

Fish Diversity of Ghat Kusumbha and Sheikhpura Block, Sheikhpura District, Bihar, India: Diversity, Habitat Characteristics, Conservation Challenges and Policy Perspectives—A Review

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ABSTRACT

Freshwater ecosystems of the Indo-Gangetic Plain support exceptional fish biodiversity and provide essential ecosystem services, including food security, livelihood generation, nutrient cycling, and ecological regulation. Bihar, with its extensive network of rivers, floodplain wetlands, ponds, oxbow lakes, irrigation canals, and seasonal water bodies, is one of India's most important inland fisheries regions. However, scientific information on the freshwater fish diversity of Ghat Kusumbha and Sheikhpura Block in Sheikhpura District remains limited. This review synthesises published literature (2000–2026) on fish diversity, habitat characteristics, conservation challenges, and management strategies relevant to the study area. Available evidence suggests that local freshwater habitats support diverse assemblages of cyprinids, catfishes, snakeheads, featherbacks, air-breathing fishes, and small indigenous fish species that are ecologically and economically significant. Habitat heterogeneity, seasonal hydrological connectivity, and floodplain dynamics are identified as the primary drivers of fish diversity and ecosystem productivity. Nevertheless, freshwater ecosystems face increasing threats from habitat degradation, wetland encroachment, agricultural runoff, pollution, overexploitation, invasive alien species, and climate change. The review highlights major research gaps, particularly the lack of comprehensive field-based biodiversity assessments, and recommends ecosystem-based fisheries management, habitat restoration, biodiversity monitoring using molecular and geospatial tools, stronger policy implementation, and active community participation. This synthesis provides a scientific baseline for future ichthyological research and supports evidence-based conservation and sustainable freshwater resource management in Sheikhpura District and comparable landscapes of the eastern Indo-Gangetic Plain.

Keywords: Freshwater fish diversity; Inland fisheries; Bihar; Sheikhpura District; Habitat ecology; Conservation biology; Wetlands; Sustainable fisheries; Indo-Gangetic Plain.

1. Introduction

Freshwater ecosystems occupy less than 1% of the Earth's surface yet support nearly half of all known fish species, making them among the most biologically diverse and ecologically important ecosystems globally. These ecosystems provide essential ecosystem services, including nutrient cycling, water purification, flood regulation, maintenance of aquatic food webs, carbon sequestration, and biodiversity conservation. Freshwater fishes are indispensable for food security, nutritional well-being, and rural livelihoods, particularly in developing countries where inland fisheries contribute substantially to dietary protein, employment, and household income (Dudgeon et al., 2006; Reid et al., 2019; FAO, 2022; IPBES, 2019). India, one of the world's megadiverse countries, harbors over 3,200 fish species, including more than 1,000 freshwater species distributed across rivers, wetlands, reservoirs, floodplain lakes, ponds, and seasonal water bodies. This remarkable diversity underpins one of the world's largest inland fisheries sectors and contributes significantly to national food production and economic development (FAO, 2022; Sarkar et al., 2008).

Bihar, located within the middle Gangetic Basin, possesses extensive freshwater resources, including the Ganga and its tributaries, floodplain wetlands (*chaurs*), oxbow lakes, irrigation canals, ponds, reservoirs, and seasonal streams that support rich ichthyofaunal diversity and rural livelihoods. Within the state, Ghat Kusumbha and Sheikhpura Block comprise interconnected freshwater habitats that function as breeding, nursery, feeding, and refuge grounds for indigenous fishes (Pandey & Bharti 2024). However, unlike the extensively studied Ganga, Gandak, and Kosi river systems, scientific documentation of fish diversity in this region remains limited. Increasing habitat degradation, pollution, wetland loss, hydrological alteration, overexploitation, invasive alien species, and climate change threaten freshwater biodiversity across the Indo-Gangetic Plain (Dudgeon et al., 2006; Reid et al., 2019; WWF, 2022). Recent advances in DNA barcoding, environmental DNA (eDNA), Geographic Information Systems (GIS), remote sensing, and long-term ecological monitoring have enhanced biodiversity assessment (Bohmann et al., 2014; Deiner et al., 2017). This review synthesizes current knowledge on fish diversity, habitat characteristics, conservation challenges, and management strategies to provide a scientific

foundation for future research, conservation planning, and sustainable freshwater fisheries management in Sheikhpura District and the middle Gangetic Basin.

2. Literature Search Methodology

This review followed a structured narrative review guided by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2020) framework to ensure transparency in literature identification, screening, and synthesis (Page et al., 2021). Relevant studies published between January 2000 and June 2026 were retrieved from Google Scholar, Scopus, Web of Science, PubMed, ScienceDirect, SpringerLink, Wiley Online Library, Taylor & Francis Online, and Crossref, together with reports from the Food and Agriculture Organization (FAO), Indian Council of Agricultural Research (ICAR), Central Inland Fisheries Research Institute (CIFRI), National Bureau of Fish Genetic Resources (NBFGR), and Government agencies. Searches employed keywords including *freshwater fish diversity*, *ichthyofauna*, *Bihar wetlands*, *Gangetic floodplain*, *Sheikhpura*, *Ghat Kusumbha*, and *aquatic biodiversity* using Boolean operators. Peer-reviewed articles and institutional reports addressing freshwater fish diversity, ecology, limnology, wetlands, fisheries, and conservation in Bihar and the Indo-Gangetic Plain were included, while marine fisheries, ornamental aquaculture, and studies lacking methodological rigor were excluded. Data on species composition, habitat characteristics, water quality, conservation status, anthropogenic threats, and management practices were extracted and synthesized thematically. Owing to limited studies from Ghat Kusumbha and Sheikhpura Block, evidence from ecologically comparable regions of the middle Gangetic Basin was critically integrated, and gaps in local knowledge were explicitly acknowledged (Defossé, & Mullier, 2019; Page et al., 2021)

