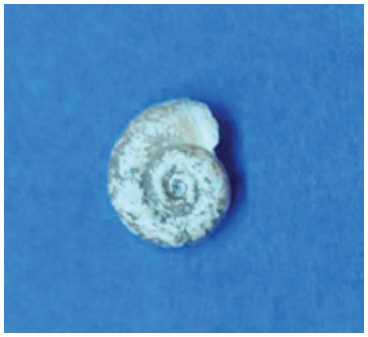
Bellamya dissmilis

Physella acuta

Lymnaea acumina



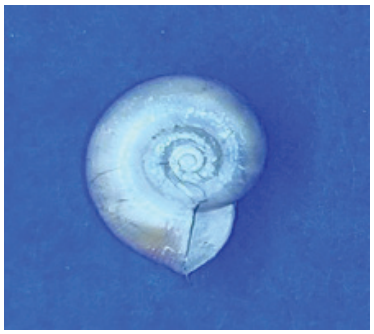
Lymnaea acumina



Gyraulus convexiusculus

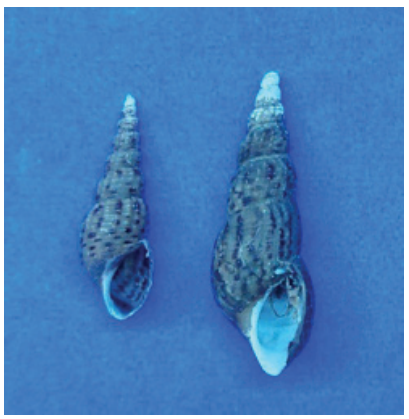
Macrochlamys indica

Ariophanta interrupta



Indoplanorbis exustus

Radix luteola

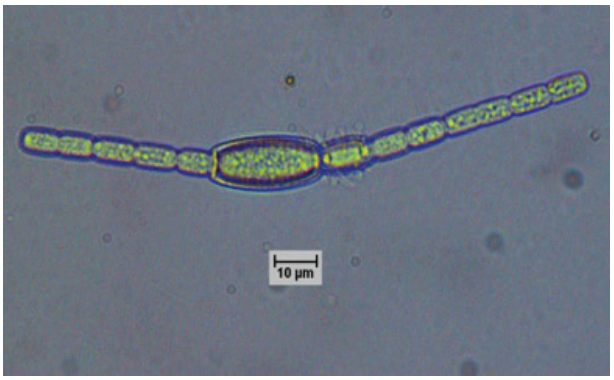


Melanoides tuberculata

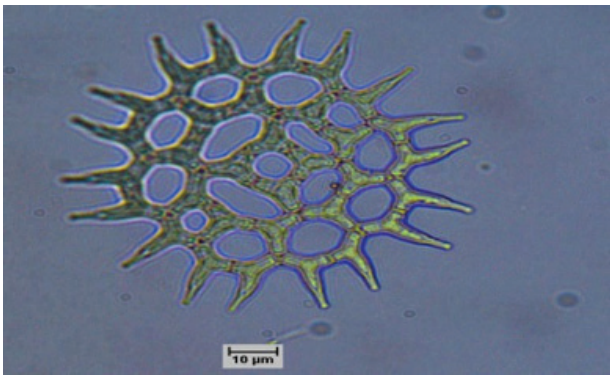
Insects

ANNEXURE-III

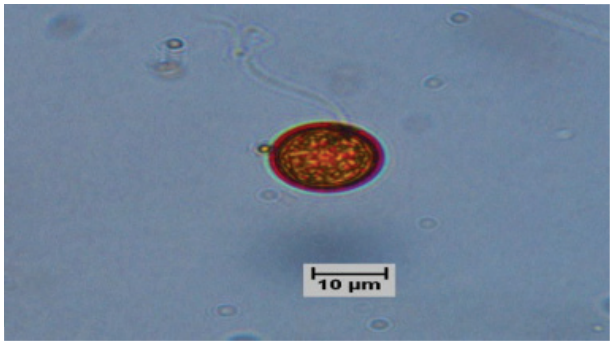
Phytophlanktonic genera recorded during the study period



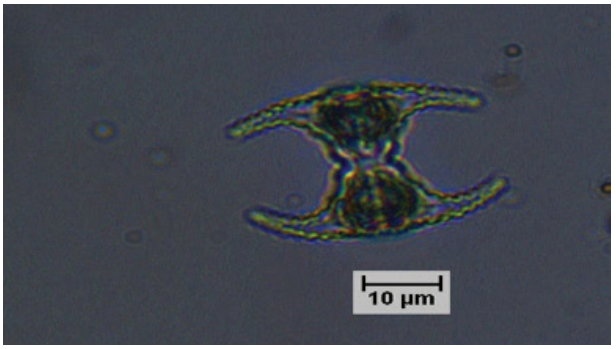
Anabaena sp.



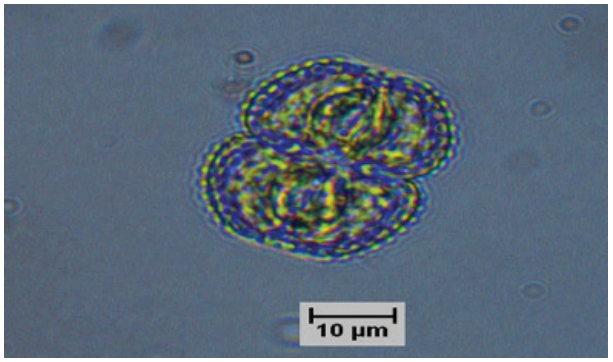
Pediastrum sp.



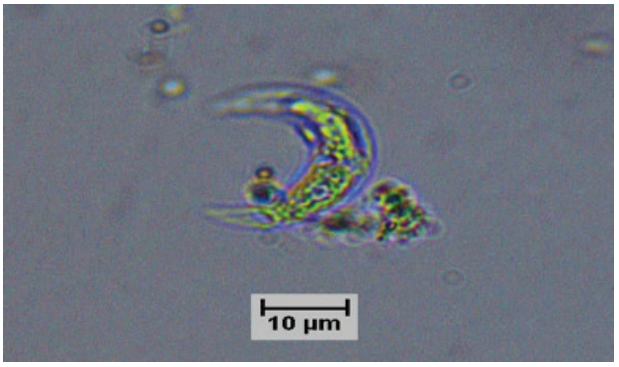
Trachelomonus sp.



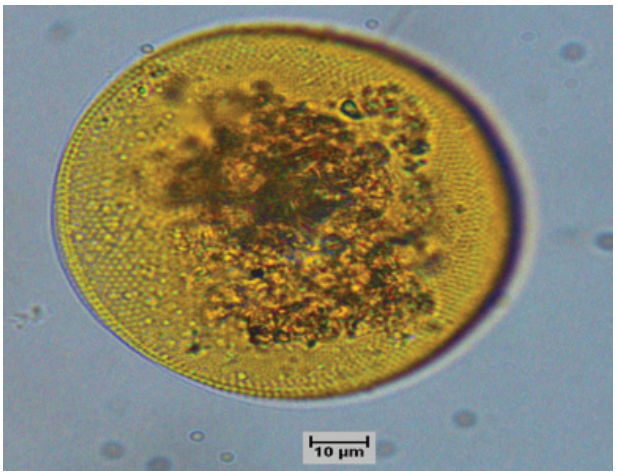
Staurastrum sp.



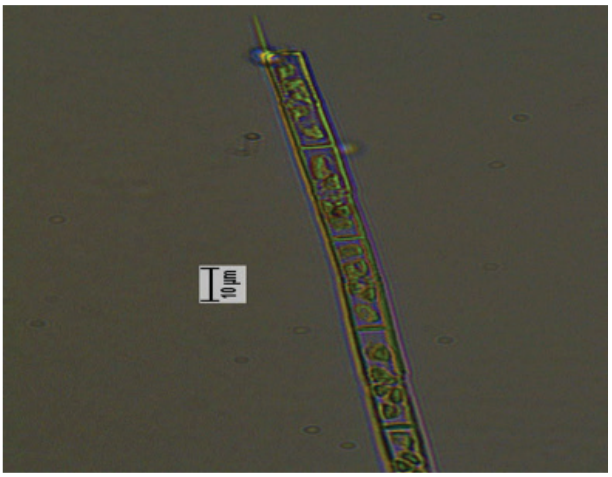
Cosmarium sp.



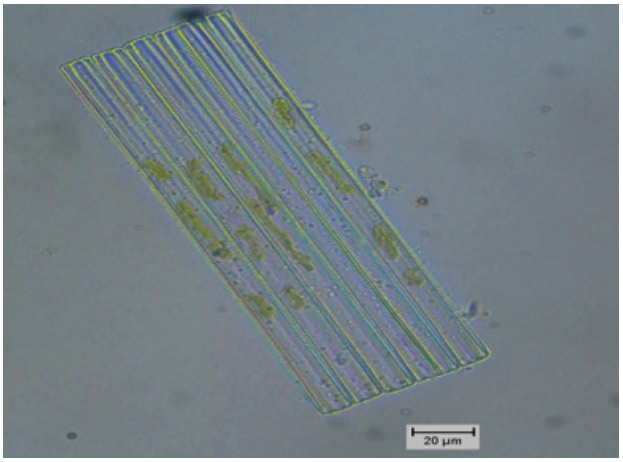
Closterium sp.



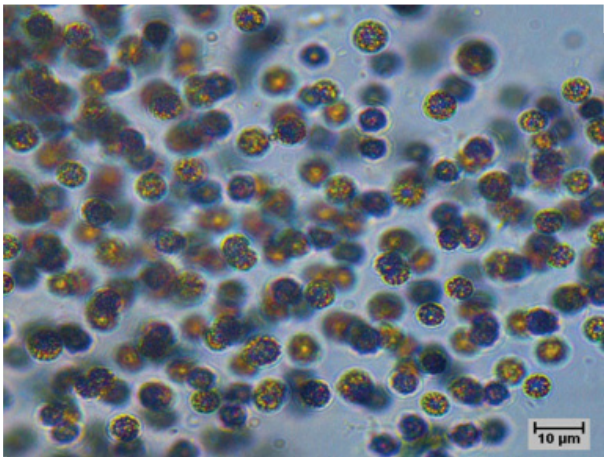
Arcella sp.



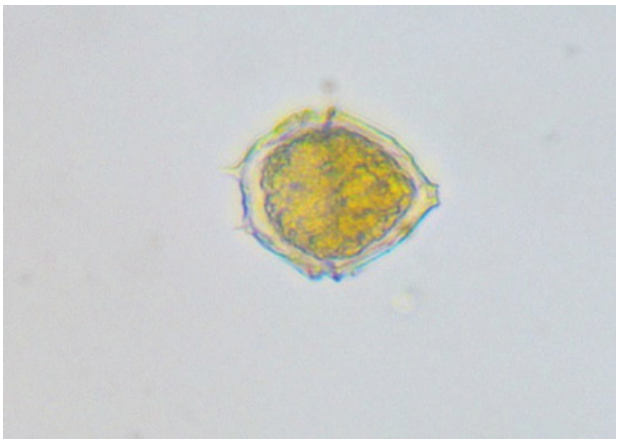
Aulacoseira sp.



