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Aquatic Biology and Fisheries with Special Reference to Conservation of Aquatic Resources in India: A Literature Review

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Abstract

India's territory encompasses diverse aquatic zones, including rivers, lakes, reservoirs, wetlands, estuaries, mangroves, reefs, and oceans. These ecosystems harbor extensive biodiversity and provide vital services like food, employment, nutrient cycling, and water regulation. Fisheries are particularly crucial for India's food security and economy. Nevertheless, these habitats face risks from degradation, pollution, over-harvesting, dams, wetland loss, invasive species, climate change, and unsustainable development. This study evaluates Indian aquatic science and fisheries, exploring conservation strategies through a review of scholarly literature and government documents. Findings indicate that effective management demands an ecosystem-based framework. Necessary actions include habitat restoration, fishing effort limits, protecting breeding sites, conserving indigenous species, managing invasives, and community involvement. Research also highlights the importance of genetic preservation, digital mapping, DNA-based monitoring, and frequent biological assessments. Ultimately, protecting India's water resources requires integrating scientific data, traditional knowledge, participatory governance, and rigorous law enforcement.

Keywords: Aquatic biology, fisheries, aquatic biodiversity, fish conservation, wetlands, marine resources, freshwater ecosystems, India, sustainable fisheries, aquatic genetic resources.

INTRODUCTION

India's subcontinent features exceptionally fertile, diverse aquatic habitats. These marine, brackish, and freshwater zones—including the Ganga, Brahmaputra, Godavari, Krishna, Cauvery, Narmada, and Mahanadi rivers, plus various reservoirs and wetlands—sustain diverse life, from teleosts and mollusks to microorganisms and avian species. These resources are vital for ecology and socioeconomics, providing food, jobs, and income for millions in fishing communities. Biologically, these species maintain trophic balance and nutrient cycles. Per the FAO (2024), India's inland fisheries are crucial for mitigating poverty and protecting biodiversity. Furthermore, Lakra and Gopalakrishnan (2021) highlight that India's vast aquatic genetic diversity, spanning the Himalayas to the deep sea, underpins aquaculture growth. However, human activities increasingly threaten these ecosystems. Pollution, habitat loss, overfishing, dam-related hydrological changes, and climate change harm biodiversity and yields. Dudgeon et al. (2006) and Cooke et al. (2016) identify habitat decay, invasive species, and unsustainable harvesting as primary risks to fish. Thus, aquatic conservation must move beyond individual species protection. Successful strategies must focus on preserving physical habitats, ecological processes, genetic diversity, and sustainable fishery management.

Objective

This comprehensive review is designed to achieve several distinct aims. These goals include:

1. recognizing the importance of the fishing industry and aquatic life sciences in the regional framework of India;
2. Examining the variety of water-based resources found throughout the Indian landmass;
3. Categorizing the major risks presently threatening the biological variety of aquatic systems and fish stocks;
4. Evaluating current strategies utilized to safeguard water-related assets;
5. Emphasizing the essential contribution of scientific inquiry and community involvement in conserving aquatic environments, while developing structures to guarantee the persistent viability of fisheries and the perpetual preservation of aquatic wealth.

2. MATERIALS AND METHODS

This study provides a narrative overview of published work concerning aquatic biology, the science of fisheries, and the protection of water resources across India.

2.1 Data Collection Information for this study was compiled from numerous academic and official sources. The search included scholarly journals and review articles, as well as documents issued by the Indian Council of Agricultural Research (ICAR), the Central Inland Fisheries Research Institute (ICAR-CIFRI), and the National Bureau of Fish Genetic Resources (ICAR-NBFGR). Additionally, the research utilized government reports from India, Food & Agriculture Organization (FAO) publications, and archives related to the conservation of wetlands and biodiversity. The gathered information spanned several fields, such as freshwater and ocean fisheries, river and estuary systems, lake-based wetlands, fish variety, and genetic materials. Topics involving conservation methodologies and sustainable fishery management were also included.

2.2 Criteria for Selection Materials were chosen for inclusion based on how closely they aligned with specific subjects. To be included, the literature had to focus on India's aquatic life, the variety and distribution of fish, or the techniques used in fishery production and oversight. Furthermore, the selection process favored works detailing threatened aquatic species, habitat destruction caused by human-led pollution or global warming, and the consequences of invasive organisms. Finally, documents were assessed on their treatment of wetland and river rehabilitation, the oversight of genetic assets, both on-site and off-site preservation techniques, and community-led fishery management models.