3. Study Area

Sheikhpura District, located in the south-central region of Bihar within the middle Gangetic alluvial plains, comprises six Community Development Blocks, including Ghat Kusumbha and Sheikhpura, the focus of this review. The district is dominated by agricultural landscapes interspersed with ponds, irrigation canals, seasonal wetlands, drainage channels, and small streams that support freshwater biodiversity and inland fisheries. Although major perennial rivers are absent, monsoon-fed aquatic habitats serve as important breeding, nursery, feeding, and refuge grounds for indigenous fish species. The region exhibits gently undulating alluvial terrain with fertile Quaternary deposits of sand, silt, and clay, supporting productive agriculture and groundwater recharge (CGWB, 2020). The tropical monsoon climate receives approximately 900–1,100 mm of annual rainfall, most of which occurs during June–September, strongly influencing habitat connectivity, fish migration, recruitment, and community dynamics (Reid et al., 2019; FAO, 2022). Predominantly sandy loam to clay loam soils promote aquatic productivity; however, intensive agriculture has increased nutrient loading and pesticide runoff, posing risks of eutrophication and freshwater habitat degradation (Dudgeon et al., 2006; CGWB, 2020).

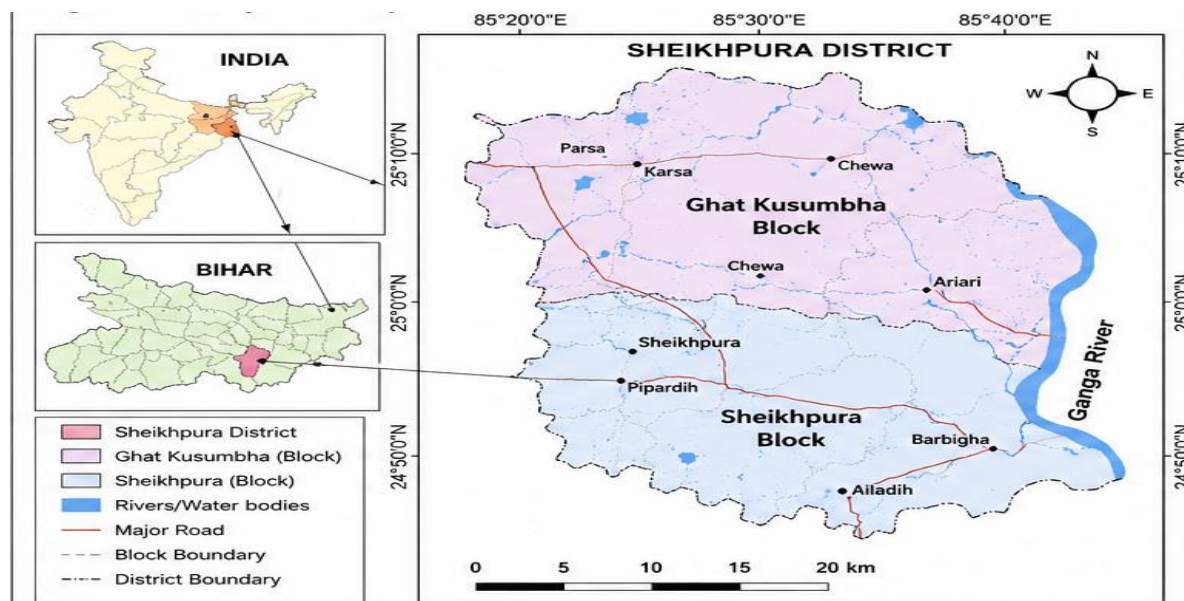


Figure 1. Study area map.

4. Freshwater Habitat Characteristics

Freshwater habitats in Ghat Kusumbha and Sheikhpura Block comprise a mosaic of natural and human-modified ecosystems, including village ponds, seasonal wetlands, irrigation canals, drainage channels, and seasonal streams. Habitat heterogeneity in hydroperiod, connectivity, vegetation, substrate, and water quality is a key determinant of freshwater fish diversity, influencing feeding, spawning, recruitment, and migration (Dudgeon et al., 2006; Tockner & Stanford, 2002). Village ponds, the dominant aquatic habitats, support aquaculture, capture fisheries, groundwater recharge, and biodiversity by providing spawning, nursery, and refuge habitats enriched with macrophytes, plankton, and benthic fauna. Seasonal wetlands, formed during the southwest monsoon, function as biodiversity hotspots where periodic flooding enhances nutrient cycling, productivity, and fish dispersal (Junk et al., 1989). Irrigation canals improve hydrological connectivity, facilitating fish movement and genetic exchange, although intensive maintenance can degrade habitat quality. Likewise, drainage channels and seasonal streams reconnect fragmented habitats during monsoon floods, supporting fish recruitment and life-cycle completion. Alterations through wetland reclamation, groundwater extraction, channel modification, and agricultural intensification increasingly threaten these ecologically important freshwater habitats (Reid et al., 2019; Davidson, 2014).

