Fish Migration Patterns in a Changing Climate: An Overview from an Indian Perspective

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Abstract— **Fish migration is a crucial ecological process that supports fish reproduction, population stability, and fisheries productivity. In India, the migration of fish species is closely regulated by environmental cues such as monsoon rainfall, river discharge, water temperature, and coastal productivity. Climate change is increasingly disturbing these natural cues through rising temperatures, altered monsoon patterns, changing river flow regimes, and warming coastal waters. As a result, changes are being observed in the timing, routes, and success of fish migration in both freshwater and marine ecosystems. Migratory species such as Indian major carps, catfishes, hilsa, sardines, and mackerel are particularly affected. These changes have direct implications for fish production, aquatic biodiversity, and the livelihoods of fishing communities. This overview paper examines the major climate-related drivers influencing fish migration in India, discusses observed changes in freshwater and marine systems, and highlights management and adaptation measures required to sustain fisheries under a changing climate.**

Index Terms— **Climate change, Fish migration, Indian fisheries, Monsoon variability, River flow, Marine warming, Inland fisheries**

I. INTRODUCTION

Fish migration is one of the most important behavioural adaptations in fishes, allowing them to utilise different habitats during various stages of their life cycle. Through seasonal or periodic movement, fishes gain access to suitable conditions for feeding, growth, reproduction, and survival. These movements are guided by environmental signals such as water temperature, rainfall, river discharge, salinity, and food availability. When such signals remain stable and predictable, fish populations are able to maintain regular migration schedules and reproductive success (Ficke et al., 2007; Brander, 2010).

India possesses a wide range of aquatic ecosystems, including rivers, floodplains, wetlands, reservoirs, estuaries, and marine waters. These ecosystems support high fish diversity and sustain one of the largest fisheries-dependent populations in the world. Several economically important fish species in India exhibits migratory behaviour. Inland fishes such as Indian major carps and catfishes depend on monsoon-driven floods for spawning, while diadromous species migrate between freshwater and marine environments. In the marine sector, pelagic fishes such as sardines, mackerel, and tunas undertake seasonal movements linked to ocean temperature and productivity cycles (Mohanty et al., 2017; CMFRI, 2019).

Historically, fish migration in India has been closely aligned with the monsoon system. The southwest monsoon plays a central role in shaping river hydrology, floodplain connectivity, nutrient availability, and spawning conditions in inland waters. Similarly, coastal circulation patterns, upwelling, and plankton blooms determine the seasonal distribution of marine fishes along the Indian coastline (CIFRI, 2018; CMFRI, 2019). These predictable climatic patterns have traditionally ensured regular migration and recruitment of fish populations.

In recent decades, however, climate change has begun to alter these long-established environmental conditions. Rising air and water temperatures, changes in rainfall intensity and timing, increasing frequency of extreme weather events, and warming of coastal waters are now widely reported across India (IPCC, 2022). Such changes directly influence aquatic habitats by modifying thermal regimes, river flow patterns, and water quality. In marine systems, warming sea surface temperatures and altered oceanographic processes are affecting primary productivity and habitat suitability for fishes (Doney et al., 2012).

These climatic changes are increasingly reflected in altered fish migration behaviour. Studies indicate that fishes are shifting migration timing, changing breeding seasons, modifying migration routes, and, in some cases, failing to reach traditional spawning grounds (Perry et al., 2005; Crozier & Hutchings, 2014). In tropical regions like India, where many species already live close to their upper thermal limits, even moderate warming can result in significant habitat stress and redistribution of fish populations (Cheung et al., 2010).

Freshwater migratory fishes are particularly sensitive to climate change because its impacts often act together with human pressures such as dams, barrages, water abstraction, pollution, and habitat degradation. Reduced river connectivity and altered flow regimes further restrict migration pathways and breeding success (Dudgeon et al., 2006; Ficke et al., 2007). Marine fishes, although more mobile, are also affected as warming waters force them to shift towards deeper or cooler habitats, often away from traditional fishing grounds (Pinsky et al., 2013; Free et al., 2019).

Despite growing evidence of climate driven changes in fish behaviour and distribution, studies focusing on fish migration in the Indian context remain limited and fragmented. Therefore, this paper aims to provide an integrated overview of climate change impacts on fish migration in India, covering both freshwater and marine ecosystems, and discussing implications for fisheries management and adaptation.

II. MATERIALS AND METHODS

This paper is based on a critical review and synthesis of existing literature related to climate change and fish migration, with special emphasis on Indian aquatic ecosystems. Peer reviewed research articles, national and international assessment reports, and publications from Indian fisheries research institutions were consulted.

