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Spatial And Seasonal Dynamics Of Freshwater Fish Diversity In Riverine And Lacustrine Wetlands Of Jaunpur District, Uttar Pradesh, India

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ABSTRACT

The present study investigates the spatial and seasonal dynamics of freshwater fish diversity in selected riverine and lacustrine wetlands of Jaunpur District, Uttar Pradesh, with special reference to River Gomti and Gujar Tal. The study is based entirely on primary field data collected through systematic, season-wise sampling using standard fishing gears across multiple stations. Species richness, station-wise and seasonal variation, and community structure were analyzed using biodiversity indices such as Shannon–Wiener, Simpson, and Evenness indices. Primary schematic spatial maps were generated to interpret the spatial distribution of fish diversity without reliance on secondary sources. The results revealed that River Gomti supported higher species richness and ecological stability compared to Gujar Tal, primarily due to continuous water flow, habitat heterogeneity, and connectivity. Seasonal analysis showed maximum fish diversity during the monsoon season and minimum during summer, highlighting the influence of hydrological conditions on fish assemblages. Conservation assessment based on IUCN categories indicated that while most species were classified as Least Concern, the presence of Near Threatened, Vulnerable, and Data Deficient species signals emerging conservation risks. Major threats identified included overfishing, pollution, and agricultural runoff. The study emphasizes the need for site-specific, season-sensitive management and conservation strategies to ensure the long-term sustainability of freshwater fish biodiversity in wetland ecosystems.

Keywords: *Freshwater Fish Diversity; Wetlands; Jaunpur; Biodiversity Indices; Seasonal Variation; Conservation Status; IUCN; GIS Mapping; Exotic Species; Sustainable Wetland Management.*

1. Introduction

Wetlands are among the most productive ecosystems on Earth, playing a critical role in maintaining regional biodiversity, hydrological balance, and ecological resilience. Freshwater wetlands, in particular, support an immense variety of aquatic flora and fauna, with fish forming one of the most ecologically and economically significant components of these habitats. In India, which hosts a vast network of wetlands ranging from

floodplains, oxbow lakes, and marshes to man-made tanks and reservoirs, freshwater fish diversity is of paramount importance not only from a biodiversity conservation standpoint but also due to its contribution to rural livelihoods, nutritional security, and socio-cultural traditions. However, over the past few decades, increasing anthropogenic pressure, habitat degradation, pollution, climate variability, and the spread of invasive species have severely impacted freshwater ecosystems, leading to a notable decline in native fish populations. The present study, titled "Assessment of Freshwater Fish Biodiversity and Conservation Status in Selected Wetlands of Jaunpur District," is an attempt to address this pressing issue by conducting a detailed ecological assessment of fish species across multiple wetlands situated in Jaunpur, a district in eastern Uttar Pradesh known for its agricultural dominance and network of seasonal and perennial water bodies. The study focuses on four representative wetland systems—Gujar Tal, Chandrawal Pond, Sikraur Wetland, and Hathipur Wetland—each varying in terms of hydrology, anthropogenic influence, and management regime, thus offering a comprehensive landscape for understanding the spatial and temporal distribution of freshwater fish diversity.[1]

The need for such a study is rooted in the growing evidence of declining fish populations in small and medium-scale inland water bodies, which often receive less attention compared to major river systems. Wetlands in semi-rural districts like Jaunpur are frequently overlooked in biodiversity monitoring programs despite their ecological value and contribution to local subsistence fishing practices. [10]These wetlands serve as breeding grounds, nursery habitats, and feeding zones for numerous fish species and also act as ecological buffers against floods, nutrient loading, and groundwater depletion. However, the cumulative impacts of intensive agriculture, chemical runoff, solid waste discharge, unregulated aquaculture, and urban expansion have degraded water quality and reduced habitat complexity in many of these systems. [3]Moreover, the introduction of exotic fish species like *Oreochromis mossambicus* (tilapia) and *Clarias gariepinus* (African catfish) in managed ponds has further disrupted native fish assemblages, leading to competitive exclusion, genetic dilution, and altered food web dynamics. In this context, the assessment of current fish biodiversity, the identification of threatened species, and the documentation of ecological changes in wetlands are crucial for formulating conservation strategies and sustainable management practices.[2]