Table 1. Major freshwater fish orders and representative families recorded from Bihar

Order	Major families	Representative genera
Cypriniformes	Cyprinidae, Cobitidae	<i>Labeo</i> , <i>Catla</i> , <i>Cirrhinus</i> , <i>Pethia</i> , <i>Puntius</i>
Siluriformes	Bagridae, Siluridae, Clariidae, Heteropneustidae	<i>Mystus</i> , <i>Wallago</i> , <i>Clarias</i> , <i>Heteropneustes</i>
Channiformes	Channidae	<i>Channa</i>
Osteoglossiformes	Notopteridae	<i>Notopterus</i> , <i>Chitala</i>
Synbranchiformes	Mastacembelidae	<i>Mastacembelus</i> , <i>Macrognathus</i>
Perciformes	Ambassidae, Cichlidae, Gobiidae	<i>Parambassis</i> , <i>Oreochromis</i> , <i>Glossogobius</i>
Beloniformes	Belonidae	<i>Xenentodon</i>
Cyprinodontiformes	Aplocheilidae	<i>Aplocheilus</i>
Anguilliformes	Anguillidae	<i>Anguilla</i>

5. Ecological Importance of Habitat Diversity

Habitat diversity represents one of the strongest predictors of freshwater fish richness and community stability. Variations in water depth, substrate composition, aquatic vegetation, hydrological connectivity, dissolved oxygen concentration, and nutrient availability create diverse ecological niches that support a broad range of fish species with differing life-history strategies (Matthews, 1998). Studies conducted in floodplain wetlands of Bihar have consistently demonstrated that structurally heterogeneous aquatic ecosystems support higher fish diversity than simplified habitats. Seasonal connectivity among ponds, wetlands, canals, and drainage channels enhances dispersal, spawning success, and recruitment while maintaining ecosystem resilience under fluctuating environmental conditions (Sarkar et al., 2008).

For Ghat Kusumbha and Sheikhpura Block, conservation of interconnected freshwater habitats rather than isolated water bodies should therefore constitute the primary objective of sustainable fisheries management. An ecosystem-based management approach that maintains hydrological connectivity, protects wetland integrity, and minimizes anthropogenic disturbances is expected to provide long-term benefits for both biodiversity conservation and rural livelihoods.

6. Ichthyofaunal Diversity of Bihar

Bihar, located within the middle Gangetic Basin, possesses one of India's richest freshwater ecosystems, comprising rivers, floodplain wetlands (*chaurs*), oxbow lakes, reservoirs, irrigation canals, ponds, and seasonal

water bodies. These diverse habitats support more than 150 freshwater fish species and sustain inland fisheries that are vital for biodiversity conservation, food security, and rural livelihoods (Lakra et al., 2010; Sudhan et al., 2017;FAO, 2022). Seasonal monsoon flooding reconnects rivers with floodplain wetlands, facilitating migration, spawning, juvenile recruitment, and genetic exchange in accordance with the Flood Pulse Concept (Junk et al., 1989). Fish diversity is primarily regulated by habitat heterogeneity, hydrological connectivity, water quality, aquatic vegetation, and climatic variability, with relatively undisturbed wetlands supporting greater species richness than highly modified aquatic habitats (Dudgeon et al., 2006; Reid et al., 2019). Taxonomically, the ichthyofauna is dominated by Cypriniformes (Cyprinidae), followed by Siluriformes, Perciformes, Synbranchiformes, Osteoglossiformes, Beloniformes, and Anguilliformes (Lakra et al., 2010, Koushlesh et al., 2021).

Table 2. Chronological review of fish diversity studies in Bihar (2000–2026)

Year	Study area	Major findings	Significance	Reference
2000–2005	Ganga River, Bihar	Baseline documentation of freshwater fish diversity and fisheries resources in the middle Gangetic Basin.	Established reference data for biodiversity assessment.	Lakra et al. (2010)
2006	Freshwater ecosystems (global relevance to Bihar)	Emphasized freshwater biodiversity as one of the world's most threatened ecosystems.	Provided the conceptual basis for freshwater conservation.	Dudgeon et al. (2006)
2010	Major rivers of India including Bihar	Reviewed fish biodiversity, habitat ecology, and conservation priorities in Indian rivers.	Developed a national framework for freshwater fish conservation.	Lakra et al. (2010)
2012	River Ganga (Bihar reach)	Documented changes in fish diversity associated with pollution, habitat degradation, and hydrological alteration.	Landmark review of fish diversity and conservation in the Ganga Basin.	Sarkar et al. (2008)
2015–2019	Floodplain wetlands of North Bihar	Regional studies assessed fish assemblages, wetland productivity, and fisheries potential.	Enhanced understanding of wetland ecology and inland fisheries.	Various authors
2020	Mone Wetland, Siwan District	Evaluated fish diversity and community structure in a river-connected wetland.	Demonstrated ecological importance of floodplain wetlands.	Kumar et al. (2020)
2021–2023	Kasaraiya Dhar Wetland, Khagaria	Recorded 58 fish species belonging to multiple families; Cyprinidae was dominant.	One of the most comprehensive recent fish diversity studies from Bihar wetlands.	Singh et al. (2023)
2023	Manjhaul Wetland, Begusarai	Reported 48 fish species including several indigenous ornamental fishes.	Highlighted the conservation importance of indigenous fish diversity.	Kumar et al. (2023)
2025	Dhurde Tal Wetland, Saran	Seasonal assessment of fish diversity and ecosystem health.	Demonstrated relationships between habitat quality and fish diversity.	Recent regional study (2025)
2026	Bihar and Middle Gangetic Basin	Recent reviews emphasized habitat connectivity, climate	Updated conservation priorities for inland fisheries.	Recent literature (2026)