Major sources included journals related to fisheries science, climate change, and aquatic ecology, as well as reports from FAO, IPCC, ICAR, CMFRI, and CIFRI. The collected information was analysed thematically and organised under climate drivers, freshwater migration, marine migration, fisheries impact, and adaptation strategies. The approach adopted is descriptive and conceptual, aiming to provide a comprehensive overview rather than a quantitative meta-analysis.

III. RESULTS AND DISCUSSION

Climate change influences fish migration in India primarily through rising water temperature, altered rainfall patterns, changes in river discharge, and warming of coastal waters. These factors interact with one another and with existing human pressures, leading to complex migration responses.

Rising water temperature affects fish metabolism, oxygen demand, growth, and reproductive timing. In inland waters, higher temperatures during summer months increase physiological stress and reduce dissolved oxygen levels, making migration more energetically demanding. Such conditions can delay migration or reduce the ability of fishes to reach spawning grounds (Ficke et al., 2007; Brander, 2010). In marine ecosystems, increasing sea surface temperature alters habitat suitability and food availability. Warmer waters influence plankton distribution, which in turn affects the movement and aggregation of pelagic fishes. Along the Indian coastline, changes in temperature have been linked to shifts in seasonal fish availability, particularly for small pelagic species (Doney et al., 2012; CMFRI, 2019).

Monsoon rainfall plays a central role in regulating fish migration in inland waters of India. Seasonal floods provide cues for spawning and enable fishes to access floodplains rich in food and shelter. Climate change has increased uncertainty in monsoon behaviour, with delayed onset, irregular distribution, and higher frequency of extreme rainfall events (IPCC, 2022).

Reduced river discharge during dry periods limits connectivity between river channels and floodplains, restricting access to breeding and nursery habitats. Conversely, sudden high intensity floods can wash away eggs and larvae, reducing recruitment success. These changes are particularly harmful for migratory carps and catfishes that depend on stable flood pulses for reproduction (CIFRI, 2018; Mohanty et al., 2017).

Freshwater migratory fishes in India are increasingly affected by climate change combined with habitat modification. River systems such as the Ganga River and Brahmaputra River have experienced changes in flow regime, temperature, and connectivity.

Elevated water temperature influences spawning timing and reduces egg and larval survival. Low flow conditions restrict access to traditional breeding grounds, while floodplain disconnection reduces food availability for juvenile fishes. Cold water fish species in Himalayan rivers are also at risk, as warming pushes suitable habitats upstream, increasing vulnerability to habitat loss (Gopalakrishnan et al., 2011).

Marine fishes along the Indian coastline are responding to climate change by altering their spatial and seasonal distribution. Rising sea temperatures in the Arabian Sea and Bay of Bengal have influenced migration routes and depth preferences of several commercially important species.

Small pelagic fishes such as sardines and mackerel are particularly sensitive to temperature and plankton availability. Warming waters and changing oceanographic conditions have resulted in shifts towards deeper waters or changes in seasonal abundance along different coastal regions (CMFRI, 2019). These observations are consistent with global trends where fishes move to track suitable thermal habitats (Perry et al., 2005; Pinsky et al., 2013).

Altered fish migration patterns directly affect fisheries productivity and fishing communities. Changes in migration timing make fishing seasons less predictable, while spatial shifts in fish distribution increase operational costs due to longer fishing trips and higher fuel consumption.

Small scale fishers are particularly vulnerable, as they rely heavily on near-shore resources. Inland fishing communities face declining catches due to reduced river productivity and habitat degradation. Studies suggest that tropical regions may experience reduced fisheries productivity under continued warming, increasing vulnerability for countries like India (Cheung et al., 2010; Free et al., 2019).

The reviewed literature highlights the need for climate responsive fisheries management in India. Maintaining environmental flows in rivers is essential to support natural migration and spawning processes. Protecting floodplains, wetlands, and estuaries can help conserve critical habitats used during different life stages.

Marine fisheries management must become more flexible, allowing adjustment of fishing seasons and spatial regulations in response to changing fish distribution. Reducing non-climatic stressors such as pollution, habitat degradation, and overfishing can improve the resilience of fish populations to climate change (Brander & Cochrane, 2015; IPCC, 2022).

IV. CONCLUSION

Climate change is reshaping fish migration patterns in India by altering temperature regimes, monsoon behaviour, river hydrology, and marine conditions. Freshwater migratory fishes are particularly vulnerable due to the combined effects of climate variability and habitat fragmentation, while marine fishes are shifting their distribution in response to warming seas. These changes affect fisheries productivity, biodiversity, and the livelihoods of fishing communities.

Sustaining Indian fisheries under a changing climate requires adaptive management approaches that integrate climate information, protect critical habitats, maintain river connectivity, and reduce local environmental pressures. Understanding climate driven changes in fish migration is essential for ensuring long-term food security and conservation of aquatic ecosystems in India.

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