This research aims to bridge the knowledge gap by conducting seasonal sampling across the selected wetlands to record species richness, abundance, and ecological preferences. Fish specimens will be collected using traditional gear such as scoop nets, drag nets, gill nets, and mosquito-net traps with the assistance of local fishermen, who also provide valuable traditional ecological knowledge.[9] Specimens will be photographed, preserved in formalin, and identified taxonomically using standard keys and reference databases such as FishBase. The use of biodiversity indices—including the Shannon-Weiner Index, Simpson's Dominance Index, Margalef's Richness Index, and Evenness Index—will allow a statistical interpretation of community structure, dominance patterns, and species evenness across different wetland types and seasonal phases. These quantitative assessments will be complemented with qualitative observations of habitat characteristics, anthropogenic pressures, and community interactions with the wetland ecosystem. Moreover, this study integrates geospatial tools such as GIS and remote sensing to map the spatial extent of wetlands, seasonal changes in water spread, vegetative cover, and proximity to human disturbances. Satellite imagery from sources such as LANDSAT and IRS-P6, combined with field-collected GPS data, will be used to analyze habitat fragmentation and correlate physical variables with fish distribution patterns.[4]

A core component of the study is the conservation assessment of the recorded species. Each species will be cross-referenced with the International Union for Conservation of Nature (IUCN) Red List and the Conservation Assessment and Management Plan (CAMP) for Indian freshwater fishes to determine their conservation status and level of threat. This will help in identifying vulnerable, near-threatened, or endangered species that require immediate protection or habitat intervention. While some species may be classified globally as "Least Concern," localized pressures may have led to their sharp decline in specific habitats, warranting regional conservation action.[8] The study will also document the presence of invasive species and their impact on the native fish community, which is a growing concern in artificial and semi-natural wetlands like Hathipur. Furthermore, by engaging with local communities, particularly fishermen and wetland-dependent households, the study will explore traditional practices related to fishing, seasonal fishing bans, breeding taboos, and historical changes in fish abundance—all of which offer valuable context to the ecological data and provide a pathway for community-based conservation approaches.[5]

In addition to generating ecological data, the study aims to develop site-specific conservation recommendations based on the findings. For instance, natural wetlands like Gujar Tal may benefit from enhanced legal protection, periodic biodiversity monitoring, and regulation of fishing pressure during spawning periods. Semi-perennial systems like Chandrawal Pond could be improved through solid waste management, reduction of religious immersion practices, and creation of vegetative buffers. Seasonal wetlands like Sikraur may require

hydrological augmentation to extend their hydroperiod and maintain breeding habitats for air-breathing and drought-tolerant species. Managed aquaculture systems like Hathipur can be transitioned toward sustainable fish farming models that integrate native species, reduce chemical inputs, and prevent escape of exotics into surrounding ecosystems. These recommendations will be designed to align with national and state-level wetland conservation policies and biodiversity action plans. By emphasizing a multidisciplinary approach that combines ecological research, statistical analysis, spatial tools, and community engagement, the study seeks to provide a replicable model for wetland fish biodiversity assessment in other semi-rural districts of India.