		resilience, and ecosystem-based fisheries management.		
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Economically important major carps (*Catla catla*, *Labeo rohita*, and *Cirrhinus mrigala*), diverse catfishes (*Mystus*, *Wallago*, *Ompok*, *Clarias*, and *Heteropneustes*), snakeheads (*Channa* spp.), and nutritionally important Small Indigenous Fish Species (SIFS), including *Amblypharyngodon*, *Esomus*, *Pethia*, *Puntius*, *Aplocheilichthys*, and *Glossogobius*, collectively sustain fisheries production and nutritional security (Jhingran, 1991; Thilsted et al., 2014). However, freshwater biodiversity is increasingly threatened by habitat fragmentation, wetland reclamation, pollution, overfishing, invasive alien species, and climate change, necessitating ecosystem-based fisheries management, wetland restoration, maintenance of environmental flows, community participation, and long-term biodiversity monitoring (Dudgeon et al., 2006; Reid et al., 2019; FAO, 2022; IPBES, 2019; Kumari et al., 2026). Although comprehensive surveys are lacking in Ghat Kusumbha and Sheikhpura Block, their habitats are expected to support representative assemblages of the middle Gangetic ichthyofauna, highlighting the need for standardized inventories using DNA barcoding, environmental DNA (eDNA), GIS-based habitat mapping, and long-term ecological monitoring to guide evidence-based conservation and sustainable fisheries management.

7. Fish Diversity of Ghat Kusumbha and Sheikhpura Block, Sheikhpura District Freshwater fishes are vital components of aquatic ecosystems, contributing to nutrient cycling, trophic regulation, ecosystem productivity, and food security. Their diversity is strongly influenced by habitat heterogeneity, hydrological connectivity, water quality, seasonal flooding, and anthropogenic disturbances, making fish assemblages reliable indicators of freshwater ecosystem health (Dudgeon et al., 2006; Matthews, 1998; Reid et al., 2019). Although comprehensive ichthyological surveys have not been conducted specifically in Ghat Kusumbha and Sheikhpura Block, the area's freshwater habitats—comprising village ponds, seasonal wetlands, irrigation canals, drainage channels, and rain-fed depressions—are ecologically comparable to other floodplain ecosystems of the middle Gangetic Basin and are therefore expected to support diverse indigenous fish communities (Lakra et al., 2010; Kumar et al., 2013; Das et al., 2022).

Probable fish assemblages include major carps (*Catla catla*, *Labeo rohita*, and *Cirrhinus mrigala*), minor carps, catfishes (*Mystus*, *Wallago*, *Ompok*, *Clarias*, and *Heteropneustes*), snakeheads (*Channa* spp.), featherbacks (*Notopterus* spp.), spiny eels (*Mastacembelus* spp.), and numerous Small Indigenous Fish Species (SIFS) such as *Puntius*, *Pethia*, *Esomus*, *Amblypharyngodon*, and *Glossogobius* (Talwar & Jhingran, 1991; Kumar et al., 2013). These species occupy diverse trophic niches and collectively support fisheries productivity, ecosystem functioning, and nutritional security. Seasonal wetlands and interconnected canal networks facilitate spawning, juvenile recruitment, dispersal, and gene flow, whereas habitat degradation, wetland reclamation, pollution, and hydrological fragmentation increasingly threaten these ecological processes (Junk et al., 1989; Dudgeon et al., 2006; Haque, & Joshi 2018; Reid et al., 2019). Because no comprehensive species inventory currently exists for the study area, future research should prioritize standardized seasonal surveys, GIS-based habitat mapping, DNA barcoding, environmental DNA (eDNA), and long-term ecological monitoring to establish baseline biodiversity data and guide ecosystem-based fisheries management (Bohmann et al., 2014; Deiner et al., 2017; Convention on Biological Diversity, 2022).

Table 3. Annotated checklist of freshwater fishes reported from adjacent Middle Gangetic Basin habitats and expected to occur in Ghat Kusumbha and Sheikhpura Block, Bihar

Sl. No.	Scientific name	Family	Common name	Habitat	Feeding guild	IUCN Status	Economic importance
1	<i>Catla catla</i>	Cyprinidae	Catla	Pond, River	Planktivore	LC	High
2	<i>Labeo rohita</i>	Cyprinidae	Rohu	Pond, River	Omnivore	LC	High
3	<i>Cirrhinus mrigala</i>	Cyprinidae	Mrigal	Pond, River	Bottom feeder	LC	High

