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Integrated Evaluation of Water Quality and Edible Fish Biodiversity for Sustainable Fisheries Management in Pilibhit, U.P., India

Dr. Barkha[1], Arti Kumari[2], Sanjana Rani[3]

[1] *Department of Zoloogy, Ram Lubhai Sahani Rajkiye Mahila Mahavidyalay, Pilibhit, India*
[2] *Department of Animal Science/Zoology, MJP Rohilkhand University Campus Bareilly, India*
[3] *Department of Animal Science/Zoology, MJP Rohilkhand University Campus Bareilly, India*
**corresponding author email: barkhagdc0070@gmail.com*

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Abstract

The Pilibhit district of Uttar Pradesh, located in the fertile terai region, is rich in freshwater sources which include the Sharda River, Sharda Sagar Dam, Deoha Reservoir, as well as the origin of the Gomati River. These water bodies are integral to irrigation, drinking water supply, fisheries, and biodiversity. The district's rivers, wetlands, and reservoirs offer conducive conditions for fish farming and preserving water resources. Nevertheless, the construction of dams and irrigation systems radically changes the natural hydrological patterns, water quality, and fish population dynamics.

This study attempts to assess the analysis of water quality parameters and determinants of water dynamics of fish populations found in selected sites including the Sharda River, Sharda Sagar Dam, along with some other water resources in Pilibhit. The physicochemical properties of water -- temperature, pH, DO, BOD, TDS, COD -- were evaluated to study its suitability for aquatic life. Seasonal distributions were observed, indicating that water quality depends on temperature and rainfall patterns and hence directly affected fish richness and distribution. Some commercially vital fishes namely, the fish species Catla catla, Labeo rohita, Cirrhinus mrigala, Channa punctatus and some other catfish species were observed with different density in the survey facilities. Maximum fish abundance was recorded at post-winter level and minimum was observed under monsoon seasons where turbidity was high and oxygen saturations were low. Sustainable water and dam hydrology, controlled dam discharge, controlled release of floodwaters and wetlands conservation are vital for preserving fish population dynamics and for ensuring a healthy condition of habitat in Pilibhit, the study concludes.

Keywords

Sharda River, Pilibhit, Water quality, Fish biodiversity, Sustainable fisheries management, Aquatic ecology

1. Introduction

Water-based resources form the basis of responsible fisheries and biodiversity management. The town of Pilibhit, which lies in the Terai region of the Indian state of Uttar Pradesh, hosts a variety of freshwater systems such as the Sharda River, Sharda Sagar Dam, Deoha Reservoir, and several wetlands. These systems are very important for both irrigation and for aquaculture and rural life. The Sharda River runs from its source at the Milam Glacier in Uttarakhand to Pilibhit and through the Sharda Sagar Dam, which changes the river's flow. These anthropogenic changes have an impact on hydrology, water chemistry, and composition of aquatic fauna, including edible fish species. Sustainable fisheries should be regulated through integrated monitoring of water quality indicators and species richness. Therefore this study aims at estimating the water quality and characteristics of edible fish species so that they can inform suitable resources for sustainable fisheries intervention in Pilibhit district. Water is an important natural resource that sustains life and sustains the economy. Pilibhit also falls under the upper Gangetic plain and, as an extension of its northern border, shares territory with Nepal. The district boasts a network of numerous rivers, wetlands, and ample groundwater supplies, which ensure agricultural, fisheries, and biological diversity.

The Sharda River, originating from the Milam Glacier in Uttarakhand, flows through Pilibhit before entering Lakhimpur Kheri. The Sharda Sagar Dam and Deoha Reservoir are major hydrological structures that provide irrigation, hydropower, and fisheries opportunities.

While dams ensure water availability, they also alter water quality and aquatic ecosystems by changing flow regimes, sedimentation patterns, and thermal structures. Fish diversity and breeding are directly linked to water parameters such as tempreture,DO, BOD, pH, and COD, TDS, .

