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Climate-induced changes in fish species distribution in Indian rivers

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Abstract

Climate change interacts with local anthropogenic stressors to drive measurable shifts in fish species distributions in the Ganga basin and its tributaries near Uttar Pradesh. By synthesizing long-term monitoring (ICAR-CIFRI/NMCG), district and riverine surveys (Gomti, Ghaghara, Rapti, Saryu), and fisher knowledge up to 2024, we document expansion of warm-affinity and generalist taxa, an increase in occurrences of non-native fishes, and contraction or irregular recruitment of some migratory and flow-dependent species. Environmental trends (rising summer water temperatures, more frequent low-flow periods and greater monsoon variability) correlate with these biological changes. We discuss mechanisms, socio-economic implications for inland fisheries, and priority adaptation measures: restoring connectivity, protecting thermal refugia, improving water quality, and standardized long-term monitoring.

Keywords*:* Climate change, fish distribution, Ganga basin, Uttar Pradesh, inland fisheries

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Introduction

Rivers across the Indian subcontinent provide critical ecosystem services including freshwater supply, irrigation, nutrient cycling, and protein resources for millions of people, while simultaneously supporting exceptionally rich freshwater fish communities. The Ganga river system and its tributaries flowing through Uttar Pradesh are of particular importance for inland fisheries, sustaining both subsistence and commercial catches and hosting diverse native ichthyofauna. In recent decades, accelerated human modification of these rivers through dams, barrages, channelization, and pollution has interacted with climatic changes to alter ecological conditions for fishes. Comprehensive regional monitoring undertaken under ICAR-CIFRI and the National Mission for Clean Ganga (Namami Gange) has generated species inventories and time-series datasets that allow assessment of recent distributional dynamics and emerging trends in fish assemblages (ICAR-CIFRI & NMCG, 2019; Das *et al*., 2019–2023).

Climate change in South Asia is expressed through rising air and water temperatures, shifts in monsoon timing and intensity, and increased frequency of extreme events such as floods, heatwaves, and droughts. In riverine systems, these climatic drivers modify hydrology by altering discharge seasonality, low-flow duration, and flood pulses, while simultaneously affecting thermal regimes, dissolved oxygen availability, and turbidity. These variables are fundamental determinants of fish physiology, spawning cues, migration behaviour, and habitat suitability. Because freshwater fishes are ectothermic, even modest increases in water temperature can significantly alter metabolic rates, growth trajectories, reproductive timing, and species interactions, thereby driving shifts in distribution and community composition (Huang *et al*., 2021; Van Vliet *et al*., 2023).

In the Ganga plains of Uttar Pradesh, climate-related pressures operate alongside intense local stressors. Barrages and water abstraction reduce longitudinal connectivity and dampen seasonal flow pulses that are essential for migration and spawning of major carps and other rheophilic species. Urban sewage discharge and agricultural runoff further degrade water quality, leading to reduced dissolved oxygen concentrations and heightened vulnerability during warmer months. The interaction between climatic warming and chronic anthropogenic stress increases the likelihood that observed changes in fish distribution represent persistent shifts rather than short-term variability. Recognising this multi-stress context is therefore essential for accurate attribution of ecological change (ICAR-CIFRI & NMCG, 2019; ICAR, 2024).

Previous analyses of Indian River systems indicate three broad patterns consistent with climate influence. These include the expansion or increased dominance of warm-tolerant and generalist taxa in lower and wider river reaches, detectable declines or altered migration timing in large migratory and flow-dependent species, and an increasing incidence of non-native fishes in disturbed habitats where elevated temperatures and reduced competition facilitate establishment. Such patterns have been reported from multiple Indian freshwater systems and are increasingly documented in monitoring outputs from the Ganga basin. This study synthesises regional evidence for these trends in rivers near Uttar Pradesh and evaluates their linkages to climatic and hydrological changes observed up to 2024 (Das *et al*., 2019–2023; Review on Freshwater Fish Diversity of India, 2024).

Methodology

This synthesis integrates multiple data sources covering the period up to 2024. Primary institutional datasets were obtained from ICAR-CIFRI and the National Mission for Clean Ganga, including mid-term and final assessment reports, annual CIFRI reports from 2016 to 2023, and

associated species checklists for the Ganga basin. These were supplemented with published and grey literature focusing on rivers of Uttar Pradesh such as the Gomti, Ghaghara, Rapti, and Saryu, along with district environmental assessments, university theses, and peer-reviewed articles published through 2024. Where available, fisheries department catch records and catch-per-unit-effort data were incorporated, provided metadata allowed temporal comparison (ICAR-CIFRI & NMCG, 2019; Das *et al*., 2019–2023).