4	<i>Labeo calbasu</i>	Cyprinidae	Calbasu	River, Wetland	Omnivore	LC	High
5	<i>Labeo bata</i>	Cyprinidae	Bata	Pond, Wetland	Omnivore	LC	Moderate
6	<i>Puntius sophore</i>	Cyprinidae	Pool Barb	Pond	Omnivore	LC	Moderate
7	<i>Pethia ticto</i>	Cyprinidae	Ticto Barb	Wetland	Omnivore	LC	Ornamental
8	<i>Amblypharyngodon mola</i>	Cyprinidae	Mola Carplet	Wetland	Omnivore	LC	Nutritional
9	<i>Esomus danricus</i>	Cyprinidae	Flying Barb	Wetland	Insectivore	LC	Low
10	<i>Rasbora daniconius</i>	Cyprinidae	Slender Rasbora	Pond	Omnivore	LC	Ornamental
11	<i>Mystus vittatus</i>	Bagridae	Striped Catfish	Pond	Carnivore	LC	Moderate
12	<i>Mystus tengara</i>	Bagridae	Tengara	Wetland	Carnivore	LC	Moderate
13	<i>Mystus cavasius</i>	Bagridae	Gangetic Mystus	River	Carnivore	LC	Moderate
14	<i>Wallago attu</i>	Siluridae	Freshwater Shark	River	Piscivore	NT	High
15	<i>Ompok pabda</i>	Siluridae	Pabda	Wetland	Carnivore	NT	High
16	<i>Clarias batrachus</i>	Clariidae	Magur	Pond	Omnivore	LC	High
17	<i>Heteropneustes fossilis</i>	Heteropneustidae	Singhi	Pond	Carnivore	LC	High
18	<i>Ailia coila</i>	Ailiidae	Ailia	River	Carnivore	NT	Moderate
19	<i>Notopterus notopterus</i>	Notopteridae	Featherback	Wetland	Carnivore	LC	High
20	<i>Chitala chitala</i>	Notopteridae	Clown Knifefish	River	Piscivore	NT	High
21	<i>Channa punctata</i>	Channidae	Spotted Snakehead	Pond	Carnivore	LC	High
22	<i>Channa striata</i>	Channidae	Striped Snakehead	Wetland	Carnivore	LC	High
23	<i>Channa marulius</i>	Channidae	Giant Snakehead	River	Piscivore	LC	High
24	<i>Channa gachua</i>	Channidae	Dwarf Snakehead	Wetland	Carnivore	LC	Moderate
25	<i>Macrogathus pancalus</i>	Mastacembelidae	Barred Spiny Eel	Wetland	Insectivore	LC	Moderate

26	<i>Mastacembelus armatus</i>	Mastacembelidae	Spiny Eel	River	Carnivore	LC	High
27	<i>Glossogobius giuris</i>	Gobiidae	Tank Goby	Pond	Carnivore	LC	Moderate
28	<i>Anabas testudineus</i>	Anabantidae	Climbing Perch	Pond	Omnivore	DD	High
29	<i>Nandus nandus</i>	Nandidae	Leaf Fish	Wetland	Carnivore	NT	Moderate
30	<i>Xenentodon cancila</i>	Belonidae	Freshwater Garfish	River	Piscivore	LC	Moderate
31	<i>Gudusia chapra</i>	Clupeidae	Indian River Shad	River	Planktivore	LC	Moderate
32	<i>Trichogaster fasciata</i>	Osphronemidae	Banded Gourami	Wetland	Omnivore	LC	Ornamental
33	<i>Trichogaster lalius</i>	Osphronemidae	Dwarf Gourami	Pond	Omnivore	LC	Ornamental
34	<i>Badis badis</i>	Badidae	Blue Perch	Wetland	Carnivore	LC	Ornamental
35	<i>Lepidocephalichthys guntea</i>	Cobitidae	Guntea Loach	Pond	Bottom feeder	LC	Moderate
36	<i>Botia dario</i>	Botiidae	Bengal Loach	River	Omnivore	LC	Ornamental
37	<i>Oreochromis niloticus</i>	Cichlidae	Nile Tilapia*	Pond	Omnivore	NE	Aquaculture
38	<i>Cyprinus carpio</i>	Cyprinidae	Common Carp*	Pond	Omnivore	VU (Wild)	Aquaculture
39	<i>Ctenopharyngodon idella</i>	Cyprinidae	Grass Carp*	Pond	Herbivore	NE	Aquaculture
40	<i>Hypophthalmichthys molitrix</i>	Cyprinidae	Silver Carp*	Pond	Planktivore	NT (Wild)	Aquaculture

Abbreviations: LC = Least Concern; NT = Near Threatened; VU = Vulnerable; DD = Data Deficient; NE = Not Evaluated.

* Introduced (exotic) species widely cultured in Bihar.

8. Taxonomic Diversity and Ecological Characteristics of the Fish Fauna

The freshwater fish fauna of Ghat Kusumbha and Sheikhpura Block reflects the broader ichthyofaunal diversity of the middle Gangetic Basin, where habitat heterogeneity supports numerous taxonomic groups. Regional studies indicate that the ichthyofauna is dominated by Cypriniformes, particularly the family Cyprinidae, followed by Siluriformes, Perciformes, Synbranchiformes, Osteoglossiformes, and Anabantiformes (Talwar & Jhingran, 1991; Kumar et al., 2013). Cyprinids form the ecological and economic foundation of inland fisheries because of their broad environmental tolerance, diverse feeding habits, and reproductive adaptability in both lentic and lotic ecosystems. Catfishes, snakeheads, featherbacks, spiny eels, gobies, and climbing perch further enhance ecological and functional diversity within freshwater habitats (Jhingran, 1991; Matthews, 1998).