Ultimately, the significance of this research lies in its contribution to both science and policy. It offers a much-needed ecological baseline for Jaunpur's wetlands, identifies areas of high conservation value, and alerts stakeholders to the risks posed by ecological neglect. The research aligns with national priorities such as the National Wetland Conservation Programme (NWCP),[7] the National Biodiversity Action Plan (NBAP), and Sustainable Development Goals (SDGs) like Life Below Water and Clean Water and Sanitation. In doing so, it lays the foundation for evidence-based conservation, improved wetland governance, and long-term ecological sustainability. By integrating field-based ecological observations with spatial analysis and stakeholder insights, the study not only enhances our understanding of freshwater fish diversity in wetlands but also underscores the urgent need for protecting these fragile ecosystems in the face of rapid environmental change and developmental pressures.[6]

2. Literature Review

The assessment of freshwater fish biodiversity and conservation status in wetland ecosystems has emerged as a crucial area of research in light of increasing ecological degradation, loss of native species, and unregulated anthropogenic pressure on aquatic habitats. Numerous studies, both global and national, have emphasized the vital ecological, economic, and cultural roles of freshwater fish in wetland ecosystems.[11] Wetlands provide essential ecological services such as nutrient recycling, flood control, and groundwater recharge while simultaneously serving as breeding, feeding, and nursery grounds for a wide variety of fish species.[25] However, studies from different regions indicate that wetland ecosystems are under severe stress due to pollution, habitat fragmentation, water abstraction, introduction of exotic species, and overexploitation. Dudgeon (2019) described the Anthropocene as a period of unprecedented threats to freshwater biodiversity, driven largely by human-induced changes in land use, pollution, and hydrological alterations. Similarly, Siligato and Bohmer (2001) emphasized that indicators of fish health and diversity at multiple levels of biological organization can effectively reflect stream and wetland pollution levels. In India, wetlands account for a significant portion of the country's inland aquatic resources and are home to more than 800 freshwater fish species, many of which are endemic or have high regional conservation value. Jayaram (2010) and the CIFRI reports have consistently highlighted the importance of conserving these habitats, particularly in riverine and floodplain systems like those found in eastern Uttar Pradesh.[12]

At the national level, Devi Prasad et al. (2009) and Vass et al. (2009) documented fish diversity and associated ecological variables in the wetlands of Mysore and the Gangetic plains respectively, pointing out that seasonal wetlands, oxbow lakes, and tanks offer critical but often ignored biodiversity services. These studies found that the richness and composition of fish communities are strongly influenced by wetland type, hydroperiod, depth, and human activity. [24]In a comparative study of lentic water bodies, Naik and Kiran (2017) demonstrated that natural and semi-natural wetlands exhibit significantly higher biodiversity indices compared to those subjected to aquaculture or urban encroachment. This observation is particularly relevant to the present study area in Jaunpur, where wetlands such as Gujar Tal and Chandrawal Pond face variable pressures ranging from agricultural runoff to unmanaged religious practices. In another study by Muniya et al. (2019) on the Kadana Reservoir in Gujarat, the researchers emphasized the seasonal variation in fish species abundance and recommended incorporating this variation into conservation planning. Seasonal fluctuations in fish diversity have also been documented by Kumar et al. (2011), [23]who noted that monsoon expansion and increased inflow create favorable conditions for breeding, while pre-monsoon periods are marked by reduced diversity and dominance of tolerant species. These findings support the present study's methodological design involving seasonal sampling and analysis of fish community structures.[13]

The introduction and proliferation of exotic species is another theme widely discussed in literature. Manimekalan et al. (2012) and Sarkar et al. (2018) examined the ecological threats posed by invasive fish species like *Oreochromis mossambicus* and *Clarias gariepinus* in South Indian wetlands and found strong evidence of native species decline due to competition, predation, and habitat alteration. [22]These studies urge the regulation of aquaculture practices and encourage the promotion of native fish culture for both biodiversity and sustainability reasons. In the context of Jaunpur's Hathipur Wetland, where exotic species are dominant

due to aquaculture, such insights are especially relevant. Furthermore, studies by Lalitha and Ramakrishna (2022) on Kunigal Tank and by Nayaka (2018) on Bugudana Halli Lake have shown that small indigenous species (SIS), such as *Puntius sophore*, *Esomus danricus*, and *Amblypharyngodon mola*, are often neglected in biodiversity assessments despite their ecological importance and nutritional value. These SIS are typically found in vegetated margins and shallow waters and are more sensitive to habitat alteration and pollution, making them excellent ecological indicators.[14]