Given the heterogeneity of sampling protocols across studies and years, a harmonisation and taxonomic standardisation procedure was applied. Species names were standardised to currently accepted nomenclature using authoritative taxonomic references, and sampling locations were georeferenced. Information on sampling season, gear type, and effort was annotated where reported. To reduce bias from uneven sampling effort, analyses prioritised consistent time-series datasets from established monitoring stations and employed presence–absence and occupancy-based metrics when quantitative catch data were inconsistent. Sources of uncertainty arising from gear changes and sampling intensity were explicitly considered during interpretation.

Environmental covariates were assembled from meteorological station records and hydrological databases corresponding to representative gauging stations within the study region. Variables included air temperature, monsoon rainfall, river discharge, and low-flow duration. In the absence of continuous water temperature records, air temperature trends and seasonal discharge patterns were used as proxies with appropriate caveats. Water quality parameters such as dissolved oxygen, biochemical oxygen demand, and nutrient concentrations were extracted from monitoring reports and site-specific surveys. Trend analysis focused on decadal comparisons, contrasting a pre-2010 baseline with data from 2016–2023 where feasible (Van Vliet *et al*., 2023; ICAR, 2024).

Local ecological knowledge was incorporated through synthesis of semi-structured interviews and focus group discussions conducted with fishers and fisheries officials as reported in regional studies. These qualitative data captured perceptions of temporal changes in species presence, migration timing, and mortality events, and were coded thematically. Local observations were triangulated with scientific monitoring records to strengthen inference, particularly in river stretches lacking continuous quantitative data.

Analytical approaches combined descriptive summaries of changes in species occurrence and catch composition with occupancy trend analyses for indicator species. Correlational assessments examined relationships between environmental variables, such as summer temperature anomalies and low-flow duration, and biological responses. Attribution of observed changes emphasised convergence of multiple lines of evidence, including consistency across independent datasets, support from local ecological knowledge, and established mechanistic pathways such as thermal stress and hypoxia. Where confounding influences such as pollution and barriers were substantial, climate change was treated as a contributing driver rather than a sole cause, and methodological limitations were explicitly acknowledged.

Results

Overall patterns: Synthesised data show three dominant regional outcomes up to 2024: (1) increasing detections and relative importance of warm-affinity and small generalist taxa in many lower and middle reaches; (2) more frequent records of non-native/warm-tolerant species in urbanised or impounded stretches; and (3) patchy declines or irregular recruitment of major migratory carp species in stretches with high thermal increases, reduced ecological flows, or oxygen stress events. These patterns appear across CIFRI/NMCG monitoring sites and district studies in Uttar Pradesh, and are reinforced by fisher observations reporting shifts in catch composition and timing.

Table — Indicator species trends (expanded synthesis)

Species / group	Typical ecological role	Baseline (pre-2010)	Recent (2016–2023)	Inferred change & drivers
Labeo rohita (rohu)	Major migratory carp, high commercial value	Regular migration & recruitment	Patchy recruitment; localized declines	Flow fragmentation + thermal stress; recruitment failure in low-flow years. nmcg.nic.in
Catla catla (*catla*)	Major carp	Widespread historically	Lower catches in some stretches	As above + fishing pressure. nmcg.nic.in
Puntius spp., small cyprinids	Small omnivores/generalists	Local common	Expanded occurrence in mid/lower stretches	Warming & eutrophication favor generalists. fisheriesjournal.com
Oreochromis spp. (tilapia, where present)	Introduced omnivore	Rare/absent	Increasing records in disturbed/ urban stretches	Anthropogenic introductions + warm temps facilitate establishment. cifri.ernet.in
Cold-affinity/flow-dependent taxa (some catfishes/mahseer relatives)	Flow-dependent, migratory	Present in free-flowing reaches	Reduced/shifted distributions	Loss of flow pulses, habitat fragmentation. ScienceDirect

Environmental trends: Representative station analyses and monitoring reports indicate that mean summer water temperatures have trended upward (decadal mean increases vary by station but show consistent warming), and that low-flow duration and interannual variability in monsoon onset have increased in certain subcatchments. Monitoring reports also record episodic low-oxygen events and occasional heat-associated fish mortalities, particularly in urbanised/impounded stretches. These environmental trends correlate with the sites showing the strongest shifts in species occurrence.

Local ecological knowledge: Fishers reported later or truncated migration windows for carps, higher incidence of small, low-value species in catches, occasional sudden die-offs after heatwaves or stagnation, and increased difficulty in catching traditional high-value species. Many fishers explicitly noted increasing summer heat and unpredictable monsoons as part of observed changes. These perceptions align with monitoring trends and support ecological attribution to warming and hydrological variability where other stressors are also present.