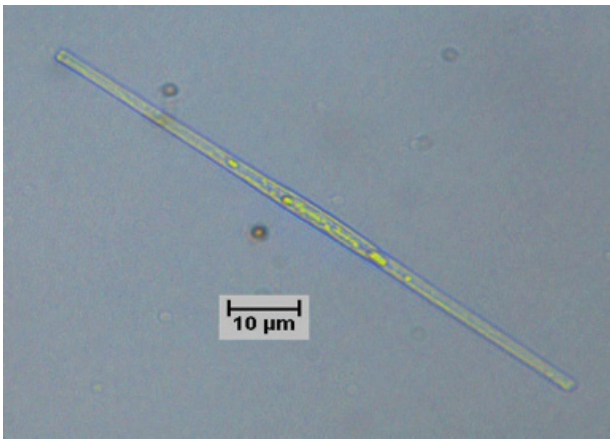
Fragillaria sp.



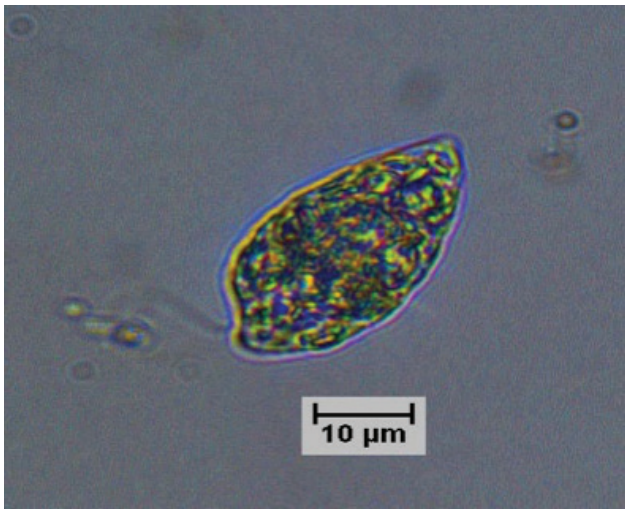
Microcystis sp.



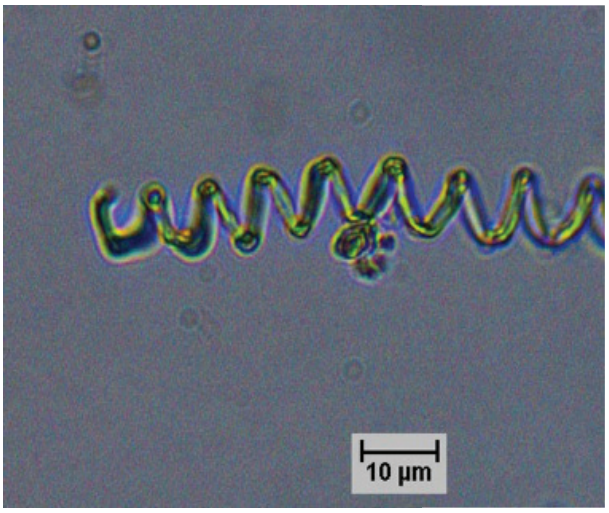
Peridinium sp.



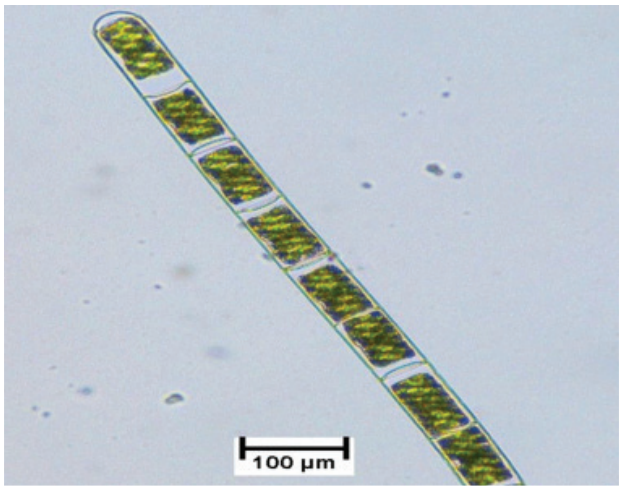
Synedra sp.



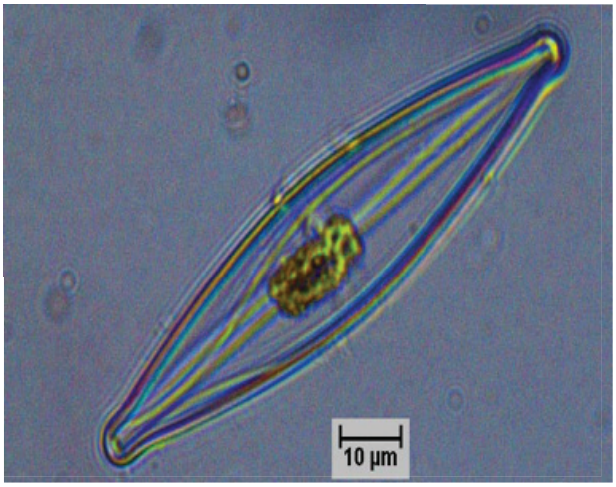
Euglena sp.



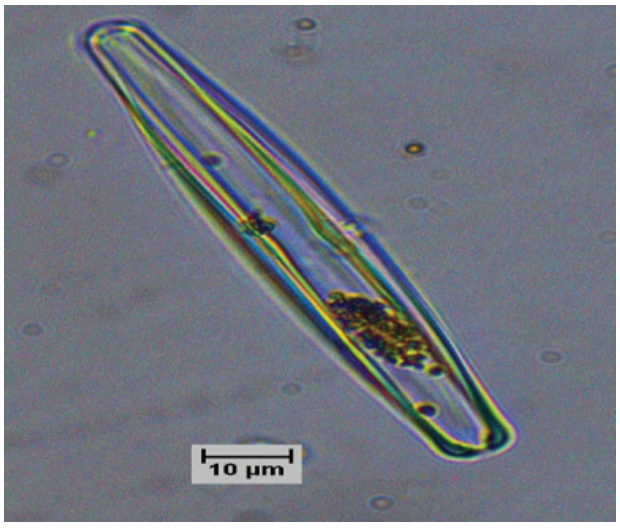
Spirulina sp.



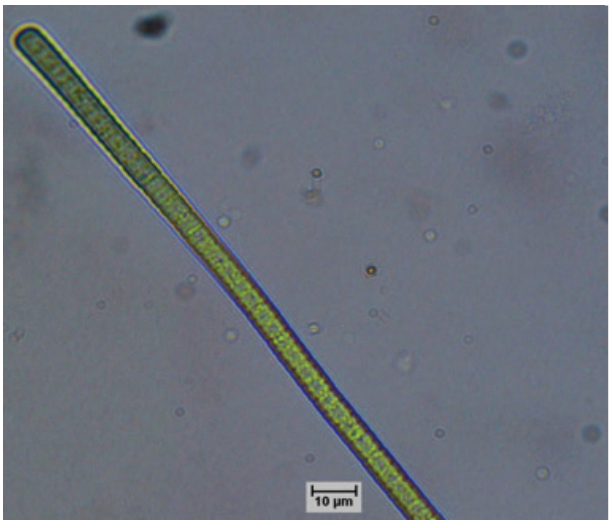
Spirogyra sp.



Oscillatoria sp.

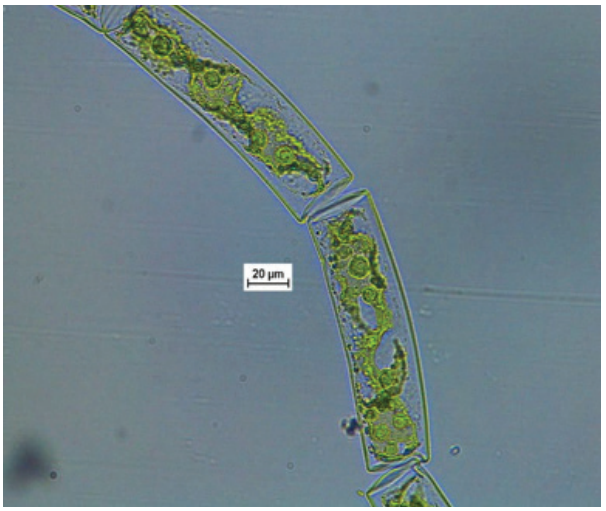


Pinnularia sp.

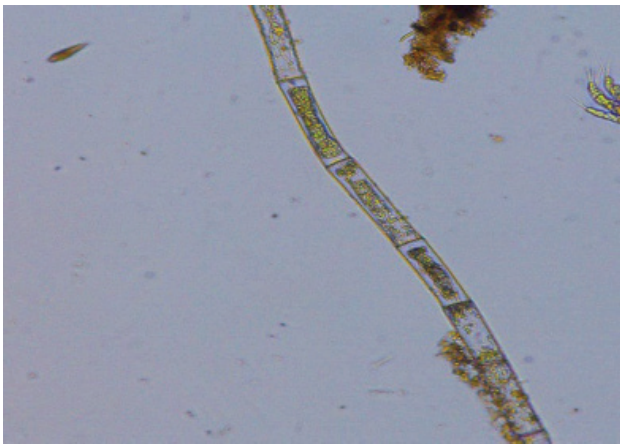


Oscillatoria sp.

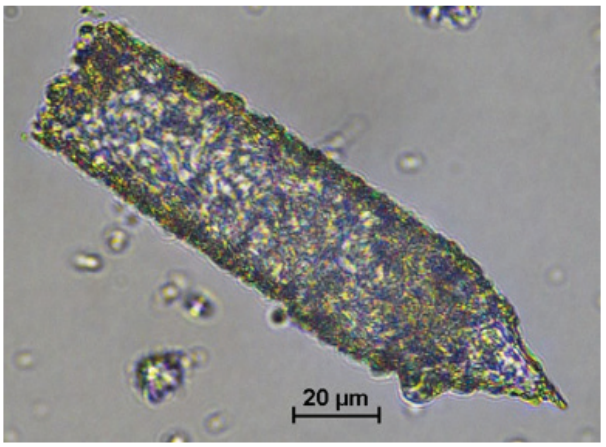
Cyclotella sp.



Mougeotia sp.



Horgonium sp.



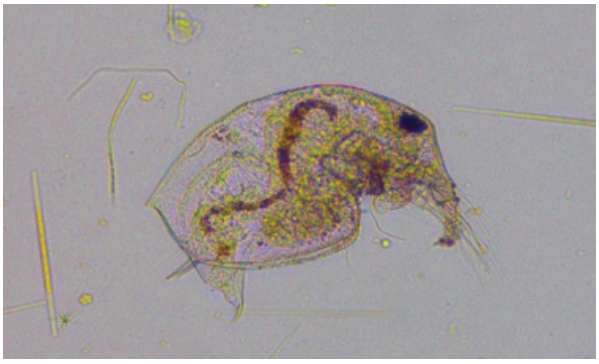
Tintinid sp.