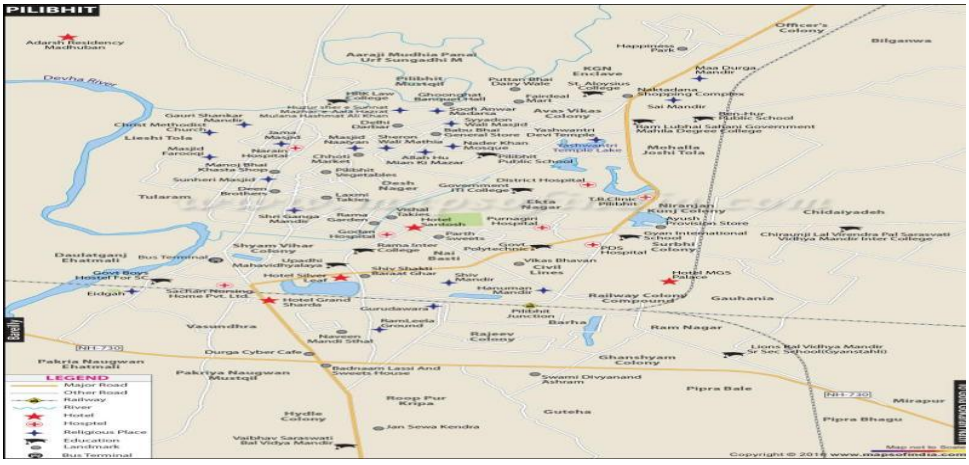

Fig. 1. Location map of Pilibhit city showing major water bodies, and sampling-related wetland sites included in the study.

The present study investigates the physicochemical parameters of different places such as Sharda River, Sharda Sagar Dam, Deoha Reservoir, and several wetlands of city Pilibhit and related activities influence fish population dynamics and fisheries management in Pilibhit district.

Figure

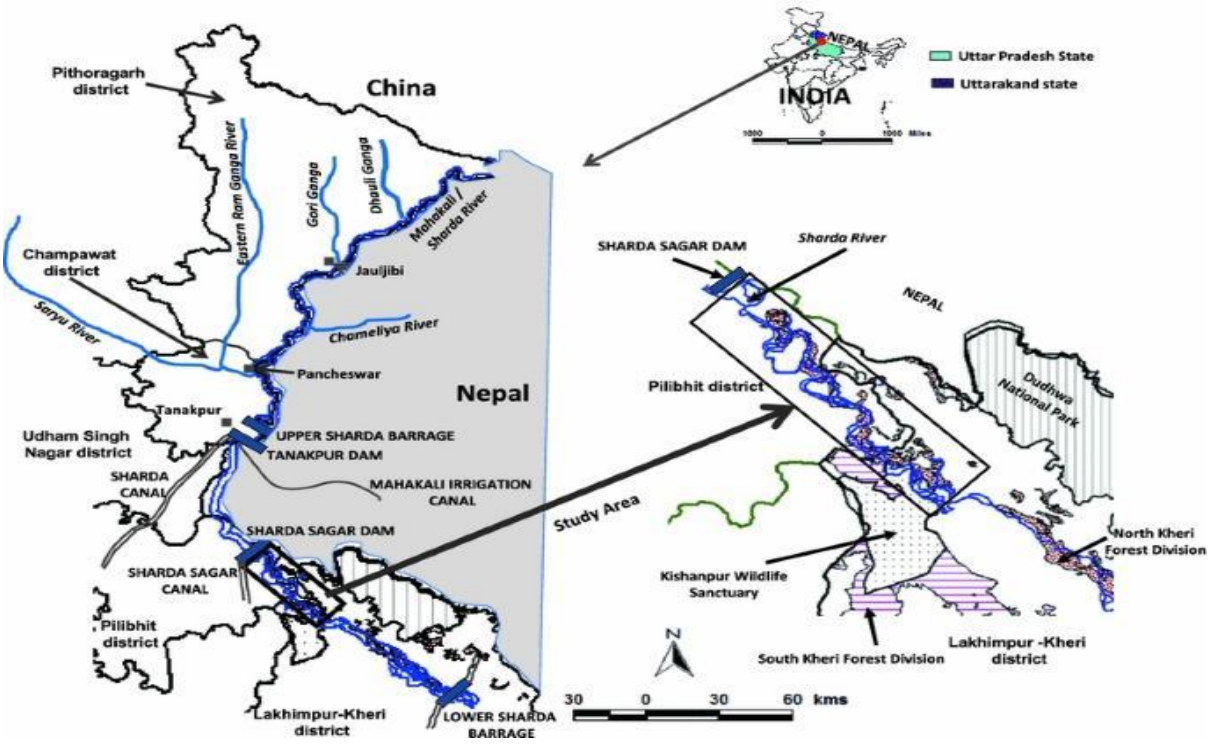

Fig. 2. Map showing the Sharda River and Sharda Sagar Dam, and their connected flow through the Pilibhit study area.