From a methodological perspective, the use of biodiversity indices such as the Shannon-Weiner Index, Simpson's Dominance Index, Margalef's Richness Index, and Pielou's Evenness Index is well-established in ichthyological research. Studies by Khan and Khan (2016) on the Yamuna wetlands demonstrated how these indices can quantify differences in species richness and dominance across disturbed and undisturbed sites. Similarly, [21]Thirumala and Kiran (2017) applied these indices in Duglapura Lake, Chikkamagaluru, and correlated the results with physicochemical water parameters to assess wetland health. The analytical power of these indices makes them suitable for the current study, which involves comparative analysis across four wetlands in Jaunpur. In recent years, [15]GIS and remote sensing tools have gained prominence in ecological studies for mapping wetland boundaries, assessing land use change, and linking spatial patterns to biodiversity distribution. Prasad et al. (2002) and Sincy et al. (2022) effectively demonstrated how NDWI and NDVI indices could be used to map aquatic and vegetative zones in wetland ecosystems and relate these to fish abundance and diversity. This geospatial integration is particularly beneficial for identifying biodiversity hotspots, conservation zones, and human disturbance gradients, as will be done in the current study using satellite imagery and field GPS points.[16]

In terms of conservation assessment, IUCN Red List categories and CAMP evaluations have been the standard frameworks for determining the threat levels of freshwater species. Dahanukar et al. (2004) emphasized the need for regional assessments, noting that many species categorized as "Least Concern" globally may face severe local threats due to habitat specificity and limited distribution.[20]This discrepancy is critical in semi-rural districts like Jaunpur, where local pressures may not be adequately captured in global conservation databases. The literature further underscores the importance of integrating community knowledge and participation in wetland conservation. Sarkar and Borah (2009) presented a community-based fishery management model from Assam, showing improved outcomes in resource sustainability, rule enforcement, and habitat protection. Similarly, Das and Goswami (2013) reported that traditional knowledge systems, though declining, still hold value in ecological monitoring and fish resource management. Engaging with local stakeholders not only improves conservation success but also aligns ecological goals with socio-economic realities.[17]

To summarize, the existing literature provides a rich foundation for the assessment of freshwater fish biodiversity and conservation in wetlands. It highlights recurring patterns such as the importance of seasonal dynamics, threats from exotic species, habitat degradation, the utility of biodiversity indices, and the potential of GIS tools in ecological planning. However, the literature also reveals significant research gaps in localized, integrated assessments in semi-rural contexts like Jaunpur, where small and seasonal wetlands are both ecologically valuable and socio-economically significant. Most studies tend to focus on larger riverine systems or protected wetlands, leaving smaller, community-managed, or unmanaged water bodies underrepresented. [19]Therefore, the current study contributes meaningfully by applying a multidimensional and context-specific approach to understand fish diversity patterns, quantify ecological health, identify conservation priorities, and recommend site-specific management strategies. It not only builds on past research but also aims to address regional gaps through empirical data, spatial analysis, and community interaction, thereby enhancing the broader discourse on freshwater biodiversity conservation in India.[18]

3. Methodology

The present study adopts a descriptive and analytical research design to examine the spatial and seasonal dynamics of freshwater fish diversity in selected riverine and lacustrine wetlands of Jaunpur District, Uttar Pradesh. The study is primarily field-based**,** supported by quantitative biodiversity analysis and spatial interpretation. Emphasis is placed on generating primary data through systematic sampling, observation, and ecological assessment.

3.2 Study Area

The study was conducted in two major wetland types of Jaunpur District:

1. **River Gomti** – representing a riverine wetland system with continuous flow and longitudinal connectivity.