ANNEXURE-IV

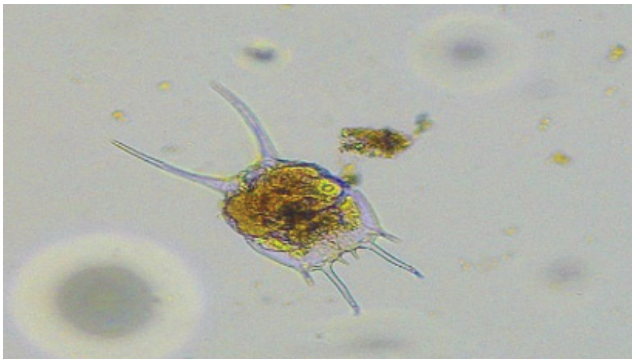
Zooplankton genera recorded during the project period

Nauplii

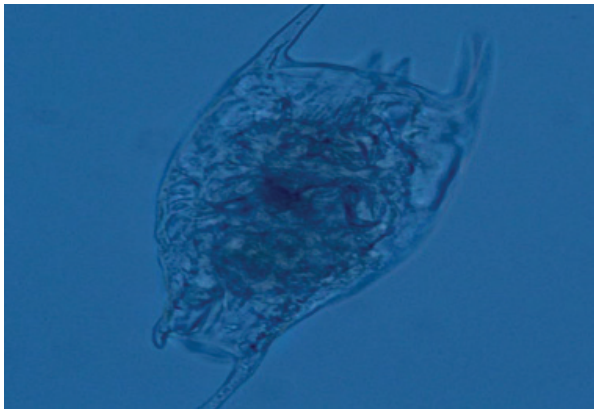
Nauplii



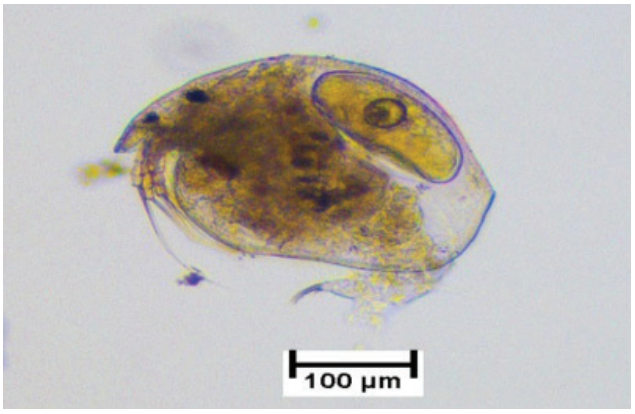
Bosmina



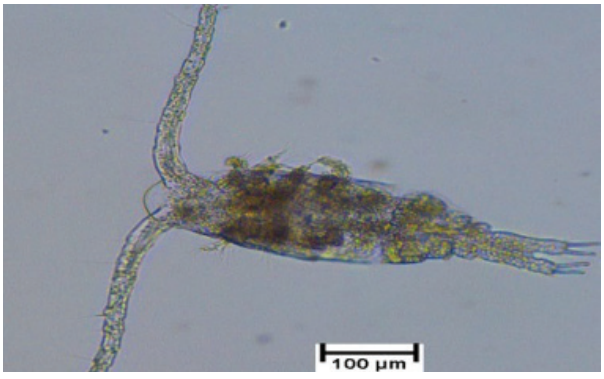
Brachionus



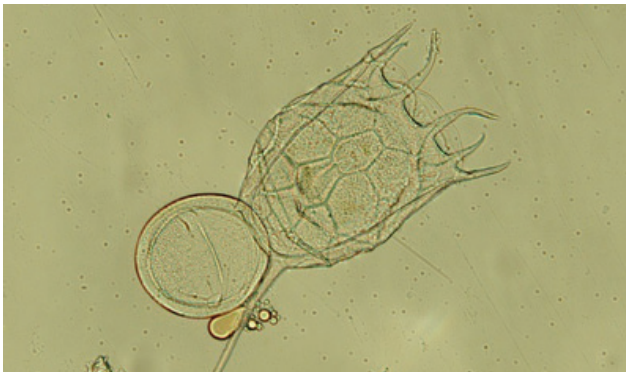
Brachionus



Chydorus



Diaptomus

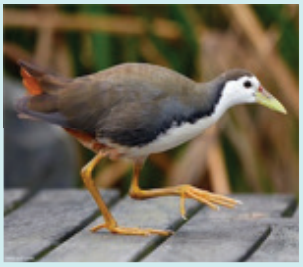


Keratella

ANNEXURE-V

List of birds of pong reservoir

Species	Common Name	Family	R/M	IUCN Status	Food and Feeding Habits
Antigone antigone 	Sarus Crane	Gruidae	R	V	Aquatic plants, grains, crustaceans, snails, large insects, amphibians, reptiles, small vertebrates and fishes
Apus affinis 	Indian House Swift	Apodidae	R	LC	Insects, grains, fruits
Accipiter badius 	Indian Shikra	Accipitridae	R	LC	Crustaceans, snails, large insects, amphibians, reptiles, small vertebrates and fishes
Accipiter badius 	Northern Goshawk	Accipitridae	R	LC	Crustaceans, snails, large insects, amphibians, reptiles, small vertebrates and fishes
Acrocephalus stentoreus 	Clamorous Reed Warbler	Musicapidae	R	LC	Grains, fruits, snails, insects

Species	Common Name	Family	R/M	IUCN Status	Food and Feeding Habits
Acrocephalus melanopogon 	Moustached Warbler	Musicapidae	M	LC	Grains, fruits, snails, insects
Acrocephalus dumetorum 	Blyth's Reed Warbler	Muscicapidae	M	LC	Grains, fruits, snails, insects
Acrocephalus agricola 	Paddy field Warbler	Musicapidae	R	LC	Grains, fruits, snails, insects
Accipiter nisus 	Asiatic Sparrow Hawk	Accipitridae	M	LC	Crustaceans, snails, large insects, amphibians, reptiles, small vertebrates and fishes
Accipiter virgatus affinis 	Besra	Accipitridae	R	LC	Crustaceans, snails, large insects, amphibians, reptiles, small vertebrates and fishes
Amaurornis phoenicurus 	Whitebreasted Waterhen	Rallidae	R	LC	Aquatic plants, seeds, fruits, insects, fishes, molluscs amphibians

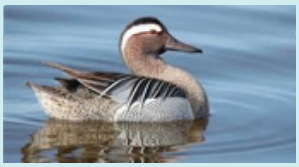
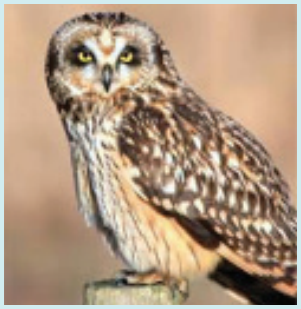
Species	Common Name	Family	R/M	IUCN Status	Food and Feeding Habits
Amaurornis akool 	Brown Crake	Rallidae	R	LC	Aquatic plants, grains, crustaceans, snails, insects and fishes
Ardeola grayii 	Indian Pond Heron	Ardeidae	R	LC	Fishes, insects, molluscs, crustaceans, worms, amphibians
Aethopyga siparaja 	Crimson Sunbird	Nectariniidae	R	LC	Aquatic plants, grains, fruits, crustaceans, snails, insects and fishes
Ardea alba 	Great Egret	Ardeidae	R	LC	Fishes, insects, molluscs, worms, crustaceans, amphibians, reptiles
Ardea cineria 	Grey Heron	Ardeidae	R	LC	Fishes, insects, molluscs, worms, crustaceans, amphibians, reptiles
Athene brama 	Spotted Owlet	Strigidae	R	LC	Fishes, insects, molluscs, worms, crustaceans, amphibians, reptiles

Species	Common Name	Family	R/M	IUCN Status	Food and Feeding Habits
Ardea purpurea 	Purple Heron	Ardeidae	R	LC	Fishes, insects, molluscs, worms, crustaceans, amphibians, reptiles
Anas poecilorhyncha 	Spot-billed Duck	Anatidae	R	LC	Seeds, aquatic plants, molluscs, insects, fish, crustaceans
Anser indicus 	Bar-Headed Goose	Anatidae	M	LC	Seeds, aquatic plants, molluscs, insects, fishes, crustaceans, grains
Anhinga melanogaster 	Oriental Darter/Snake Bird	Phalacrocoracidae	R	NT	Fishes, insects, molluscs, crustaceans, worms, amphibians, reptiles
Acridotheres tristis 	Indian Myna	Sturnidae	R	LC	Seeds, grains, fruits, insects, molluscs, crustaceans, worms
Acridotheres fuscus 	Jungle Myna	Sturnidae	R	LC	Seeds, grains, fruits, insects, molluscs, crustaceans, worms
Anthus trivialis 	Tree Pipit	Motacillidae	R	LC	Seeds, grains, fruits, insects, molluscs, crustaceans, worms

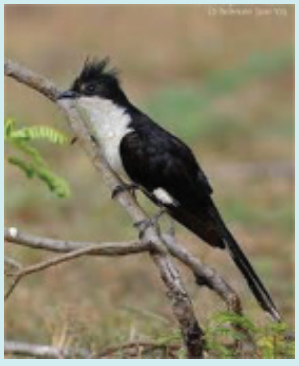
Species	Common Name	Family	R/M	IUCN Status	Food and Feeding Habits
Anthus rufulus 	Indian Paddy field Pipit	Motacillidae	R	LC	Seeds, grains, fruits, insects, molluscs, crustaceans, worms
Anthus campestris 	Tawny Pipit	Motacillidae	R	LC	Seeds, grains, fruits, insects, molluscs, crustaceans, worms
Anthus cervinus 	Red Throated Pipit	Motacillidae	R	LC	Seeds, grains, fruits, insects, molluscs, crustaceans, worms
Anthus roseatus 	Rosy Pipit	Motacillidae	R	LC	Seeds, grains, fruits, insects, molluscs, crustaceans, worms
Anthus similis 	Long-Billed Pipit	Motacillidae	R	LC	Seeds, grains, fruits, insects, molluscs, crustaceans, worms
Alcedo atthis 	Indian Small Blue Kingfisher	Alcedinidae	R	LC	Fishes, insects, molluscs, crustaceans, worms, amphibians, reptiles
Arenaria interpres 	Ruddy Turnstone	Scolopacidae	M	LC	Fishes, insects, molluscs, crustaceans, worms, amphibians, reptiles

Species	Common Name	Family	R/M	IUCN Status	Food and Feeding Habits
Anastomus oscitans 	Asian Openbill	Ciconiidae	R	LC	Fishes, insects, molluscs, crustaceans, worms, amphibians, reptiles
Actitis hypoleucos 	Common Sandpiper	Scolopacidae	R	LC	Grains, fruits, molluscs, insects, fishes, crustaceans
Aquila heliaca 	Eastern Imperial Eagle	Accipitridae	R	V	Crustaceans, snails, insects, amphibians, reptiles, small vertebrates and fishes
Aquila nipalensis 	Steppe Eagle	Accipitridae	R	EN	Crustaceans, snails, insects, amphibians, reptiles, small vertebrates and fishes
Aquila clanga 	Greater Spotted Eagle	Accipitridae	R	V	Crustaceans, snails, insects, amphibians, reptiles, small vertebrates and fishes
Aythya marila 	Scaup Duck	Anatidae	R	LC	Aquatic plants, crustaceans, molluscs, insects and fishes