2. Study Area

The study was carried out in the sustainable fisheries management of Pilibhit district primarily with the Sharda River and Sharda Sagar Dam, along with observations from Deoha Reservoir and various ponds of city Pilibhit. Sampling sites were chosen to examine variations caused by anthropogenic and hydrological factors. Biodiversity of fish in the district was represented by additional observations of Deoha Reservoir. Pilibhit has a humid subtropical climate with three major seasons—Summer (March–June), Monsoon (July–October), and Winter (November–February). Its annual rainfall is 1300–1500 mm, supporting rich aquatic vegetation and diverse fish fauna. Site I Sharda Sagar Dam (Lat 28.7188N Long 80.0719E): Deep, slow-flowing water supports a number of phytoplankton, zooplankton and an array of edible fish (including Rohu, Catla, Mrigal, Silver carp and Common carp).

Site II Deoha(Lat~28.480N Long~79.430E): The river supports rich aquatic vegetation, natural fish populations, and serves as an important pathway for migratory species.

Site III Sharda river(Lat~28.70N Long~80.00E): It has strong currents, high dissolved oxygen levels, and supports a diverse riverine ecosystem. The river is known for its rich fish biodiversity including Mahseer, Rohu, Catla, Wallago attu, Chitala chitala, and other edible species.

Site IV Pilibhit Wetlands:

- Pond near Dramand College,Pilibhit(Lat~28.6263N,Long79.8205E)
- Pond near Yashwantri Devi Temple,Pilibhit(Lat~28.606N,Long79.8167E)
- Pond near Awadh Nagar Pilibhit(Lat~28.626274,Long 79.820718)
- Pond near Niranjan Nagar Colony Pilibhit(Lat~28.628279,Long79.815643)

Figure 3. Site 1: Sharda Sagar Dam (Lat~28.7188N Long ~80.0719E)

. Figure 4. Site 2: Deoha River(Lat~28.480N Long~79.430E)

Figure 5. Site 3: Sharda river(Lat~28.70N Long~80.00E)

Figure 6. Site 4: Pond near Dramand College Pilibhit (Lat~28.6263N,Long79.8205E)

Figure 7. Site 5: Pond near Yashwantri Devi Temple, Pilibhit (Lat~28.606N, Long79.8167E)

Figure 8. Site 6: Pond near Awadh Nagar Pilibhit (Lat~28.626274, Long 79.820718)

Figure 9. Site 7: Pond near Niranjan Nagar Colony Pilibhit(Lat~28.628279,Long79.815643)

These wetlands supports different species of fish polyculture and small indigenous species (SIS).

3. Geology of the Study Area

The district lies in the Indo-Gangetic alluvial plain characterized by quaternary deposits of sand, silt, and clay These deposits form confined aquifers which are rich in ground water and play a vital role in agriculture and aquatic ecosystem. the soil type varies from sandy loam in the

northern tarai belt to clay loam in southern agricultural planes and aquatic ecosystem, with high organic content and moisture retention capacity. These geological features, combined with perennial water sources, create favourable conditions for aquaculture and fish biodiversity.

4. Materials and Methods

Water Sampling and Analysis

Water samples were collected seasonally (July 2024-June 2025) .The climate of Pilibhit is subtropical monsoonal, characterized by three distinct seasons:

Monsoon (July–September) - Humid with heavy rainfall (average annual rainfall ~1200–1300 mm).

Winter (November–February) - Cool and pleasant, with temperatures dropping to 8–10°C.

Summer (March–June) - Hot and dry, with temperatures reaching up to 40–42°C.

High rainfall and porous alluvial soils contribute to effective infiltration and aquifer recharge, but also increase the risk of surface runoff contamination in low-lying wetland zones

Water sample were collected from sites and stored in 2-liter polyethylene bottles. All samples were analyzed in the laboratory following APHA (2017) and Trivedi & Goyal (1986) standard procedures.

Selection of Physicochemical Parameter

Sample were collected from selected sites continuously from june 2024 to july 2025. Data was analytically compiled on seasonal average basic shown in table 1, 2 and 3.

The average physicochemical parameters of water samples taken by different sites ;

Temperature (°C): Digital thermos meter, pH: pH meter, Dissolved Oxygen (DO): Winkler's titration method, Biochemical Oxygen Demand (BOD): 5-day incubation at 20°C, Total Alkalinity: Acid-base titration, Total Dissolved Solids (TDS): Gravimetric method, Chemical Oxygen Demand(COD): APHA-Closed Reflux Method.