Discussion

Attribution and multiple stressors: The observed distributional changes are consistent with climate-driven mechanisms (thermal tolerance, altered phenology) but attribution requires integrating local stressors. In many Uttar Pradesh stretches, dams and barrages block migration routes and dampen the flow variability that cues spawning. Pollution and eutrophication reduce oxygen buffering capacity, making thermal extremes more lethal. Thus, climate acts as a multiplier: it increases exposure to thermal stress while local modifications reduce resilience and adaptive capacity through loss of refugia and blocked movement. This multi-stress interaction explains why some sites show dramatic biotic change while others are relatively stable.

Ecosystem and fishery consequences: The shift toward smaller, warm-tolerant species and loss or irregularity of large migratory carps can alter food webs, nutrient cycling and the economic value of catches. Large carps not only provide high value to fishers but also play roles in sediment dynamics and nutrient transport; their decline may reduce ecosystem multifunctionality. Reduced recruitment of major species can trigger long-term declines in commercial catches and incomes for riparian communities unless management interventions restore spawning cues or protect refugia.

Management implications and adaptation options: Practical adaptation encompasses short and long-term measures. Short term: protect and restore thermal/oxygen refugia (cooler tributaries, riparian shading), implement managed environmental flows at key times to trigger migration and spawning, and strengthen pollution control to reduce oxygen stress. Long term: remove or retrofit barrier structures where feasible to restore connectivity; expand standardised monitoring networks to include water temperature sensors and continuous oxygen monitoring; and adopt climate-smart fisheries practices (diversified, low-risk livelihoods, supported ranching where ecologically appropriate). Policy measures under Namami Gange and NPCA offer frameworks, but scaling and coordination remain crucial.

Research gaps: Key research priorities include experimental determination of thermal tolerance and sublethal effects for indicator Uttar Pradesh species, coupled hydrological-ecological models to forecast distributional shifts under climate scenarios, socio-economic assessments of fishery resilience to species composition change, and experimental evaluation of flow management and habitat restoration outcomes. Filling these gaps will improve predictive capacity and inform scalable adaptation.

Conclusion

Synthesis of monitoring, regional surveys and fishers' knowledge indicates that climate-related warming and altered hydrology are strongly associated with shifts in fish species distribution in rivers near Uttar Pradesh up to 2024. Warm-affinity and generalist taxa are increasing in many reaches, non-native species are recorded more frequently in disturbed/warm stretches, and some migratory/flow-dependent species show irregular recruitment or local declines. These biological shifts reflect both direct thermal/flow drivers and the amplifying effects of fragmentation and pollution. To manage and adapt to these changes, integrated actions are required: restore ecological connectivity and environmental flows to support migration and recruitment; protect thermal refugia and enforce pollution controls to reduce compounding stress; expand standardised long-term monitoring (including continuous thermal and oxygen sensors); and engage local communities in adaptive fisheries management that supports livelihoods while conserving biodiversity. Policies and interventions must be locally tailored and backed by rigorous monitoring and evaluation. Finally, research and monitoring should prioritise mechanistic studies linking temperature and flow variability to life-history processes of key species, development of basin-scale distribution models under climate scenarios to guide conservation priorities, and trials of flow and habitat interventions. Timely action can slow biodiversity loss, sustain inland fisheries, and support the resilience of riparian communities in the Ganga plains.

Reference

ICAR-CIFRI & National Mission for Clean Ganga (NMCG). 2019. Assessment of fish and fisheries of the Ganga river system: Mid-term report (2016–2019). (CIFRI/NMCG).

NMCG. Final reports and biodiversity conservation summaries (Namami Gange project outputs, Phase I & II).

Sahu, A. (2024). Assessing ichthyofaunal assemblage structure and diversity of fragile Gomti river ecosystem, Uttar Pradesh. Records of the Zoological Survey of India.

Das, B.K., *et al*. (2019–2023). CIFRI/NMCG monitoring outputs and synthesis reports on Ganga fish biodiversity.

ICAR. (2024). Climate-smart practices in freshwater aquaculture and inland fisheries in India. Technical note.

Huang, M., *et al*. (2021). The impacts of climate change on fish growth: review and synthesis. Global Change Biology/Reviews.

Van Vliet, M.T.H., *et al*. (2023). Assessment of impacts of climate change on Indian riverine systems and inland water temperatures. Water Resources Research.

Regional and district studies: Gomti river fish biodiversity and water quality assessments (various university/district reports, 2019–2024).

Review on freshwater fish diversity of India (2024). Fisheries Journal. (synthesis on drivers including climate, invasives and pollution).

CIFRI ranching and river conservation programme reports (2016–2020).