Agri Articles
(e-Magazine for Agricultural Articles)
Volume: 06, Issue: 01 (JAN-FEB, 2026)
Available online at http://www.agriarticles.com
©Agri Articles, ISSN: 2582-9882

Impact of Climate Change on Riverine Fishing

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Riverine fisheries are among the most climate-sensitive natural resource systems, as they depend heavily on hydrological regimes, water quality, and ecological connectivity. Climate change, manifested through rising temperatures, altered precipitation patterns, increased frequency of extreme climatic events, and sea-level rise, is exerting profound impacts on river ecosystems and the livelihoods of millions dependent on inland capture fisheries. In tropical countries such as India, where rivers support rich fish biodiversity and provide food security and employment to economically vulnerable communities, these impacts are particularly severe. This review examines the impacts of climate change on riverine fishing with emphasis on hydrological alterations, fish physiology, reproductive dynamics, biodiversity loss, water quality degradation, and socio-economic consequences. The paper further discusses adaptation and management strategies necessary to ensure the sustainability of riverine fisheries under changing climatic conditions.

Keywords: Climate change; Riverine fisheries; Hydrology; Fish biodiversity; Inland fisheries; India

Introduction

Riverine fisheries constitute a vital component of inland fisheries, contributing significantly to food security, nutrition, livelihoods, and rural employment worldwide. Rivers and their associated floodplains are among the most productive aquatic ecosystems, providing essential breeding, feeding, and nursery habitats for a wide range of fish species. In India, riverine fisheries support millions of small-scale fishers and contribute substantially to inland fish production, particularly in states with extensive river networks such as Bihar, Uttar Pradesh, West Bengal, and Assam. Climate change has emerged as a major global challenge affecting both natural ecosystems and human societies. The Intergovernmental Panel on Climate Change (IPCC) identifies inland water ecosystems as among the most vulnerable to climate variability and long-term climatic shifts. Unlike marine systems, riverine ecosystems are highly sensitive to changes in precipitation, temperature, and catchment-level processes. Even minor alterations in climatic parameters can significantly disrupt river flow regimes, water quality, and aquatic biodiversity. Over recent decades, riverine fisheries have already experienced increasing pressure from anthropogenic activities, including dam construction, pollution, overfishing, sand mining, and habitat fragmentation. Climate change acts as a multiplier of these stressors, intensifying their effects and accelerating the decline of fish populations. Understanding the impacts of climate change on riverine fisheries is therefore essential for developing effective adaptation and management strategies.

Climate Change and River Hydrology

Hydrology is the primary driver of riverine ecosystem functioning, directly influencing habitat availability, productivity, and fish life cycles. Climate change affects river hydrology

mainly through alterations in precipitation patterns, temperature, evapotranspiration, and the frequency and intensity of extreme weather events.

Altered Rainfall Patterns: Changes in monsoon onset, intensity, and spatial distribution have been widely reported across South Asia. Erratic rainfall results in reduced base flows during dry seasons, sudden high-flow events during intense rainfall, and increased inter-annual variability in river discharge. Floodplains, which play a crucial role in fish breeding and recruitment, depend on predictable seasonal flooding. Climate-induced changes in flood timing and duration disrupt the spawning cycles of many fish species, particularly Indian major carps (*Catla catla*, *Labeo rohita*, and *Cirrhinus mrigala*), which rely on monsoon-driven floods for successful reproduction.

Increased Frequency of Floods and Droughts: Extreme flood events can wash away fish eggs, larvae, and juveniles, destroy fishing gear and landing infrastructure, and increase sediment load and turbidity. Conversely, prolonged droughts reduce river depth and longitudinal connectivity, leading to the concentration of fish in shrinking habitats, increased competition and predation, and higher fishing pressure and mortality. Such hydrological instability directly affects catch per unit effort (CPUE) and threatens the long-term sustainability of riverine fisheries.

Rising Water Temperature and Thermal Stress

One of the most direct consequences of climate change is the increase in air and water temperatures. River water temperature plays a critical role in regulating fish physiology, metabolism, growth, and reproduction.

Physiological Impacts on Fish: Elevated water temperatures increase metabolic rates in fish, thereby increasing oxygen demand while simultaneously reducing the solubility of dissolved oxygen (DO) in water. This imbalance results in thermal stress, reduced growth efficiency, and increased susceptibility to diseases. Many riverine fish species possess narrow thermal tolerance limits, and prolonged exposure to elevated temperatures can lead to sub-lethal stress or mortality.