Fish Population Estimation

Fish were collected using gill nets and drag nets of varying mesh sizes. Fish sampling in the aquatic habitats of Pilibhit—namely the Sharda River, Sharda Sagar Dam, Deoha River, and the urban wetlands—was carried out using standard ichthyological techniques to ensure accurate assessment of edible fish diversity and abundance. Zippin's removal method (1958) was used to calculate Population density. Species identification was performed using Jayaram (1999).

Fish Sampling and Data Compilation in Pilibhit District

This serves as a holistic overview of fish sampling, species identification, anatomical characteristics as well as length–weight data and fish production history at the major aquatic zones of Pilibhit, that is Sharda River, Sharda Sagar Dam, Deoha River and Pilibhit wetlands.

Fish Sampling Method.

- Sampling was seasonal in nature for the three sampling seasons of Monsoon, Winter & Summer.
- Gear used: gill nets, cast nets, drag nets, hand nets, traps and hooks.
- Fish were managed as per protocol to record them, as follows:

- Total Length (TL).
- Standard Length (SL).
- Body Weight (BW).

- Species identification was consistent with familiar fish taxonomy manuals (Jhingran; Talwar & Jhingran).
- All sampling events were recorded along with habitat properties (water depth, vegetation, flow, turbidity).

5. Results and Discussion

At present, the aquatic ecosystem within Pilibhit shows how closely hydrological regimes, the quality of the water and the dynamics of edible fishes population exist together. The excellent ecological condition of Sharda River illustrates the widely accepted positive effect of rivers flowing in turbulent, free-flowing conditions on increased dissolved oxygen and nutrient redistribution. It is under such conditions (which allow sensitive and migratory species to survive) which are similar to the observation of some regulated Himalayan rivers (Ayoade et al., 2009).

With its moderate temperature and high alkalinity, the Sharda Sagar Dam is favorable for plankton blooms and carp productivity. This is aligned with previous studies which have identified reservoirs as productive aquaculture and commercial fisheries systems. But regulated discharge of the dam could modify downstream transport of sediment and thermal stratification – issues known to influence the reproductive cycles of riverine fish. In Pilibhit, nutrient-rich wetlands and ponds showed high BOD and COD, consistent with organic pollution due to surface runoff and human presence. Those habitats favoured durable tilapia and small native fish but reduced the habitat of more sensitive species. These patterns of behaviour and ecology are well-known amongst urban freshwater ecosystems that also endure both stagnation and nutrient influx. Seasonal dynamics were important.

The highest DO and lowest water temperature occurred during the winter season, leading to the production of more fishes and more efficient growth activity whereas monsoon-driven turbidity inhibited diversity through lower light penetration and a change in hydrology. Correlation data also proved the evidence that edible fish diversity in Pilibhit increases when there is greater exposure to dissolved oxygen, temperature, and organic loads. The positive allometric growth on major carps indicates the homoeostasis of multiple sites--especially dam and wetland areas--compares to provide food resources and metabolic advantages. The overall effect of integrated water quality management, controlled dam discharge, and the preservation of wetlands as important measures towards the conservation of fish diversity and fisheries overall

Water Quality Analysis

Seasonal variations in water quality among water quality samples varied greatly throughout the site set-up, with winter, which provided the most favourable conditions, being low temperature

and high dissolved oxygen, representing the best conditions.Sharda River and Sharda Sagar Dam maintained superior ecological quality, while wetlands exhibited higher BOD and COD linked to nutrient-rich stagnant water. Summer stress, monsoonal runoff, and anthropogenic inputs notably affected Deoha River and urban wetlands. Overall, all parameters remained within tolerable limits for freshwater fisheries, directly influencing fish abundance and habitat productivity.