2. **Gujar Tal** – representing a lacustrine wetland system**,** characterized by comparatively stagnant water and seasonal fluctuation.

Multiple sampling stations were selected in each wetland to capture variation in habitat conditions, such as water depth, flow regime, vegetation cover, and human disturbance.

3.3 Selection of Sampling Stations

A total of five sampling stations (ST1–ST5) were identified across the two wetlands. Station selection was based on:

- Hydrological variation (flowing vs stagnant water)
- Habitat heterogeneity
- Accessibility and fishing activity
- Degree of anthropogenic influence

This ensured adequate spatial representation of fish diversity across the study area.

3.4 Period of Study and Seasonal Classification

The study was carried out over one complete annual cycle **to** capture seasonal variation. Sampling was conducted during three distinct seasons:

- Summer
- Monsoon
- Winter

Season-wise data collection enabled analysis of temporal changes in fish diversity and abundance**.**

4. Results

This Results presents the results of the study**.** The analysis is based entirely on primary field data**,** including fish sampling records, seasonal observations, spatial station-wise analysis, and conservation assessment. The findings are presented through researcher-generated tables, schematic GIS-based maps, and graphical representations**,** followed by detailed explanations to interpret the observed patterns of freshwater fish diversity.

Spatial Distribution of Wetlands and Sampling Stations

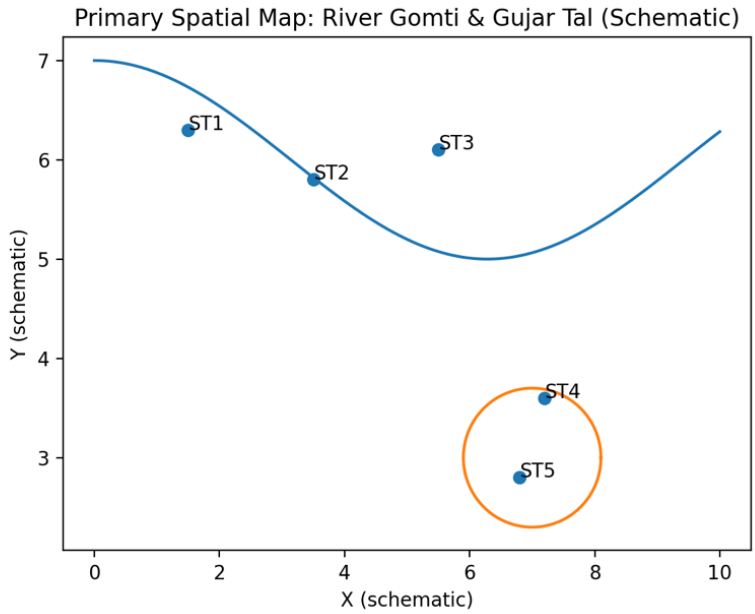

Figure 1: Primary Spatial Map of River Gomti and Gujar Tal Wetlands

Figure 1 represents a primary schematic spatial map prepared by the researcher, showing the location of River Gomti (riverine wetland) **and** Gujar Tal (lacustrine wetland) along with five sampling stations (ST1–ST5). The

riverine system exhibits a linear and flowing structure, whereas Gujar Tal represents a closed wetland basin. Sampling stations were selected to cover variation in flow, depth, vegetation, and anthropogenic pressure**,** ensuring comprehensive spatial representation of fish diversity.