Species	Common Name	Family	R/M	IUCN Status	Food and Feeding Habits
Aythya ferina 	Common Pochard	Anatidae	M	V	Aquatic plants, crustaceans, molluscs, insects and fishes
Anser anser 	Greylag Goose	Anatidae	R	LC	Aquatic plants, crustaceans, molluscs, insects and fishes
Anser albifrons 	Greater White-fronted Goose	Anatidae	M	LC	Aquatic plants, crustaceans, molluscs, insects and fishes
Anas clypeata 	Northern Shoveler	Anatidae	M	LC	Aquatic plants, crustaceans, molluscs, insects and fishes
Aegithalos concinnus 	Black-Throated Tit	Paridae	R	LC	Seeds, grains, fruits, insects, molluscs, crustaceans, worms
Aythya fuligula 	Tufted Duck	Anatidae	M	LC	Aquatic plants, crustaceans, molluscs, insects and fishes

Species	Common Name	Family	R/M	IUCN Status	Food and Feeding Habits
Anas penelope 	Eurasian Wigeon	Anatidae	M	LC	Aquatic plants, crustaceans, molluscs, insects and fishes
Anas querquedula 	Garganey	Anatidae	M	LC	Aquatic plants. insects, molluscs, crustaceans, worms, fishes
Aythya nyroca 	Ferruginous Duck	Anatidae	M	NT	Aquatic plants, seeds. insects, molluscs, crustaceans, worms, fishes
Anas acuta 	Northern Pintail	Anatidae	M	LC	Aquatic plants, seeds. insects, molluscs, crustaceans, worms, fishes
Asio flammeus 	Short-Eared Owl	Strigidae	R	LC	Insects, amphibians, reptiles, small vertebrates and fishes
Anas crecca 	Common Teal	Anatidae	M	LC	Aquatic plants. insects, molluscs, crustaceans, worms, fishes
Anas platyrhynchos 	Mallard	Anatidae	M	LC	Aquatic plants, seeds. insects, molluscs, crustaceans, worms, fishes

Species	Common Name	Family	R/M	IUCN Status	Food and Feeding Habits
Anas strepera 	Gadwall	Anatidae	M	LC	Aquatic plants, crustaceans, molluscs, insects and fishes
Buteo rufinus 	Long-Legged Buzzard	Accipitridae	M	LC	Crustaceans, snails, insects, amphibians, reptiles, small vertebrates and fishes
Buteo buteo 	Common Buzzard	Accipitridae	R	LC	Crustaceans, snails, insects, amphibians, reptiles, small vertebrates and fishes
Bubulcus ibis 	Cattle Egret	Ardeidae	R	LC	Crustaceans, snails, insects, amphibians, reptiles, small vertebrates and fishes
Cettia brunnifrons 	Grey-Sided Bush Warbler	Muscicapidae	R	LC	Seeds, grains, fruits, insects, molluscs, crustaceans, worms
Ceryle rudis 	Pied Kingfisher	Alcedinidae	R	LC	Fishes, aquatic insects, amphibians, reptiles, crustaceans

Species	Common Name	Family	R/M	IUCN Status	Food and Feeding Habits
Centropus sinensis 	Common Crow Pheasant	Cuculidae	R	LC	Crustaceans, snails, insects, amphibians, reptiles, small vertebrates and fishes
Coracias benghalensis 	Northern Roller	Coraciidae	R	LC	Seeds, grains, fruits, insects, molluscs, crustaceans, worms
Calandrella brachydactyla 	Greater Short-Toed Lark	Alaudidae	R	LC	Seeds, grains, fruits, insects, molluscs, crustaceans, worms
Calandrella raytal 	India Sand Lark	Alaudidae	R	LC	Seeds, grains, fruits, insects, molluscs, crustaceans, worms
Ciconia episcopus 	Woolly-Necked Stork	Ciconiidae	R	NT	Fishes, insects, molluscs, crustaceans, worms, amphibians, reptiles
Clamator jacobinus 	Pied Crested Cuckoo	Cuculidae	R	LC	Seeds, grains, fruits, insects, molluscs, crustaceans, worms

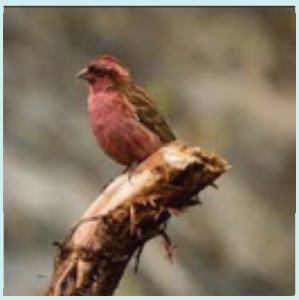
Species	Common Name	Family	R/M	IUCN Status	Food and Feeding Habits
Cuculus micropterus 	Indian Cuckoo	Cuculidae	R	LC	Seeds, grains, fruits, insects, molluscs, crustaceans, worms
Calidris ferruginea 	Curlew Sandpiper	Scolopacidae	R	LC	Fruits, insects, molluscs, worms, amphibians, reptiles
Charadrius dubius 	Indian Little Ringed Plover	Charadriidae	R	LC	Seeds, insects, molluscs, worms, amphibians, reptiles
Charadrius mongolus 	Lesser Sand Plover	Charadriidae	R	LC	Seeds, insects, molluscs, worms, amphibians, reptiles
Charadrius leschenaultii 	Greater Sand Plover	Charadriidae	M	LC	Seeds, insects, molluscs, worms, amphibians, reptiles
Charadrius alexandrinus 	Kentish Plover	Charadriidae	M	LC	Seeds, insects, molluscs, worms, amphibians, reptiles
Charadrius hiaticula 	Common Ringed Plover	Charadriidae	M	LC	Seeds, insects, molluscs, worms, amphibians, reptiles

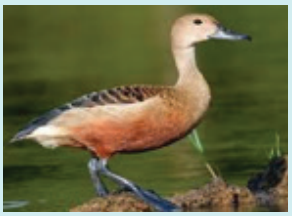
Species	Common Name	Family	R/M	IUCN Status	Food and Feeding Habits
Circus aeruginosus 	Western Marsh Harrier	Accipitridae	M	LC	Fishes, insects, molluscs, crustaceans, worms
Circus cyaneus 	Hen Harrier	Accipitridae	R	LC	Crustaceans, snails, insects, amphibians, reptiles, small vertebrates and fishes
Circus melanoleucos 	Pied Harrier	Accipitridae	R	LC	Crustaceans, snails, insects, amphibians, reptiles, small vertebrates and fishes
Circaetus gallicus 	Short-Toed Eagle	Accipitridae	R	LC	Crustaceans, snails, insects, amphibians, reptiles, small vertebrates and fishes
Ciconia nigra 	Black Stork	Ciconiidae	R	LC	Crustaceans, snails, insects, amphibians, reptiles, small vertebrates and fishes
Copsychus saularis 	Indian Magpie Robin	Muscicapidae	R	LC	Crustaceans, snails, insects, amphibians, reptiles, small vertebrates and fishes

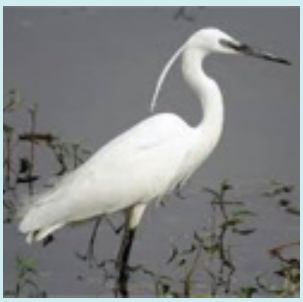
Species	Common Name	Family	R/M	IUCN Status	Food and Feeding Habits
Cercomela fusca 	Brown Rock Chat	Muscicapidae	R	LC	Seeds, insects, amphibians, worms
Coturnix coturnix 	Common Quail	Phasianidae	R	LC	Seeds, insects, amphibians, worms
Columba livia 	Indian Little Ringed Plover	Columbidae	R	LC	Seeds, insects, amphibians, worms
Caprimulgus asiaticus 	Indian Little Nightjar	Caprimulgidae	R	LC	Seeds, insects, amphibians, worms
Calidris testacea 	Curlew Sandpiper	Charadriidae	R	LC	Seeds, insects, amphibians, worms
Caprimulgus indicus 	Indian Jungle Nightjar	Caprimulgidae	R	LC	Seeds, insects, amphibians, worms
Corvus splendens 	Indian House Crow	Corvidae	R	LC	Seeds, insects, amphibians, worms, reptiles, small vertebrates

Species	Common Name	Family	R/M	IUCN Status	Food and Feeding Habits
Corvus macrorhynchos 	Indian Jungle Crow	Corvidae	R	LC	Seeds, insects, amphibians, worms, reptiles, small vertebrates
Chlidonias hybridus 	Whiskered Tern	Laridae	R	LC	Fshes, insects, molluscs, crustaceans, worms, amphibians
Chroicocephalus brunnicephalus 	Brown-Headed gull	Laridae	R	LC	Fishes, insects, molluscs, crustaceans, worms, amphibians
Chroicocephalus genei 	Slender-Billed Gull	Laridae	R	LC	Fishes, insects, molluscs, crustaceans, worms, amphibians, reptiles
Calidris minuta 	Little Stint	Charadriidae	M	LC	Insects, molluscs, crustaceans, worms

Species	Common Name	Family	R/M	IUCN Status	Food and Feeding Habits
Calidris temminckii 	Temminck's Stint	Scolopaciidae	M	LC	Fishes, insects, molluscs, crustaceans, worms
Coracina macei 	Large Cuckoo Shrike	Campephagidae	R	LC	Seeds, insects, amphibians, worms, reptiles
Chrysomma sinense 	Western Yellow-Eyed Babbler	Muscicapidae	M	LC	Seeds, insects, amphibians, worms, reptiles
Cyornis rubeculoides 	Blue-Throated Flycatcher	Musiciapidae	M	LC	Seeds, insects, amphibians, worms, reptiles
Culicicapa ceylonensis 	Grey-Headed Canary Flycatcher	Muscicapidae	M	LC	Seeds, insects, amphibians, worms, reptiles
Carduelis cannabina 	Eurasian Linnet	Fringillidae	M	LC	Seeds, insects, worms, fruits

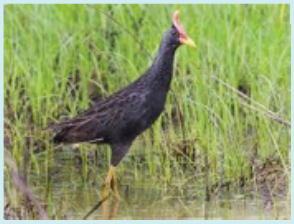
Species	Common Name	Family	R/M	IUCN Status	Food and Feeding Habits
Carduelis carduelis 	European Goldfinch	Fringillidae	M	LC	Seeds, insects, worms, fruits
Carduelis spinoides 	Yellow-Breasted Greenfinch	Fringillidae	R	LC	Seeds, insects, worms, fruits
Carpodacus erythrinus 	Indan Rosefinch	Fringillidae	R	LC	Seeds, insects, worms, fruits
Carpodacus rodochrous 	Pink-Browed Rose Finch	Fringillidae	R	LC	Seeds, insects, worms, fruits
Calidris subminuta 	Long-Toed stint	Charadriidae	R	LC	Fishes, insects, molluscs, crustaceans, worms, seeds
Calidris alpina 	Dunlin	Scolopacidae	R	LC	Insects, molluscs, crustaceans, worms, seeds, fishes