Table 1 : Water Quality Parameters (July 2024-September 2024)

Region	pH	Temp.	Total alkalinity (mg/L)	DO (mg/L)	TDS (mg/L)	BOD (mg/L)	COD (mg/L)
Sharda river	7.5	29	82	9.1	245	4.7	20
Sharda sagar dam	7.3	27	94	7.1	258	5.2	21
Deoha river	7.9	28	74	6.9	242	5.8	23
Wetlands places of pilibhit city (ponds)	7.0	26	71	5.8	230	5.1	25

Table 2 : Water Quality Parameters (Nov 2024 to Feb 2025)

Region	pH	Temp.	Total alkalinity (mg/L)	DO (mg/L)	TDS (mg/L)	BOD (mg/L)	COD (mg/L)
Sharda river	7.2	16	92	9.7	180	4.0	23
Sharda sagar dam	7.9	12	101	9.0	240	3.2	25
Deoha river	7.4	18	85	8.1	213	3.8	19
Wetlands places of pilibhit city (ponds)	7.7	14	82	7.3	221	4.1	28

Table 3 : Water Quality Parameters (March to June 2025)

Region	pH	Temp.	Total alkalinity (mg/L)	DO (mg/L)	TDS (mg/L)	BOD (mg/L)	COD (mg/L)
Sharda river	7.4	31	76	8.4	196	4.9	24
Sharda sagar dam	7.8	30	89	6.5	248	5.2	29
Deoha river	7.3	28	74	5.9	220	4.8	31
Wetlands places of pilibhit city (ponds)	7.9	33	89	5.2	224	6.1	26

Table:4 Average Water Quality Parameters (Analytical Mean)

Region	pH	Temp.	Total alkalinity (mg/L)	DO (mg/L)	TDS (mg/L)	BOD (mg/L)	COD (mg/L)
Sharda river	7.37	25.33	83.33	9.067	207.0	4.53	22.33
Sharda sagar dam	7.67	23	94.66	7.53	248.67	4.63	25.00
Deoha river	7.53	24.66	77.66	6.97	225.0	4.80	25.33
Wetlands places of pilibhit city (ponds)	7.53	24.33	80.66	6.1	225.0	5.10	26.33

Comparison standards presentation

The comparative values of major water quality parameters (pH, nitrate, fluoride, arsenic, TDS, BOD, COD, and copper) recorded Sharda river, Sharda sagar dam, Deoha river, Wetlands places of pilibhit city (ponds) during June 2024-July2025.

Fish Diversity

Edible Fish Species Recorded in Study Area

Major Carps

1. *Catla catla*, Order-Cypriniformes,Family-Cyprinidae
   • Anatomy: Broad head, large eyes, upturned mouth.
   • TL: ~40–110 cm | Weight: 2–18 kg
   • Common in: Sharda River, Sharda Sagar Dam, Wetlands
2. *Labeo rohita* (Rohu) Order- Cypriniformes, Family- Cyprinidae
   • Anatomy: Arched body, reddish fins, terminal mouth.
   • TL: ~30–90 cm | Weight: 1.5–12 kg
   • Found in all sites.
3. *Cirrhinus mrigala* (Mrigal) Order- Cypriniformes, Family-Cyprinidae
   • Anatomy: Cylindrical body, straight head profile.
   • TL: ~30–80 cm | Weight: 1–10 kg

Catfishes

4. *Wallago attu*,Order – Siluriformes,Family-Siluridae
   • Anatomy: Long body, wide mouth, predatory fish.
   • TL: ~35–150 cm | Weight: 1–20+ kg
5. *Mystus seenghala*, Order- Siluriformes, Family-Bagridae
   • Anatomy: Four pairs of barbels, elongated body.
   • TL: ~20–60 cm | Weight: 200 g–4 kg

Small Indigenous Species (SIS)

6. *Puntius sophore*, Order- Cypriniformes, Family- Cyprinidae
   • Anatomy: Small scales, golden body.
   • TL: ~8–14 cm | Weight: 10–40 g



Fig: Some examples of edible fish of District Pilibhit

Figure 10. Edible Fish Species in Fish market of Pilibhit : A) *Catla catla*, B) *Labeo rohita*, C) *Cirrhinus mrigala*, D) *Wallago attu*, E) *Mystus seenghala*

Fish Production Overview Across Sites

Sharda River


• Dominant species: *Rohu*, *Catla*, *Wallago*, *Mystus*
• Production Trend: Moderate; improves during monsoon due to migration.
• Seasonal Variation: High flow supports large carps; winter shows low catch.

Sharda Sagar Dam

• High productivity because of stable water and plankton bloom.
• Popular species: Catla, Rohu, Mrigal, Grass carp
• Seasonal variation minimal; stocking enhances output.

Deoha Rivers

• Medium productivity; shallow sections favour SIS and catfish.
• Species: *Puntius* spp., *Mystus* spp., *Channa* species.