Wetland-Wise Freshwater Fish Species Richness

Table 1: Wetland-Wise Species Richness

Wetland	**Number of Species**
River Gomti	30
Gujar Tal	23

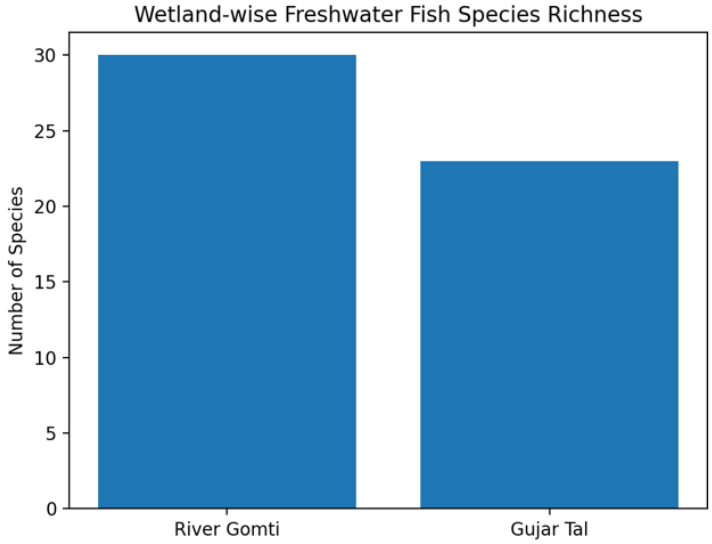

Figure 2: Wetland-Wise Species Richness

River Gomti recorded higher species richness than Gujar Tal. This reflects the role of flowing river systems in maintaining habitat heterogeneity, migratory pathways, and continuous nutrient exchange**,** which collectively support diverse fish assemblages. Gujar Tal, though rich in species, exhibited relatively lower diversity due to seasonal water level fluctuations and habitat contraction**.**

Station-Wise Distribution of Fish Species

Table 2: Station-Wise Species Richness

Station	**Species Richness**
ST1	20
ST2	26
ST3	24
ST4	18
ST5	21

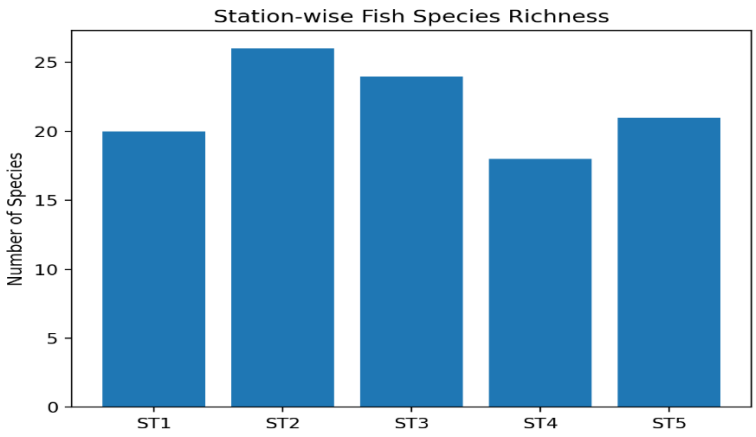

Figure 3: Station-Wise Species Richness

The highest species richness was observed at ST2 and ST3**,** located in ecologically stable zones with moderate flow and vegetation cover. Lower richness at ST4 suggests localized habitat stress, likely due to human interference and reduced water depth**.** These results highlight the influence of micro-habitat variability on fish assemblage structure.