Freshwater fishes occupy diverse ecological niches that regulate ecosystem functioning through herbivory, planktivory, omnivory, benthivory, insectivory, detritivory, and piscivory, thereby maintaining nutrient cycling, energy flow, and food-web stability (Matthews, 1998). Seasonal hydrological connectivity among ponds,

wetlands, irrigation canals, and drainage channels facilitates migration, spawning, juvenile recruitment, and genetic exchange, sustaining fish populations across the landscape (Junk et al., 1989; Tockner & Stanford, 2002). Ecologically important groups include major carps (*Catla catla*, *Labeo rohita*, and *Cirrhinus mrigala*), catfishes (*Mystus*, *Wallago*, *Ompok*, *Clarias*, and *Heteropneustes*), snakeheads (*Channa* spp.), climbing perch (*Anabas testudineus*), featherbacks (*Notopterus notopterus* and *Chitala chitala*), spiny eels (*Mastacembelus armatus* and *Macrognathus pancalus*), and Small Indigenous Fish Species (SIFS) such as *Amblypharyngodon*, *Esomus*, *Pethia*, *Puntius*, *Glossogobius*, and *Aplocheilichthys*. Besides maintaining ecological balance, SIFS provide affordable sources of protein and essential micronutrients for rural communities (Thilsted et al., 2014). However, habitat degradation, pollution, invasive species, overexploitation, and climate change increasingly threaten both taxonomic and functional diversity throughout the Gangetic Basin (Dudgeon et al., 2006; Reid et al., 2019). Future studies integrating conventional surveys with DNA barcoding, environmental DNA (eDNA), and GIS-based habitat assessment are essential for strengthening biodiversity inventories and ecosystem-based fisheries management (Bohmann et al., 2014; Deiner et al., 2017).

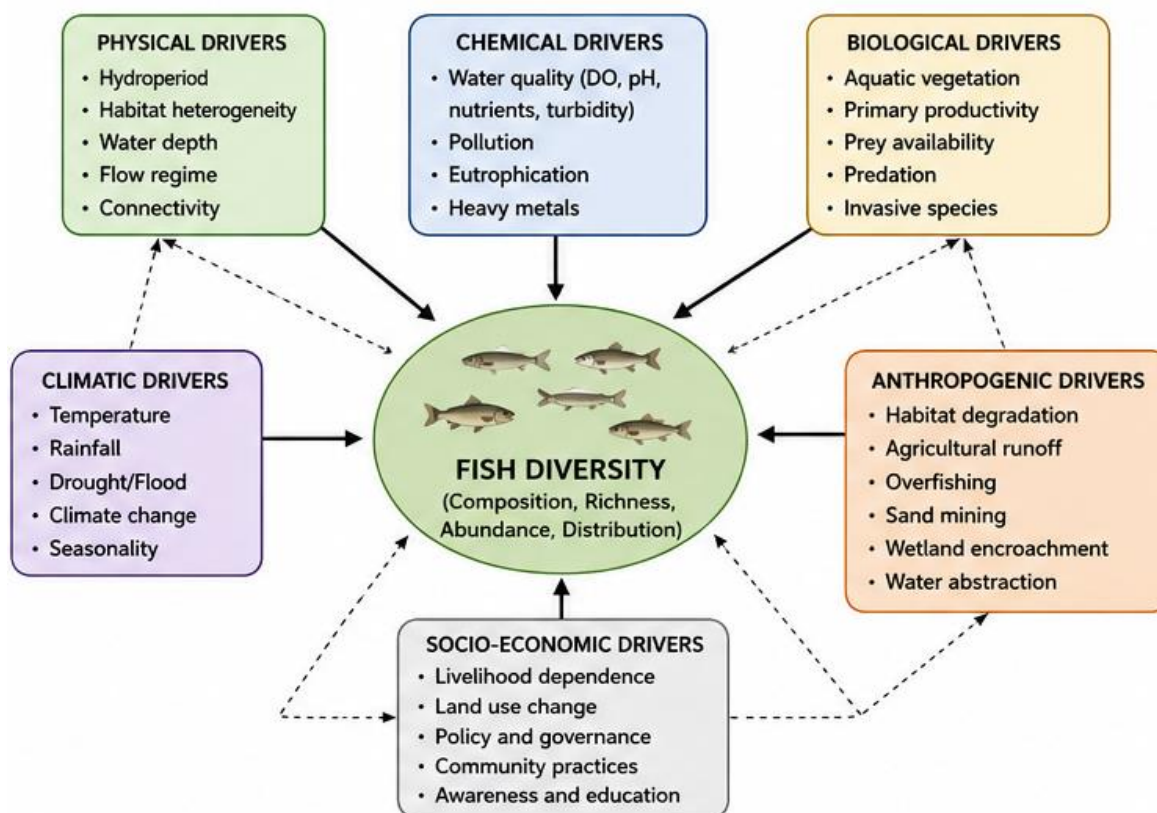


Figure 2. Conceptual framework of environmental drivers affecting fish diversity.