Species	Common Name	Family	R/M	IUCN Status	Food and Feeding Habits
Dicrurus macrocercus 	King Crow	Dicruridae	R	LC	Grains, fruits, molluscs, insects, fishes, crustaceans
Dicrurus leucophaeus 	Ashy Drongo	Dicruridae	R	LC	Grains, fruits, molluscs, insects, fishes, crustaceans
Dendrocygna javanica 	Lesser whistling Teal	Anatidae	R	LC	Aquatic plants. insects, molluscs, crustaceans, worms, fishes
Dinopium benghalense 	Northern Golden-Backed Woodpecker	Picidae	R	LC	Grains, fruits, flower nectar, molluscs, insects
Dendrocops mahrattensis 	Yellow-Fronted Woodpecker	Picidae	R	LC	Grains, fruits, flower nectar, molluscs, insects
Dendrocops auriceps 	Brown-Fronted Woodpecker	Picidae	R	LC	Grains, fruits, flower nectar, molluscs, insects

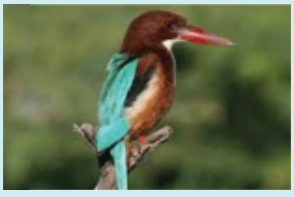
Species	Common Name	Family	R/M	IUCN Status	Food and Feeding Habits
Dendrocitta vagabunda 	Western Tree Pie	Corvidae	R	LC	Grains, fruits, flower nectar, molluscs, insects
Dicaeum agile 	Thick-Billed Flowerpecker	Dicaeidae	M	LC	Grains, fruits, flower nectar, insects
Dupetor flavicollis 	Black Bittern	Ardeidae	R	LC	Crustaceans, molluscs, insects and fishes
Egretta garzetta 	Little Egret	Ardeidae	R	LC	Fishes, insects, molluscs, crustaceans, worms, amphibians, reptiles
Estrilda amandava 	Red Munia	Ploceidae	R	LC	Grains, fruits, molluscs, insects
Eudynamys scolopacea 	Indian Koel	Cuculidae	R	LC	Grains, fruits, molluscs, insects

Species	Common Name	Family	R/M	IUCN Status	Food and Feeding Habits
Esacus recurvirostris 	Great Stone Plover	Burhinidae	M	NT	Fishes, insects, molluscs, crustaceans, worms, amphibians, reptiles
Eremopterix grisea 	Ashy-Crowned Finch Lark	Alaudidae	R	LC	Grains, fruits, molluscs, insects, crustaceans
Emberiza leucocephalos 	Red-Headed Bunting	Emberizidae	R	LC	Grains, fruits, molluscs, insects, crustaceans
Emberiza buchanani 	Grey-Necked Bunting	Emberizidae	R	LC	Grains, fruits, molluscs, insects, crustaceans
Emberiza stewarti 	White-Capped Bunting	Emberizidae	R	LC	Grains, fruits, molluscs, insects, crustaceans
Emberiza cia 	Rock Bunting	Emberizidae	R	LC	Grains, fruits, molluscs, insects, crustaceans

Species	Common Name	Family	R/M	IUCN Status	Food and Feeding Habits
Elanus caeruleus 	Black-Winged Kite	Anatidae	R	LC	Fishes, insects, molluscs, crustaceans, worms, amphibians, reptiles, small vertebrates
Falco pregrinus 	Peregrine Falcon	Falconidae	R	LC	Fishes, insects, molluscs, crustaceans, worms, amphibians, reptiles, small vertebrates
Falco peregrinator 	Shaheen Falcon	Falconidae	M	LC	Fishes, insects, molluscs, crustaceans, worms, amphibians, reptiles, small vertebrates
Falco tinnunculus 	European Kestrel	Falconidae	M	LC	Fishes, insects, molluscs, crustaceans, worms, amphibians, reptiles, small vertebrates
Francolinus francolinus 	Indian Black Partridge	Phasianidae	R	LC	Fishes, insects, molluscs, crustaceans, worms, amphibians, reptiles, small vertebrates
Francolinus pondicerianus 	North Indian Grey Partridge	Phasianidae	R	LC	Fishes, insects, molluscs, crustaceans, worms, amphibians, reptiles

Species	Common Name	Family	R/M	IUCN Status	Food and Feeding Habits
Fulica atra 	Common Coot	Rallidae	M	LC	Aquatic plants, insects, molluscs, worms, small fishes
Ficedula tricolor 	Slaty Blue Flycatcher	Muscicapidae	R	LC	Fruits, insects, molluscs, crustaceans, worms
Ficedula parva 	Red-Throated Flycatcher	Muscicapidae	R	LC	Fruits, insects, molluscs, crustaceans, worms
Ficedula superciliaris 	Ultramarine Flycatcher	Muscicapidae	M	LC	Fruits, insects, molluscs, crustaceans, worms
Gallicrex cinerea 	Watercock	Rallidae	R	LC	Fishes, insects, molluscs, crustaceans, worms, amphibians, reptiles
Gallinula chloropus 	Common Moorhen	Rallidae	R	LC	Grains, fruits, molluscs, insects, fishes, crustaceans, amphibians

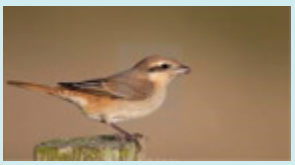
Species	Common Name	Family	R/M	IUCN Status	Food and Feeding Habits
Gallinago stenura 	Pintail Snipe	Charadriidae	M	LC	Grains, fruits, molluscs, insects, fishes, crustaceans, amphibians
Glareola maldivarum 	Oriental Pratincole	Burhinidae	M	LC	Fishes, insects, molluscs, crustaceans, worms, amphibians
Glaucidium radiatum 	Jungle Owlet	Strigidae	R	LC	Fishes, insects, molluscs, crustaceans, reptiles, worms, amphibians
Garrulax variegatus 	Variegated Laughing Thrush	Muscicapidae	M	LC	Grains, fruits, molluscs, insects, crustaceans, amphibians
Garrulax lineatus 	Streaked Laughing Thrush	Muscicapidae	R	LC	Grains, fruits, molluscs, insects, crustaceans, amphibians
Galerida cristata 	Indian Crested Lark	Alaudidae	R	LC	Fruits, insects, molluscs, crustaceans, reptiles, worms, amphibians

Species	Common Name	Family	R/M	IUCN Status	Food and Feeding Habits
Glareola lactea 	Small Indian Pratincole	Glareolidae	R	LC	Fruits, insects, molluscs, crustaceans, reptiles, worms, amphibians
Gallinago gallinago 	Fantail Snipe	Charadriidae	M	LC	Insects, molluscs, crustaceans, reptiles, worms, amphibians
Gallus gallus 	Red Junglefowl	Phasianidae	R	LC	Insects, molluscs, crustaceans, reptiles, worms, amphibians
Gyps fulvus 	Indian Griffon Vulture	Accipitridae	R	LC	Fishes, aquatic insects , amphibians, reptiles, crustaceans, small vertebrates
Gyps himalayensis 	Himalayan Griffin	Accipitridae	M	NT	Fishes, aquatic insects , amphibians, reptiles, crustaceans, small vertebrates
Halcyon smyrnensis 	White-Throated Kingfisher	Alcedinidae	R	LC	Fishes, aquatic insects , amphibians, reptiles, crustaceans

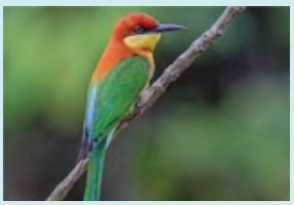
Species	Common Name	Family	R/M	IUCN Status	Food and Feeding Habits
Hydrophasianus chirurgus 	Pheasant-Tailed Jacana	Jacanidae	R	LC	Aquatic plants, grains, crustaceans, snails, large insects, amphibians, reptiles, small vertebrates and fishes
Hierococcyx varius 	Common Hawk Cuckoo	Cuculidae	R	LC	Fruits, insects, molluscs, crustaceans, worms
Haematopus ostralegus 	Oystercatcher	Haemato-podidae	R	NT	Insects, molluscs, crustaceans, worms
Haliaeetus leucoryphus 	Pallas Fishing Eagle	Accipitridae	R	EN	Insects, molluscs, crustaceans, worms
Hieraaetus fasciatus 	Bonelli's Eagle	Accipitridae	R	LC	Crustaceans, snails, large insects, amphibians, reptiles, small vertebrates and fishes
Hieraaetus pennatus 	Booted Eagle	Accipitridae	R	LC	Crustaceans, snails, large insects, amphibians, reptiles, small vertebrates and fishes
Hirundo rupestris 	Eurasian Crag Martin	Hirundinidae	M	LC	Insects, molluscs, crustaceans, worms

Species	Common Name	Family	R/M	IUCN Status	Food and Feeding Habits
Hirundo smithii 	Indian Wire-Tailed Swallow	Hirundinidae	R	LC	Insects, molluscs, crustaceans, worms
Hippolais caligata 	Booted Warbler	Muscicapidae	M	LC	insects, molluscs, crustaceans, worms
Himantopus himantopus 	Black-winged stilt	Muscicapidae	M	LC	Insects, molluscs, crustaceans, worms
Ichthyaetus ichthyaetus 	Great black-headed gull	Recurvirostri-dae	R	LC	Fishes, insects, molluscs, crustaceans
Ixobrychus cinnamomeus 	Cinnamon Bittern	Ardeidae	R	LC	Fishes, insects, molluscs, crustaceans, worms, amphibians, reptiles
Ixobrychus sinensis 	Yellow Bittern	Ardeidae	R	LC	Fishes, insects, molluscs, crustaceans, worms, amphibians, reptiles

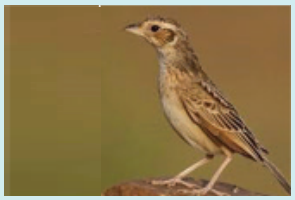
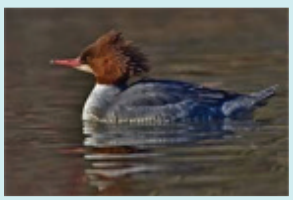
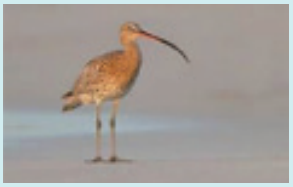
Species	Common Name	Family	R/M	IUCN Status	Food and Feeding Habits
Larus michahellis 	Yellow-Legged Gull	Laridae	M	LC	Fishes, insects, molluscs, crustaceans, worms, amphibians, reptiles
Larus canus 	Mew Gull	Laridae	M	LC	Fishes, insects, molluscs, crustaceans, worms, amphibians, reptiles
Lophura leucomelanos 	Kalij Pheasant	Phasianidae	R	LC	Insects, molluscs, crustaceans, worms, amphibians, reptiles
Larus cachinnans 	Caspian Gull	Laridae	M	LC	Fishes, insects, molluscs, crustaceans, worms, amphibians, reptiles
Larus fuscus 	Lesser Black-Backed Gull	Laridae	M	LC	Fishes, insects, molluscs, crustaceans, worms, amphibians, reptiles
Larus ridibundus 	Black-Headed Gull	Laridae	M	LC	Fishes, insects, molluscs, crustaceans, worms, amphibians, reptiles
Larus minutus 	Little Gull	Laridae	M	LC	Fishes, insects, molluscs, crustaceans, worms, amphibians, reptiles