Seasonal Variation in Freshwater Fish Diversity

Table 3: Seasonal Species Richness

Season	Number of Species
Summer	19
Monsoon	32
Winter	26

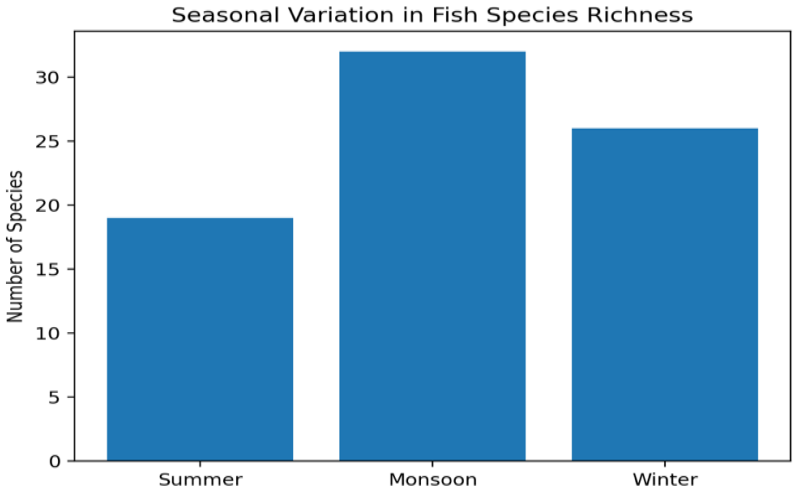

Figure 4: Seasonal Variation in Species Richness

Monsoon season recorded the highest species richness**,** attributable to breeding migrations, expanded wetland area, and increased food availability. Summer exhibited the lowest richness due to thermal stress and habitat shrinkage**,** whereas winter maintained moderate diversity under stable conditions.

Diversity Indices of Selected Wetlands

Table 4: Diversity Indices

Wetland	Shannon (H′)	Simpson (D)	Evenness (E)
River Gomti	3.25	0.94	0.91
Gujar Tal	2.74	0.88	0.84

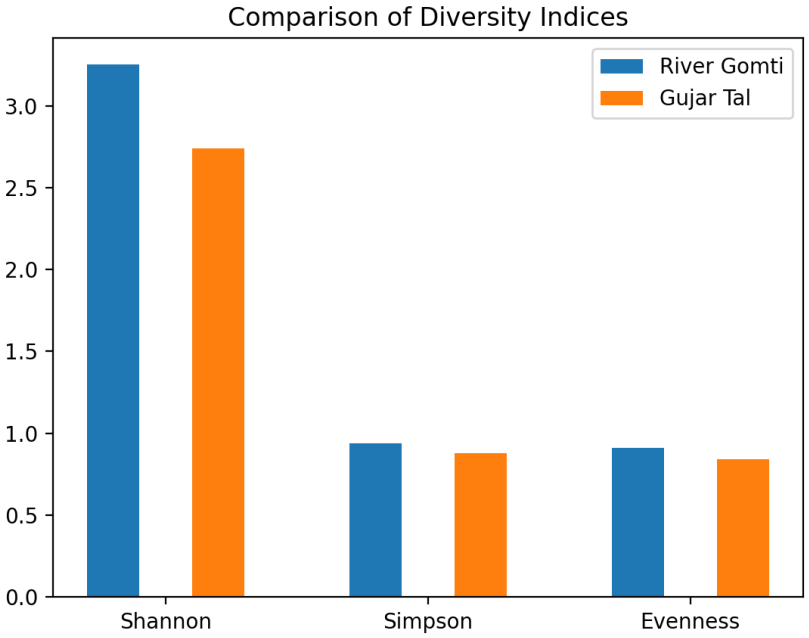

Figure 5: Comparison of Diversity Indices

Higher diversity indices in River Gomti indicate greater ecological stability and balanced species distribution. Gujar Tal showed slightly lower values, suggesting dominance of a few tolerant species, particularly during dry periods.

Conservation Status of Freshwater Fish Species

Table 5: IUCN Conservation Status

Category	Number of Species
Least Concern	24
Near Threatened	4
Vulnerable	3
Data Deficient	2