9. Habitat Characteristics and Environmental Drivers of Fish Diversity

Habitat quality is a fundamental determinant of freshwater fish diversity because physical, chemical, and biological attributes regulate species distribution, abundance, reproduction, and ecosystem productivity. Fish assemblages are strongly influenced by habitat heterogeneity, hydrological connectivity, water quality, substrate composition, and aquatic vegetation, making them reliable indicators of freshwater ecosystem health (Dudgeon et al., 2006; Matthews, 1998; Reid et al., 2019). In Ghat Kusumbha and Sheikhpura Block, freshwater habitats comprise village ponds, seasonal wetlands, irrigation canals, drainage channels, and rain-fed depressions that collectively support inland fisheries and aquatic biodiversity. Seasonal monsoon flooding reconnects these habitats, promoting nutrient exchange, fish migration, spawning, juvenile recruitment, and maintenance of ecological connectivity in accordance with the Flood Pulse Concept (Junk et al., 1989). Village ponds provide breeding, nursery, feeding, and refuge habitats, while seasonal wetlands serve as highly productive spawning grounds enriched with aquatic vegetation and food resources. Irrigation canals and drainage channels further facilitate seasonal dispersal and genetic exchange among fish populations, thereby enhancing ecosystem resilience (Tockner & Stanford, 2002).

Water quality variables including temperature, dissolved oxygen, pH, turbidity, conductivity, and nutrient availability directly influence habitat suitability and fish productivity, whereas excessive agricultural runoff can trigger eutrophication, algal blooms, and oxygen depletion (Wetzel, 2001). Aquatic macrophytes and heterogeneous substrates increase habitat complexity by providing spawning sites, shelter, and benthic feeding habitats (Matthews, 1998). However, agricultural intensification, wetland encroachment, pollution, groundwater abstraction, channel modification, invasive alien species, and climate change increasingly degrade these ecosystems and disrupt hydrological processes (Dudgeon et al., 2006; Reid et al., 2019; IPCC, 2023). Conserving habitat heterogeneity through wetland restoration, protection of village ponds, sustainable agriculture, environmental flow maintenance, and community participation is therefore essential. Future research integrating standardized seasonal surveys, limnological monitoring, Geographic Information Systems (GIS), remote sensing, DNA barcoding, and environmental DNA (eDNA) will strengthen evidence-based conservation and sustainable fisheries management in Sheikhpura District (Bohmann et al., 2014; Deiner et al., 2017).

10. Conservation Challenges to Freshwater Fish Diversity

Freshwater ecosystems are among the most threatened ecosystems globally, despite occupying less than 1% of the Earth's surface while supporting nearly half of all fish species and approximately one-third of vertebrate diversity (Dudgeon et al., 2006). In the middle Gangetic Basin, increasing anthropogenic pressures have accelerated freshwater biodiversity loss through habitat degradation, hydrological alteration, pollution, overexploitation, invasive alien species, and climate change (Reid et al., 2019). Although comprehensive ichthyological surveys are unavailable for Ghat Kusumbha and Sheikhpura Block, regional evidence suggests that these threats similarly affect local ponds, wetlands, irrigation canals, and drainage systems, reducing fish diversity and ecosystem resilience (Kumar et al., 2013). Habitat loss resulting from agricultural expansion, wetland reclamation, pond filling, and infrastructure development has diminished spawning and nursery habitats while disrupting seasonal hydrological connectivity essential for fish migration and gene flow (Dudgeon et al., 2006; Junk et al., 1989). Water pollution from fertilizers, pesticides, domestic wastewater, and solid waste further degrades aquatic habitats through eutrophication, oxygen depletion, and contamination, adversely affecting fish growth, reproduction, and survival (Wetzel, 2001). Unsustainable fishing practices, including capture of juveniles, fine-mesh nets, poisoning, and electric fishing, together with invasive alien fishes such as *Oreochromis niloticus*, *Cyprinus carpio*, and *Ctenopharyngodon idella*, have intensified pressure on indigenous fish populations (FAO, 2022). Climate change, manifested through irregular monsoon rainfall, rising temperatures, droughts, and floods, further threatens seasonal wetlands and small ponds that depend on monsoon recharge (IPCC, 2023; Reid et al., 2019). Addressing these challenges requires standardized biodiversity surveys, long-term water-quality monitoring, DNA barcoding, environmental DNA (eDNA), GIS and remote sensing-based habitat mapping, invasive species assessment, and climate vulnerability analyses (Bohmann et al., 2014; Deiner et al., 2017). Integrating scientific research with ecosystem-based fisheries management, wetland restoration, sustainable agriculture, and community participation will provide the foundation for long-term conservation of freshwater fish diversity in Sheikhpura District.

11. Conservation Strategies and Policy Perspectives

The conservation of freshwater fish diversity requires an integrated approach that combines habitat protection, sustainable fisheries management, scientific research, community participation, and effective policy implementation. Freshwater ecosystems are complex socio-ecological systems in which biodiversity conservation and human well-being are closely interconnected. Sustainable management should therefore maintain ecological integrity while ensuring food security, rural livelihoods, and the continued provision of ecosystem services (Dudgeon et al., 2006; FAO, 2022; Reid et al., 2019). In Ghat Kusumbha and Sheikhpura Block, freshwater habitats—including village ponds, seasonal wetlands, irrigation canals, and drainage channels—support indigenous fish diversity, groundwater recharge, irrigation, and rural fisheries. Their long-term conservation depends on maintaining habitat quality, ecological connectivity, and adaptive ecosystem-based management.