Shifts in Species Distribution: Rising temperatures favour thermally tolerant and opportunistic species, which are often small-sized and of lower economic value, while large-bodied and slow-growing species decline. Cold-water and migratory species are particularly vulnerable, resulting in shifts in species composition, reduction in the average size of fish caught, and a decline in economically important species.

Impacts on Fish Reproduction and Migration

Fish reproduction in riverine ecosystems is closely synchronized with environmental cues such as water temperature, flow velocity, turbidity, and photoperiod. Climate change disrupts these cues in multiple ways. Altered flow regimes may delay or prevent spawning migrations, resulting in reduced egg production, lower hatching success, and poor larval survival. Floodplain-dependent species are especially affected, as reduced floodplain inundation limits access to shallow, nutrient-rich breeding and nursery habitats. Additionally, climate-induced low-flow conditions intensify the impacts of existing barriers such as dams and barrages. Reduced water depth and flow velocity restrict upstream and downstream movement of migratory fishes, thereby accelerating population decline.

Water Quality Degradation

Climate change indirectly affects riverine fisheries through the deterioration of water quality. Elevated temperatures combined with organic pollution increase biochemical oxygen demand (BOD), leading to hypoxic conditions. Fish kills become more frequent during summer low-flow periods and following floods due to the decomposition of organic matter.

Increased nutrient runoff during intense rainfall events promotes eutrophication, resulting in algal blooms that reduce light penetration and dissolved oxygen availability. Furthermore, heavy rainfall accelerates soil erosion, increasing sediment loads in rivers. Excessive sedimentation smothers spawning grounds, reduces benthic biodiversity, and negatively affects filter-feeding and bottom-dwelling fish species.

Loss of Fish Biodiversity and Community Structure

Climate change is altering the structure and functioning of riverine fish communities. Large, long-lived, and migratory species are more vulnerable due to longer generation times, specific habitat requirements, and limited adaptive capacity. Endemic and threatened species face an increased risk of local extinction. Disturbed riverine ecosystems also favour invasive and exotic species that are more adaptable to temperature fluctuations and degraded water quality. This leads to biotic homogenization, reduced ecological resilience, and a decline in the economic value of riverine fisheries.

Socio-economic Impacts on Riverine Fishing Communities

Riverine fishing is predominantly small-scale and subsistence-based, making fishing communities highly vulnerable to climate change. Unpredictable fish availability and declining catches reduce income stability and livelihood security. Fishers are often compelled to increase fishing effort, use smaller mesh sizes, or adopt destructive fishing practices, creating a vicious cycle of overexploitation and resource depletion. Climate-related disasters such as floods and droughts disproportionately affect fishing households by damaging homes, boats, and fishing gear. Limited access to credit, insurance, and alternative livelihood opportunities further exacerbates the vulnerability of riverine fishing communities.

Indian Riverine Fisheries under Climate Change

In India, the impacts of climate change are evident in major river systems such as the Ganga, Brahmaputra, Mahanadi, and their tributaries. Altered monsoon patterns affect floodplain fisheries in the Gangetic basin, while reduced environmental flows threaten carp recruitment. The combined effects of climate change and anthropogenic pressures have intensified the decline of riverine fisheries. Smaller rivers such as the Burhi Gandak are experiencing reduced flow variability, habitat degradation, and declining fish diversity, directly affecting local fisheries and fishing-dependent livelihoods.

Adaptation and Management Strategies

Addressing climate change impacts on riverine fisheries requires integrated and adaptive management approaches. Key strategies include maintaining environmental flows, restoring floodplains and wetlands, and protecting critical spawning and nursery habitats. Seasonal fishing bans aligned with breeding periods, gear and mesh-size regulations, and community-

based fisheries management are essential for sustaining fish stocks. Livelihood diversification through the integration of aquaculture and culture-based fisheries, skill development, and alternative income opportunities can enhance the adaptive capacity of fishing communities. Strengthening social safety nets and institutional support systems is also crucial for building resilience to climate change.

Conclusion

Climate change poses a significant threat to riverine fisheries by altering hydrological regimes, increasing thermal stress, degrading water quality, and disrupting fish reproductive and migratory processes. These impacts are compounded by existing anthropogenic pressures, resulting in declining fish stocks and increased livelihood insecurity for riverine fishing communities. Sustainable management of riverine fisheries under changing climatic conditions requires ecosystem-based approaches, adaptive governance, and active participation of local stakeholders. Proactive adaptation measures are essential to conserve fish biodiversity and ensure the long-term sustainability of riverine fisheries, particularly in climate-vulnerable regions such as India.

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