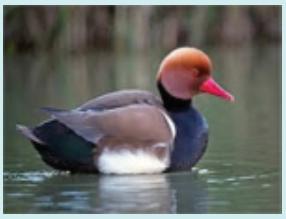
Species	Common Name	Family	R/M	IUCN Status	Food and Feeding Habits
Luscinia svecica 	Bluethroat	Muscicapidae	M	LC	Grains, fruits, molluscs, insects, crustaceans
Luscinia pectoralis 	White-Tailed Rubythroat	Muscicapidae	M	LC	Grains, fruits, molluscs, insects, crustaceans
Luscinia brunnea 	Indian Blue Robin	Muscicapidae	R	LC	Molluscs, insects, crustaceans
Locustella naevia 	Grasshopper Warbler	Muscicapidae	R	LC	Grains, fruits, molluscs, insects, crustaceans
Lanius vittatus 	Indian Bay-Backed Shrike	Laniidae	R	LC	Molluscs, insects, crustaceans, amphibians, reptiles
Lanius isabellinus 	Rufous-Tailed Shrike	Laniidae	R	LC	Molluscs, insects, crustaceans, amphibians, reptiles
Lanius schach 	Rufous-Backed Shrike	Laniidae	R	LC	Molluscs, insects, crustaceans, amphibians, reptiles

Species	Common Name	Family	R/M	IUCN Status	Food and Feeding Habits
Lymnocryptes minimus 	Jack Snipe	Rostratulidae	M	LC	Seeds, plants, insects, molluscs, crustaceans, worms
Limosa limosa 	Black-Tailed Godwit	Charadriidae	M	NT	Aquatic plants, insects, molluscs, worms
Mesophoyx intermedia 	Median Egret	Ardeidae	R	LC	Molluscs, insects, crustaceans, amphibians, reptiles, fishes
Milvus migrans govinda 	Pariah Kite	Accipitridae	M	LC	Molluscs, insects,Crustaceans, amphibians, reptiles, fishes
Milvus migrans lineatus 	Black-Eared or Large Indian Kite	Accipitridae	R	LC	Molluscs, insects, rustaceans, amphibians, reptiles, fishes
Motacilla alba 	White Wagail	Motacillidae	R	LC	Molluscs, insects, crustaceans, amphibians, reptiles, fishes
Motacilla citreola 	Citrine Wagtail	Motacillidae	R	LC	Molluscs, insects, crustaceans, amphibians, reptiles, fishes

Species	Common Name	Family	R/M	IUCN Status	Food and Feeding Habits
Mycteria leucocephala 	Painted Stork	Ciconiidae	M	NT	Fishes, insects, molluscs, crustaceans, worms, amphibians, reptiles
Motacilla flava 	Yellow Wagtail	Motacillidae	R	LC	Seeds, grains, insects, worms, molluscs, reptiles
Monticola solitarius 	Blue Rock Thrush	Muscicapidae	R	LC	Grains, fruits, molluscs, insects, crustaceans, amphibians
Monticola cinclorhynchus 	Blue-Headed Rock Thrush	Musiciapidae	R	LC	Fruits, molluscs, insects, crustaceans, amphibians, reptiles
Myophonus caeruleus 	Blue Whistling Thrush	Muscicapidae	R	LC	Fruits, molluscs, insects, crustaceans, amphibians, reptiles
Merops leschenaulti 	Chestnut-Headed Bee-Eater	Meropidae	R	LC	Fruits, molluscs, insects, spiders, amphibians
Miliaria calandra 	Corn Bunting	Emberizidae	R	LC	Insects, spiders, fruits, seeds

Species	Common Name	Family	R/M	IUCN Status	Food and Feeding Habits
Melophus lathami 	Crested Bunting	Emberizidae	R	LC	Insects, spiders, fruits, seeds
Merops persicus 	Crested Bunting	Emberizidae	R	LC	Insects, spiders, fruits, seeds
Megalurus palustris 	Blue-Cheeked Bee-Eater	Meropidae	R	LC	Insects, spiders, fruits, seeds
Merops orientalis 	Indian Small Green Bee-Eater	Meropidae	R	LC	Fruits, molluscs, insects, spiders, amphibians
Merops philippinus 	Blue-Tailed Bee-Eater	Meropidae	R	LC	Fruits, molluscs, insects, spiders, amphibians
Psilogon virens 	Great Barbet	Capitonidae	R	LC	Fruits, molluscs, insects, spiders, amphibians
Megalaima zeylanica 	Brown-Headed Barbet	Capitonidae	R	LC	Fruits, molluscs, insects, spiders, amphibians

Species	Common Name	Family	R/M	IUCN Status	Food and Feeding Habits
Megalaima asiatica 	Blue-Throated Barbet	Capitonidae	R	LC	Fruits, molluscs, insects, spiders, amphibians
Megalaima haemacephala 	Crimson-Breasted Barbet	Capitonidae	R	LC	Fruits, molluscs, insects, spiders, amphibians
Mirafra erythroptera 	Indian Bush Lark	Alaudidae	R	LC	Fruits, seeds, molluscs, insects, spiders, amphibians
Muscicapa dauurica 	Asian Brown Flycatcher	Muscicapidae	R	LC	Fruits, seeds, molluscs, insects, spiders
Motacilla cinerea 	Grey Wagtail	Motacillidae	R	LC	Seeds, grains, insects, worms
Mergus merganser 	Goosander	Anatidae	M	LC	Aquatic plants, insects, molluscs, crustaceans, worms, fishes
Numenius arquata 	Eurasian Curlew	Charadriidae	R	NT	Seeds, insects, molluscs, worms, crustaceans

Species	Common Name	Family	R/M	IUCN Status	Food and Feeding Habits
Nectarinia asiatica 	Purple Sunbird	Nectariniidae	R	LC	Seeds, grains, insects, worms
Numenius phaeopus 	Whimbrel	Scolopacidae	R	LC	Seeds, insects, molluscs, crustaceans, worms
Netta rufina 	Red-Crested Pochard	Anatidae	R	LC	Seeds, insects, molluscs, crustaceans, worms, fishes
Neophron percnopterus 	Egyptian Vulture	Accipitridae	M	EN	Fishes, insects, molluscs, crustaceans, worms, amphibians, reptiles, small vertebrates
Nycticorax nycticorax 	Night Heron	Ardeidae	R	LC	Fishes, insects, molluscs, crustaceans, worms, amphibians, reptiles, small vertebrates
Orthotomus sutorius 	Indian Tailorbird	Muscicapidae	R	LC	Flower nectar, seeds, insects, molluscs, worms
Oriolus oriolus 	Indian Golden Oriole	Oriolidae	R	LC	Flower nectar, seeds, insects, molluscs, worms

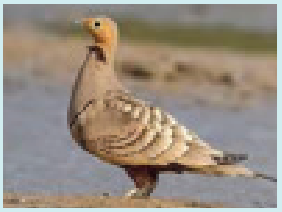
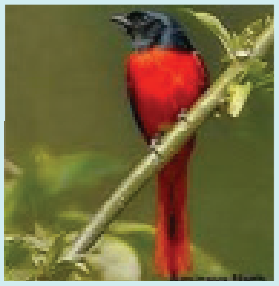
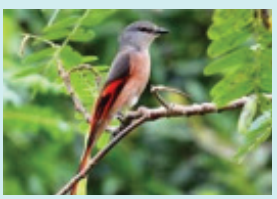
Species	Common Name	Family	R/M	IUCN Status	Food and Feeding Habits
Pavo cristatus 	Indian Peafowl	Phasianidae	R	LC	Flower nectar, seeds, insects, molluscs, worms, reptiles, amphibians
Oenanthe deserti 	Desert Wheatear	Muscicapidae	R	LC	Seeds, insects, molluscs, worms
Oenanthe picata 	Variable Wheatear	Muscicapidae	R	LC	Seeds, insects, molluscs, worms
Otus sunia 	Oriental Scops Owl	Strigidae	R	LC	Fishes, insects, molluscs, crustaceans, worms, amphibians, reptiles, small vertebrates
Pernis ptilorhyncus 	Oriental Honey Buzzard	Accipitridae	R	LC	Insects, amphibians, reptiles, small mammals, nestlings and eggs of birds, worms, fruits and berries
Porphyrio porphyrio 	Purple Swamphen	Rallidae	M	LC	Vegetable matter, insects, arthopods, molluscs, small fishes

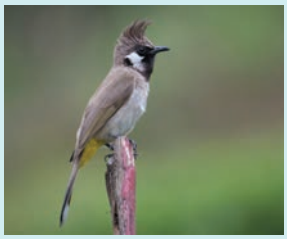
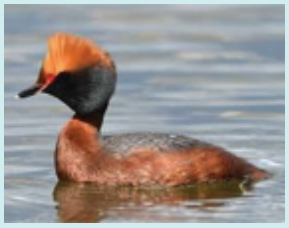
Species	Common Name	Family	R/M	IUCN Status	Food and Feeding Habits
Perdicula asiatica 	Jungle Bush Quail	Phasianidae	R	LC	Insects, molluscs, crustaceans, worms, amphibians, reptiles
Phaenicophaeus leschenaultii 	Western Sirkeer Cuckoo	Cuculidae	R	LC	Grains, fruits, molluscs, insects, worms
Psittacula eupatria 	Large Indian Parakeet	Psittacidae	R	NT	Grains, fruits, seeds, insects
Psittacula krameri 	Northern Rose-Ringed Parakeet	Psittacidae	R	LC	Grains, fruits, seeds, insects
Psittacula himalayana 	Himalayan Slaty-Headed Parakeet	Psittacidae	R	LC	Grains, fruits, seeds, insects
Pitta brachyura 	Indian Pitta	Pittidae	R	LC	Insects, fruits, molluscs, worms, spiders
Pseudibis papillosa 	Red-Naped Ibis	Threskiornith-idae	R	LC	Fishes, insects, molluscs, crustaceans, worms, amphibians, reptiles, seeds

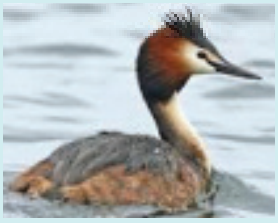
Species	Common Name	Family	R/M	IUCN Status	Food and Feeding Habits
Phylloscopus fuligiventer 	Smoky Warbler	Muscicapidae	R	LC	Insects, fruits, molluscs, worms, spiders
Phylloscopus griseolus 	Sulphur-Bellied Warbler	Muscicapidae	M	LC	Insects, fruits, molluscs, worms, spiders
Phoenicurus ochruros 	Black Redstart	Muscicapidae	R	LC	Insects, fruits, molluscs, worms, spiders
Phoenicurus caeruleocephalus 	Blue-Capped Redstart	Muscicapidae	R	LC	Insects, fruits, molluscs, worms, spiders
Phoenicurus frontalis 	Blue-Fronted Redstart	Muscicapidae	R	LC	Insects, fruits, molluscs, worms, spiders
Phylloscopus collybita 	Brown Chiffchaff	Muscicapidae	R	LC	Insects, fruits, molluscs, worms, spiders