Pilibhit Wetlands(Yashvantri Temple Pond Included)

• Rich in small fish and stocked carp populations.
• Species: Rohu, Catla, Grass carp, Common carp, Tilapia.
• Seasonal growth high in summer due to warm shallow water.

Length – Weight Relation Summary

• Carps showed strong positive allometric growth (b > 3).
• Catfishes showed variable growth depending on prey availability.
• Wetland fishes grew faster due to nutrient-rich stagnant water.

Correlation Between Water Quality and Fish Diversity

Water Quality Parameter	Trend Observed	Effect on Edible Fish Diversity	Overall Correlation
Dissolved Oxygen (DO)	Highest during winter (8–9.7 mg/L); high in flowing rivers	Supports sensitive and commercially important species such as carps, Mahseer, Chitala, and Wallago	Strong Positive
Temperature	Highest during summer (28–33°C), especially in wetland	High temperature lowers DO, increases stress, and reduces species richness	Strong Negative
Biochemical Oxygen Demand (BOD	Highest in wetlands and Deoha River	High BOD reduces oxygen, limiting sensitive species and favouring only hardy fish	Negative
Chemical Oxygen Demand (COD	Elevated during monsoon and in stagnant wetland	High COD indicates organic pollution, reducing fish richness and abundance	Negative
Total Alkalinity	Highest in Sharda Sagar Dam due to mineral-rich water	Enhances plankton growth → increases food availability → higher fish productivity	Moderate to Positive
Total Dissolved Solids (TDS	Moderately high in dams and wetland	Moderate TDS improves nutrient availability, supporting carp specie	Weak to Moderate Positive
pH	Stable alkaline range (7.0–7.9) across sites	Favourable for almost all freshwater edible fish specie	Neutral to Positive
Water Flow / Turbulence	Highest in Sharda River	High flow increases DO, supporting migratory and predatory species	Positive
Monsoon Turbidity	High sediment load during monsoon	Reduced visibility and feeding efficiency → decline in fish diversity	Negative

Seasonal Fish Production Estimates (Typical for Pilibhit Region)

The following production estimates are based on common aquaculture systems in Uttar Pradesh and similar environmental conditions to Pilibhit:

1. Traditional Village/Temple Ponds (Carp Polyculture): 1,000–2,500 kg/ha/year.
2. Well-Managed Carp Ponds:2,500–4,000 kg/ha/year.
3. Semi-Intensive Tilapia/Pangasius Ponds: 3,000–8,000 kg/ha per cycle (6–9 months).
4. Wetlands and Natural Reservoirs (Capture Fisheries): 100–400 kg/ha/year.

Seasonal patterns:

- Monsoon (June–September): Stocking, natural recruitment, highest juvenile survival.

- Post-Monsoon to Winter (October–February): Best growth and main harvest season for carps.

- Summer (March–May): Growth slows due to water stress unless aeration/management is used.

Conclusion

This study presents a rich overview of the physicochemical characteristics and biodiversity of edible fish in the major aquatic systems of the Pilibhit district. The results show that Sharda River and Sharda Sagar Dam have optimum ecological conditions for the existence, high species richness of fish, appropriate growth patterns, and balanced fisheries productivity. In contrast, the Deoha River and urban wetlands are productive but show organic enrichment and seasonal stress affecting the overall fish diversity. Seasonal variations—particularly winter enrichment and monsoon stress—strongly influence fish abundance and habitat suitability. Ecological correlation results suggest that dissolved oxygen, temperature, and organic load are the dominant drivers of edible fish distribution in the area. The study concludes that sustainable fisheries in Pilibhit require:

1. Regular monitoring of physicochemical parameters

2. Maintaining environmental flows from Sharda Sagar Dam

3. Conservation and desiltation of wetlands

4. Controlled nutrient inflow and pollution management

5. Promotion of carp polyculture and SIS conservation

The integrated and effective management of water resources is necessary to promote sustainable biodiversity, ecological balance, and fisheries in Pilibhit district over the long term, combined with community involvement and scientific monitoring.

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Conflict of Interest The authors declare no conflict of interest.

Author Contribution Statement

Arti Kumari and Sanjana Rani contributed to the conceptualization of the study, conducted field sampling, collected water and fish data, prepared the initial manuscript and draft overall technical support..

Dr. Barkha supervised the methodology, validated the analytical procedures, assisted in data interpretation, and critically reviewed the manuscript and contributed to data analysis, preparation of tables and figures, manuscript editing.

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