Habitat conservation forms the cornerstone of freshwater biodiversity protection because habitat degradation remains the leading cause of global freshwater fish declines (Dudgeon et al., 2006). Conservation priorities should focus on protecting ponds, wetlands, drainage channels, and irrigation canals from encroachment, pollution, excessive siltation, and unsustainable land-use changes. Restoration efforts should include scientifically planned desiltation, rehabilitation of native aquatic vegetation, stabilization of pond margins, and restoration of hydrological connectivity among fragmented aquatic habitats to enhance spawning, recruitment, and seasonal migration of fishes (Junk et al., 1989; Tockner & Stanford, 2002). Sustainable fisheries management should further integrate biodiversity conservation with fish production through ecosystem-based approaches, including seasonal fishing bans during breeding periods, minimum mesh-size regulations, protection of spawning grounds, regulation of stocking practices, promotion of indigenous fish culture, and prohibition of destructive fishing methods such as poisoning and electric fishing. Community-based fisheries management involving fisher cooperatives,

Panchayati Raj Institutions, and local stakeholders has been shown to improve resource stewardship and long-term sustainability (FAO, 2022).

Special attention should be given to Small Indigenous Fish Species (SIFS) because they contribute significantly to biodiversity, ecosystem functioning, and household nutrition. Conservation strategies should prioritize the protection of shallow wetlands, village ponds, rice-field ecosystems, and aquatic vegetation that support these species throughout their life cycle. Reducing pesticide contamination, preventing wetland conversion, and integrating indigenous fishes into ecologically sustainable culture systems can simultaneously enhance biodiversity conservation and nutritional security (Thilsted et al., 2014). Public awareness programmes and active community participation are equally important for promoting the ecological and socioeconomic value of indigenous fish resources.

Maintaining water quality is equally critical for sustaining freshwater biodiversity. Agricultural runoff, untreated domestic wastewater, and indiscriminate waste disposal contribute to eutrophication, contamination, and declining dissolved oxygen levels. Adoption of integrated nutrient management, environmentally friendly agricultural practices, riparian buffer zones, wastewater treatment, and regular monitoring of physicochemical parameters can substantially improve aquatic habitat quality (Wetzel, 2001). Furthermore, climate change is expected to alter rainfall patterns, hydrological regimes, and water availability, increasing the vulnerability of freshwater ecosystems (IPCC, 2023). Climate adaptation strategies should therefore emphasize wetland restoration, groundwater conservation, maintenance of environmental flows, habitat connectivity, and long-term ecological monitoring.

India has established several policy instruments supporting freshwater biodiversity conservation, including the Biological Diversity Act, 2002, the Wetlands (Conservation and Management) Rules, 2017, the National Biodiversity Action Plan, the National Fisheries Policy, the Pradhan Mantri Matsya Sampada Yojana (PMMSY), and the National Plan for Conservation of Aquatic Ecosystems (NPCA). However, stronger coordination among government agencies, researchers, and local communities is required for effective implementation. Future research should prioritize standardized biodiversity surveys, DNA barcoding, environmental DNA (eDNA), GIS and remote sensing-based habitat mapping, long-term ecological monitoring, invasive species assessment, and climate vulnerability studies (Bohmann et al., 2014; Deiner et al., 2017). Collectively, these measures will strengthen ecosystem resilience, improve evidence-based conservation planning, and ensure the sustainable management of freshwater resources in Ghat Kusumbha and Sheikhpura Block and the wider middle Gangetic Basin.

12. Conclusion

Freshwater ecosystems are among the most biologically diverse and ecologically important ecosystems, providing essential ecosystem services, supporting inland fisheries, and sustaining rural livelihoods. This review synthesized the available scientific literature on freshwater fish diversity, habitat characteristics, conservation challenges, and management strategies relevant to Ghat Kusumbha and Sheikhpura Block of Sheikhpura District, Bihar. Although comprehensive ichthyological studies from the study area remain limited, evidence from the middle Gangetic Basin indicates that local freshwater habitats, including village ponds, seasonal wetlands, irrigation canals, and drainage channels, support diverse assemblages of indigenous fishes and contribute significantly to regional biodiversity and fisheries productivity (Kumar et al., 2013; Reid et al., 2019).

The review identifies habitat heterogeneity and seasonal hydrological connectivity as the primary factors sustaining fish diversity. Monsoon-driven flood dynamics facilitate spawning, migration, recruitment, and gene flow, highlighting the ecological importance of conserving interconnected freshwater habitats (Junk et al., 1989). However, these ecosystems are increasingly threatened by habitat degradation, wetland encroachment, pollution, hydrological fragmentation, overexploitation, invasive alien species, and climate change, all of which reduce biodiversity and ecosystem resilience (Dudgeon et al., 2006; Reid et al., 2019).

A major finding is the significant knowledge gap regarding the ichthyofauna of Sheikhpura District. Future research should prioritize systematic biodiversity inventories using standardized field surveys, DNA barcoding, environmental DNA (eDNA), Geographic Information Systems (GIS), remote sensing, and long-term ecological monitoring to establish reliable baseline data (Bohmann et al., 2014; Deiner et al., 2017). Conservation efforts should adopt an ecosystem-based approach integrating habitat restoration, sustainable fisheries management, pollution control, community participation, and effective implementation of existing policies, including the Biological Diversity Act (2002), Wetlands (Conservation and Management) Rules (2017), NPCA, and PMMSY. Overall, this review provides a scientific foundation for future research, evidence-based policymaking, and sustainable management of freshwater biodiversity in Sheikhpura District and the wider middle Gangetic Basin.

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