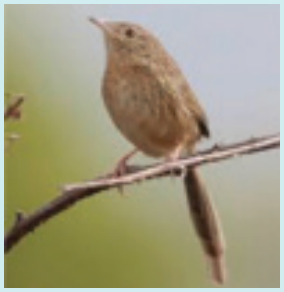
Species	Common Name	Family	R/M	IUCN Status	Food and Feeding Habits
Phylloscopus humei 	Hume's Warbler	Muscicapidae	M	LC	Insects, fruits, molluscs, worms, spiders
Phylloscopus sindhianus 	Mountain Chiff Chaff	Muscicapidae	R	LC	Insects, fruits, molluscs, worms, spiders
Phylloscopus subviridis 	Brook's Leaf Warbler	Muscicapidae	M	LC	Insects, fruits, molluscs, worms, spiders
Phylloscopus trochiloides 	Greenish Warbler	Muscicapidae	R	LC	Insects, fruits, molluscs, worms, spiders
Phylloscopus occipitalis 	Western-Crowned Warbler	Muscicapidae	M	LC	Insects, fruits, molluscs, worms, spiders
Passer domesticus 	Indian House Sparrow	Ploceidae	R	LC	Insects, fruits, molluscs, worms, spiders, grains
Pseudibis papillosa 	Chestnut-Shouldered Petronia	Ploceidae	R	LC	Insects, fruits, molluscs, worms, spiders, grains, amphibians, reptiles

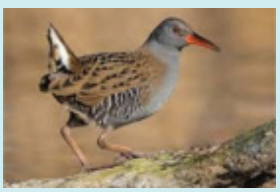
Species	Common Name	Family	R/M	IUCN Status	Food and Feeding Habits
Ploceus philippinus 	Weaver Bird	Ploceidae	R	LC	Insects, fruits, molluscs, worms, spiders, grains, amphibians, reptiles
Ploceus benghalensis 	Black-Throated Weaver Bird	Ploceidae	R	LC	Insects, fruits, molluscs, worms, spiders, grains, amphibians, reptiles
Ploceus manyar 	Indian Streaked Weaver Bird	Ploceidae	R	LC	Insects, fruits, molluscs, worms, spiders, grains, amphibians, reptiles
Phalacrocorax fuscicollis 	Indian Cormorant	Phalacrocora - cidae	R	LC	Molluscs, worms, insects, crustaceans, amphibians, reptiles, fishes
Phalacrocorax niger 	Little Cormorant	Phalacrocora - cidae	R	LC	Molluscs, worms, insects, crustaceans, amphibians, reptiles, fishes
Phalacrocorax carbo 	Great Cormorant	Phalacrocora - cidae	R	LC	Molluscs, worms, insects, crustacea ns, amphibians, reptiles, fishes

Species	Common Name	Family	R/M	IUCN Status	Food and Feeding Habits
Phylloscopus humei 	Osprey	Accipitridae	R	LC	Fishes, insects, molluscs, crustaceans, worms, amphibians, reptiles
Picus canus 	Grey-Headed Woodpecker	Picidiae	R	LC	Grains, fruits, flower nectar, molluscs, insects
Pterocles exustus 	Chestnut-Bellied Sand grouse	Pteroclididae	R	LC	Grains, fruits, flower nectar, molluscs, insects
Pericrocotus ethologus 	West Himalayan Long-Tailed Minivet	Campephagi-dage	M	LC	Grains, fruits, flower nectar, molluscs, insects, spiders
Pericrocotus cinnamomeus 	Northern Small Minivet	Campephagi-dage	M	LC	Grains, fruits, flower nectar, molluscs, insects, spiders
Pericrocotus roseus 	Rosy Minivet	Campephagi-dage	M	LC	Grains, fruits, flower nectar, molluscs, insects, spiders

Species	Common Name	Family	R/M	IUCN Status	Food and Feeding Habits
Pycnonotus leucogenys 	White-Cheeked Bulbul	Pycnonotidae	R	LC	Grains, fruits, flower nectar, molluscs, insects, spiders
Pycnonotus cafer 	Red-Vented Bulbul	Pycnonotidae	R	LC	Grains, fruits, flower nectar, molluscs, insects, spiders
Pomatorhinus erythrogenys 	West Himalayan Rusty-Cheeked Scimitar Babbler	Muscicapidae	M	LC	Grains, fruits, flower nectar, molluscs, insects, spiders
Platalea leucorodia 	Eurasian Spoonbill	Threskiornith-idae	R	LC	Fishes, insects, molluscs, crustaceans, worms
Podiceps nigricollis 	Black-necked Grebe	Podicipedidae	M	LC	Fishes, insects, molluscs, crustaceans, worms
Podiceps auratus 	Slavonian Grebe	Podicipedidae	M	VU	Fishes, insects, molluscs, crustaceans, worms

Species	Common Name	Family	R/M	IUCN Status	Food and Feeding Habits
Podiceps grisegena 	Red-Necked Grebe	Podicipedidae	M	LC	Fishes, insects, molluscs, crustaceans, worms
Podiceps cristatus 	Great Crested Grebe	Podicipedidae	M	LC	Fishes, insects, molluscs, crustaceans, worms
Philomachus pugnax 	Ruff	Charadriidae	M	LC	Fishes, insects, molluscs, crustaceans, worms, amphibians
Prunella strophiata 	Rufous-Breasted Accentor	Muscicapidae	M	LC	Grains, fruits, flower nectar, molluscs, insects, spiders
Prunella atrogularis 	Black-Throated Accentor	Muscicapidae	M	LC	Grains, fruits, flower nectar, molluscs, insects, spiders
Parus major 	Grey Tit	Paridae	M	LC	Insects, molluscs, crustaceans, worms, amphibians
Pluvialis squatarola 	Grey Plover	Charadriidae	M	LC	Insects, molluscs, crustaceans, worms, amphibians, fishes

Species	Common Name	Family	R/M	IUCN Status	Food and Feeding Habits
Pluvialis fulva 	Pacific Golden Plover	Charadriidae	M	LC	Insects, molluscs, crustaceans, worms, amphibians, Fishes
Prinia buchanani 	Rufous-Fronted Prinia	Muscicapidae	M	LC	Insects, molluscs, crustaceans, worms, amphibians
Prinia hodgsonii 	Grey-Breasted Prinia	Muscicapidae	R	LC	Insects, molluscs, crustaceans, worms, amphibians
Prinia crinigera 	Striated Prinia	Muscicapidae	R	LC	Insects, molluscs, crustaceans, worms, amphibians
Prinia inornata 	Plain Prinia	Muscicapidae	R	LC	Insects, molluscs, crustaceans, worms, amphibians
Prinia socialis 	Northern Ashy Wren Warbler	Muscicapidae	R	LC	Insects, molluscs, crustaceans, worms, amphibians
Prinia socialis 	Northern Ashy Wren Warbler	Muscicapidae	R	LC	Insects, molluscs, crustaceans, worms, amphibians

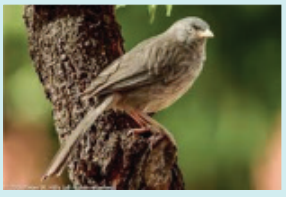
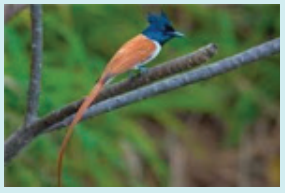
Species	Common Name	Family	R/M	IUCN Status	Food and Feeding Habits
Prinia sylvatica 	Jungle Prinia	Muscicapidae	R	LC	Insects, molluscs, crustaceans, worms, amphibians
Porzana pusilla 	Baillon's Crake	Rallidae	R	LC	Insects, crustaceans, worms, amphibians, fishes, molluscs, grains
Porzana fusca 	Ruddy-Breasted Crake	Rallidae	R	LC	Insects, molluscs, crustaceans, worms, fishes, amphibians, grains
Riparia riparia 	Siberian Collared Sand Martin	Hirundinidae	M	LC	Aquatic plants, insects, molluscs, crustaceans, worms, amphibians, grains, fishes
Riparia paludicola 	Plain Martin	Hirundinidae	M	LC	Aquatic plants, insects, molluscs, crustaceans, worms, amphibians, grains, fishes
Rallus aquaticus 	Water Rail	Rallidae	R	LC	Aquatic plants, insects, molluscs, crustaceans, worms, fishes, amphibians
Rhipidura aureola 	Northern White-Browed Fantail Flycatcher	Muscicapidae	R	LC	Insects, molluscs, spiders, worms, amphibians, fruits

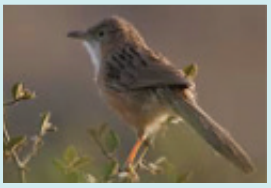
Species	Common Name	Family	R/M	IUCN Status	Food and Feeding Habits
Riphidura albicollis 	White Throated Fantail	Muscicapidae	M	LC	Insects, molluscs, spiders, worms, amphibians, fruits
Rhipidura hypoxantha 	Yellow-Bellied Fantail	Muscicapidae	M	LC	Insects, molluscs, spiders, worms, amphibians, fruits
Rostratula benghalensis 	Greater Painted Snipe	Rostratulidae	M	LC	Fishes, insects, molluscs, crustaceans, worms, amphibians, reptiles, seeds
Recurvirostra avocetta 	Pied Avocet	Recurvirostri-dae	R	LC	Fishes, insects, molluscs, crustaceans, worms
Rynchops albicollis 	Scissorbill	Laridae	M	EN	Fishes, insects, molluscs, crustaceans, worms, amphibians, reptiles, seeds
Spilornis cheela 	Crested Serpent Eagle	Accipitridae	R	LC	Fishes, insects, molluscs, crustaceans, worms, amphibians, reptiles, small vertebrates
Sitta castanea 	Chestnut-Bellied Nuthatch	Sittidae	R	LC	Insects, molluscs, spiders, worms, amphibians, fruits

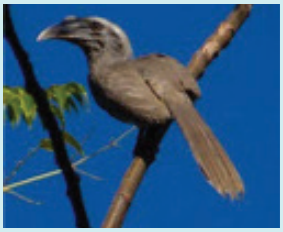
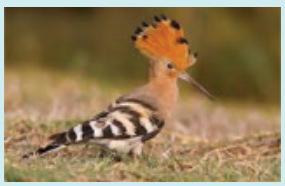
Species	Common Name	Family	R/M	IUCN Status	Food and Feeding Habits
Sylvia curruca 	Lesser White Throat	Muscicapidae	M	LC	Insects, molluscs, spiders, worms, seeds, fruits
Sylvia althaea 	Hume's Lesser White Throat	Musccicapide	M	LC	Insects, molluscs, spiders,worms, seeds, fruits
Sylvia nana 	Desert Warbler	Muscicapidae	R	LC	Insects, molluscs, spiders, worms, seeds, fruits
Sterna aurantia 	River Tern	Laridae	R	NT	Small fishes, molluscs, insects, amphibians
Saxicola torquata 	African stonechat or common stonechat	Muscicapidae	M	LC	Insects, molluscs, crustaceans, worms, spiders, fruits, seeds
Saxicola leucura 	White Tailed Stone Chat	Muscicapidae	R	LC	Insects, molluscs, crustaceans, worms, spiders, fruits, seeds