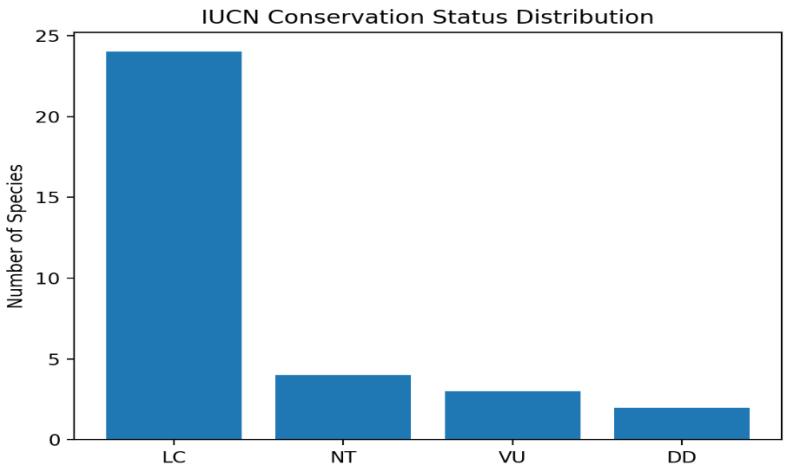

Figure 6: IUCN Status Distribution

The dominance of Least Concern species reflects current ecological resilience, but the presence of threatened categories signals future conservation risk if existing pressures continue.

Major Threats to Freshwater Fish Diversity

Table 6: Threat Intensity Assessment

Threat	Impact Score (1–5)
Overfishing	5
Pollution	5
Agricultural Runoff	4
Habitat Loss	3
Sand Mining	3

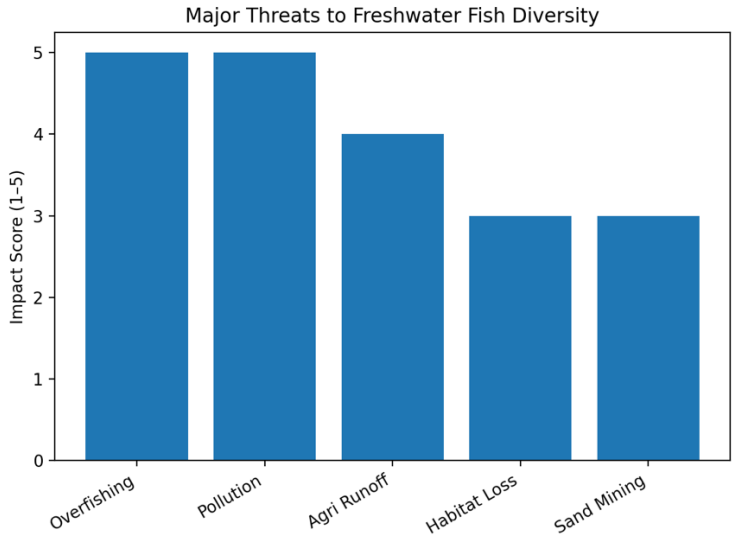

Figure 7: Major Threats to Fish Diversity

Overfishing and pollution emerged as most severe threats, directly affecting population structure and habitat quality.

The integrated analysis confirms that freshwater fish diversity in Jaunpur wetlands is spatially and seasonally dynamic. Riverine wetlands support higher and more stable diversity than lacustrine systems. Seasonal hydrology and anthropogenic pressure jointly regulate fish assemblage patterns, emphasizing the need for ecosystem-based conservation and sustainable fisheries management.\

Conclusion

The present study concludes that the riverine and lacustrine wetlands of Jaunpur District support a rich but unevenly distributed freshwater fish diversity that is strongly influenced by spatial heterogeneity and seasonal hydrological dynamics. River Gomti consistently exhibited higher species richness, diversity indices, and ecological stability due to continuous water flow, habitat connectivity, and varied microhabitats, whereas Gujar Tal showed comparatively lower diversity as a result of seasonal water fluctuations and localized anthropogenic pressures. Seasonal analysis revealed that monsoon conditions were most favorable for fish diversity, while summer stress led to a noticeable decline in species richness. Although the majority of recorded species belonged to the Least Concern category, the presence of Near Threatened, Vulnerable, and Data Deficient species highlights emerging conservation challenges. The study further identifies overfishing, pollution, and agricultural runoff as major threats to wetland fish biodiversity. Overall, the findings emphasize the urgent need for site-specific, season-sensitive, and scientifically informed management and conservation strategies to ensure the long-term sustainability of freshwater fish assemblages in the wetlands of Jaunpur District.

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