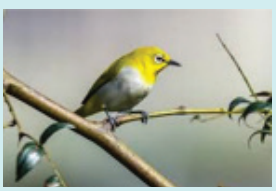
Species	Common Name	Family	R/M	IUCN Status	Food and Feeding Habits
Saxicola ferrea 	Grey Bushchat	Muscicapidae	R	LC	Insects, molluscs, worms, spiders, fruits, seeds, amphibians
Saxicola caprata 	Northern Pied Bushchat	Muscicapidae	R	LC	Insects, molluscs, worms, spiders, fruits, seeds, amphibians
Saxicoloides fulicata 	Indian Robin	Muscicapidae	R	LC	Insects, molluscs, worms, spiders, fruits, seeds, amphibians
Sterna acuticauda 	Black-Bellied Tern	Laridae	R	EN	Insects, molluscs, crustaceans, worms, spiders, fishes
Sternula albifrons 	Little Tern	Laridae	R	LC	Fishes, insects, amphibians, molluscs
Streptopelia orientalis 	Western Turtle Dove	Columbidae	R	V	Insects, molluscs, worms, spiders, fruits, seeds, amphibians
Sturnus pagodarum 	Brahminy Myna	Sturnidae	R	LC	Grains, fruits,flower nectar, molluscs,worms, insects,amphibians

Species	Common Name	Family	R/M	IUCN Status	Food and Feeding Habits
Sturnus roseus 	Rosy Starling	Sturnidae	R	LC	Grains, fruits, flower nectar, molluscs, worms, insects, amphibians
Sturnus vulgaris 	European Starling	Sturnidae	R	LC	Grains, fruits, flower nectar, molluscs, worms, insects, amphibians
Streptopelia decaocto 	Eurasian Collared Dove	Columbidae	R	LC	Grains, fruits, flower nectar, molluscs, worms, insects, amphibians
Streptopelia tranquebarica 	Red Collared Dove	Columbidae	R	LC	Grains, fruits, flower nectar, molluscs, worms, insects, amphibians
Streptopelia chinensis 	Indian Spotted Dove	Columbidae	R	LC	Grains, fruits, flower nectar, molluscs, worms, insects, amphibians
Streptopelia senegalensis 	Indian Little Brown Dove	Columbidae	R	LC	Grains, fruits, flower nectar, molluscs, worms, insects, amphibians

Species	Common Name	Family	R/M	IUCN Status	Food and Feeding Habits
Tringa guttifer 	Spotted Greenshank	Charadriidae	R	EN	Insects, molluscs, crustaceans, worms, amphibians, reptiles, fishes
Tringa nebularia 	Greenshank	Charadriidae	M	LC	Fishes, insects, molluscs, crustaceans, worms, amphibians, reptiles
Turdus boulboul 	Grey-Winged Blackbird	Muscicapidae	R	LC	Fishes, insects, molluscs, crustaceans, worms, amphibians, reptiles
Tachymarptis melba 	Alpine Swift	Apodidae	R	LC	Insects, fungus, worms, fruits
Turdoides striatus 	Sind Jungle Babbler	Muscicapidae	R	LC	Grains, fruits, flower nectar, molluscs, worms, insects
Terpsiphone paradisi 	Asian Paradise Flycatcher	Muscicapidae	R	LC	Grains, fruits, flower nectar, molluscs, worms, insects

Species	Common Name	Family	R/M	IUCN Status	Food and Feeding Habits
Tephrodornis pondicerianus 	Sind Woodshrike	Campephagi-dae	R	LC	Grains, fruits, flower nectar, molluscs, worms, insects
Tringa erythropus 	Spotted Redshank	Charadriidae	M	LC	Fishes, insects, molluscs, crustaceans, worms, amphibians, reptiles
Turdoides caudatus 	Common Babbler	Muscicapidae	R	LC	Grains, fruits, flower nectar, molluscs, worms, insects
Turdoides earlei 	Western Striated Babbler	Muscicapidae	R	LC	Grains, fruits, flower nectar, molluscs, worms, insects
Tringa ochropus 	Green Sandpiper	Charadriidae	M	LC	Seeds, plants, insects, molluscs, crustaceans, worms, amphibians, reptiles, fishes
Tringa hypoleucos 	Common Sandpiper	Charadriidae	R	LC	Insects, molluscs, crustaceans, worms, amphibians, reptiles, fishes
Tringa glareola 	Wood Sandpiper	Charadriidae	R	LC	Seeds, plants, insects, molluscs, crustaceans, worms, fishes

Species	Common Name	Family	R/M	IUCN Status	Food and Feeding Habits
Tringa stagnatilis 	Marsh Sandpiper	Charadriidae	M	LC	Seeds, plants, insects, molluscs, crustaceans, worms, fishes
Turnix suscitator 	Barred Button Quail	Phasianidae	R	LC	Seeds, plants, insects, molluscs, crustaceans, worms
Tockus birostris 	Grey Hornbill	Bucerotidae	R	LC	Grains, fruits, flower nectar, molluscs, worms, insects
Treron phoenicoptera 	Yellow-Footed Green Pigeon	Columbidae	R	LC	Grains, fruits, flower nectar, molluscs, worms, insects
Tadorna ferruginea 	Ruddy Shelduck	Anatidae	M	LC	Aquatic plants, insects, molluscs, crustaceans, worms, fishes
Upupa epops 	European Hoopoe	Upupiidae	R	LC	Grains, fruits, flower nectar, molluscs, worms, insects

Species	Common Name	Family	R/M	IUCN Status	Food and Feeding Habits
Vanellus duvaucelii 	River Lapwing	Charadriidae	R	NT	Grains, fruits, flower nectar, molluscs, worms, insects
Vanellus leucurus 	White-Tailed Lapwing	Charadriidae	R	LC	Grains, fruits, flower nectar, molluscs, worms, insects
Vanellus vanellus 	Northern Lapwing	Charadriidae	M	NT	Seeds, grains, insects, worms, molluscs
Vanellus indicus 	Red-Wattled Lapwing	Charadriidae	R	LC	Grains, fruits, flower nectar, molluscs, worms, insects
Vanellus malabaricus 	Yellow-Wattled Lapwing	Charadriidae	R	LC	Grains, fruits,flower nectar, molluscs,worms, insects
Xenus cinereus 	Terek Sandpiper	Charadriidae	M	LC	Grains, fruits, flower nectar, reptiles, amphibians, molluscs, worms, insects, fishes
Zosterops palpebrosa 	Indian White-Eye	Zosteropidae	R	LC	Grains, fruits, flower nectar, molluscs, worms, insects

ANNEXURE - VI

Socioeconomic survey schedule performa

भाकृअनुप - केन्द्रीय अन्तर्स्थलीय मात्स्यिकी अनुसंधान संस्थान
बैरकपुर, कोलकाता -700 120, पश्चिम बंगाल
ICAR -CENTRAL INLAND FISHERIES RESEARCH INSTITUTE
Barrackpore, Kolkata -700 120, West Bengal
☎ 033-2592-1190/91 : 033-2545-1063, ई-मेल/e-mail : director.cifri@gmail.com

SURVEY SCHEDULE

Activity: Socioeconomic status of fisher communities

FISHER'S LEVEL

Date Reservoir Data collector Schedule

A. Household (HH) information

i. Name of the head: _____ Phone Number: _____

ii. Village: _____, P.S.: _____

Dist: _____

iii.Details of the family members:

Sr. No	Relation	Age	Education	Major occupation	Other occupation	Total monthly income (Rs.)
1	Family head					
2						
3						
4						
5						
6						
7						

B. Socio-economic information:

i. Total Household income/month: ₹ _____

Any occupation Migration: Yes / No

ii. Income sources of the HH and livelihood

Sr. No.	Particulars	Income generating activity(√)	Subsistence activity*(√)	Devote how much time in day /week (%)	Daily/monthly income(₹) from B/C	Imputed monthly income (₹) from D/E
	A.	B.	C.	D.	E.	F.
1.	Crop farming					
2.	Horticulture /plantation					
3.	AH/Poultry					
4.	Labour wage					
5.	Fisheries					
6.	Aquaculture					
7.	Fish vending					
8.	Business					
9.	Govt. Service					
10.	Pension					

*Only for home consumption

iii. Major asset and liabilities (√)

Asset		**Asset**		**Asset**	
Pucca house		Mobile phones		Music system	
Own source of drinking water		Computer / Laptop		By cycle	
Own toilet		Camera		Bike / moped	
Owned agri. Land (acre)		Colour TV		4 wheeler	
Tractor / Power tiller		Refrigerator		Loan amount	
Harvester		Water purifier		Source	
Thresher		Washing machine		Repayed?	
Sprayer		Geyser			
Electricity		A/C or Cooler			

iv. Monthly routine expenses (₹)

Items		**Items**		**Items**	
Food		Transport		Education Pvt. /Govt. school	
Fuel		Utilities bill		Edu. expenses	
Clothing		Household Items		Houserent	
Medical		Social Obligations		Others	

C. Fishing gears owned

Items	Mesh size (mm)	Total Numbers/kg	Unit price (Rs./piece/kg)
Gill net			
Scoop net			
Dragnet			
Cast net			
Long line			
Sieve net			
Other			
Boat (non-motorized)			
Boat (motorized)			

Total no. of fishermen in the village: _____

ii. Group-wise monthly catchfrom wetland and fishers' price (Rs./kg)

Particular	**IMC**	**Minor carp**	**Big cat fishes**	**Small cat fishes**	**Exotic**	**Prawn**	**Others**
April – June							
Catch (kg)							
Price (Rs./kg)							
July-Sept							
Catch (kg)							
Price (Rs./kg)							
Oct-Dec							
Catch (kg)							
Price (Rs./kg)							
Jan-March							
Catch (kg)							
Price (Rs./kg)							

iii. Particulars of fishing in the reservoir

Particular	April - June	July-Sept	Oct-Dec	Jan-March	Yearly total
No. of efforts per day					
Avg. no. of family members involved in fishing					
Avg. time for fishing per day (Hrs)					
Diesel required per day (lit)					
Avg. qty (kg) caught per day/week by the HH					
Share of Cage culture					
Avg. home consumption per day/week (kg)					
To whom sale					

iv. Labour wage (₹/day):

Man_____ Women _____ Children _____

C. Constraints

D. Special observations

Image18 *Report writing and policy formulation*

Photo credit: CarrotFilms.GIZ

Image 19 *Large (27 kg) Catla catla catch at Dhametha landing centre during the post-monsoon season of 2020*

Registered Offices:

Bonn and Eschborn, Germany
Friedrich-Ebert-Allee 32 + 36
53113 Bonn, Germany

Dag-Hammarskjold-Weg 1-5
65760 Eschborn, Germany

Email: info@giz.de

A2/18, Safdarjung Enclave
New Delhi-110029, India
Tel: +91 11 4949 5353
Fax: +91 11 4949 5391

Email: biodiv.india@giz.de