2.3 Analysis Method The assembled literature underwent a qualitative review to pinpoint major aquatic environments and fishery resources. This evaluation concentrated on identifying the critical ecological and biological stressors impacting these systems. Additionally, the research analyzed existing conservation measures intended to protect these habitats while identifying gaps in current academic studies and the regulatory structures governing aquatic resource oversight.

3. RESULTS AND DISCUSSION

3.1 Indian Aquatic Ecosystems the Indian subcontinent features a multifaceted array of aquatic environments, spanning the Himalayan drainage basins, limnological systems, artificial reservoirs, riverine wetlands, brackish estuaries, mangrove biomes, scleractinian reefs, and oceanic territories. These diverse habitats provide niches for complex *ichthyological* and aquatic communities. In an investigation of eight primary Indian river systems—specifically the Ganga, Brahmaputra, Mahanadi, Godavari, Krishna, Cauvery, Narmada, and Tapti—Das et al. (2021) underscored that systematic population surveillance is vital for tracking variations in species composition and abundance. Such data establishes a fundamental reference point for fishery regulation and conservation strategies. Furthermore, floodplain wetlands constitute a significant inland fishery asset. Sarkar et al. (2021) observed that these ecosystems, particularly within eastern and northeastern provinces, represent a major reservoir of biological variety. Nevertheless, anthropogenic pressures, characterized by habitat degradation and chemical pollutants, are driving a reduction in fish biodiversity. The northeastern region is especially noteworthy for its high degree of freshwater endemism. Through a meta-analysis of 187 studies conducted between 2000 and 2025, Debnath (2026) identified significant species richness and socio-economic value in this area, while noting that environmental modification, climatic instability, and pollution remain the foremost threats.

3.2 The Importance of Fisheries Assets Fisheries occupy a central role in the Indian socio-economic landscape, functioning as: • A fundamental source of dietary protein; • A critical sector for labor and vocational stability; • A financial driver for artisanal and commercial fishing groups; • A source of raw inputs for industrial manufacturing; • A contributor to international trade balances; • A focal point for cultural heritage and leisure; and • A provider

of indispensable ecological services. Aquaculture, particularly within freshwater environments, has facilitated a substantial increase in fish production. Lakra and Gopalakrishnan (2021) noted that inland aquaculture is witnessing rapid growth and serves as a cornerstone of the national fishery infrastructure. While the expansion of this sector should remain compatible with biological preservation, the excessive exploitation of wild populations can lead to demographic collapse, altered age structures, and a loss of genetic breadth. Thus, management frameworks must strike a balance between harvest yields and ecological sustainability.

3.3 Fluvial Biodiversity and Preservation: India's riverine networks support both resident and migratory fish, many of which depend on specific micro-environmental conditions for spawning, feeding, and dispersal. Human-induced changes, such as the implementation of hydraulic barriers, water extraction, riverbed mining, and contamination, can disrupt these life cycles. Das et al. (2021) argued that recurrent assessments are necessary because existing data is often fragmented, with many river systems lacking recent biological documentation. Continuous observation is therefore required to detect shifts in biodiversity. For instance, evidence suggests that alterations in water chemistry, physical habitat structure, flow regimes, and anthropogenic encroachment have impacted the ichthyofauna of the Ganga. Periodic ecological audits are essential for refining preservation strategies. Recently, stock augmentation and river ranching have been utilized to restore declining populations. In 2026, ICAR-CIFRI released indigenous fingerlings into the lower Ganga to rejuvenate native stocks and enhance biological output. Furthermore, the Alaknanda River saw the targeted release of the critically endangered Himalayan Golden Mahseer (Tor putitora). Such initiatives demonstrate how scientifically-driven stocking can complement habitat protection and regulatory oversight.

3.4 Wetland Management and Conservation Wetlands are highly productive ecotones that harbor diverse biological communities, including birds and microbes. In India, floodplain wetlands are integral to small-scale fishing operations and local livelihoods. Sarkar et al. (2021) noted that these areas are under increasing stress from habitat conversion, pollution, high fishing pressure, and climate-related shifts. Consequently, wetland management must harmonize biodiversity conservation with the socio-economic needs of local residents. The Wetlands (Conservation and Management) Rules, 2017 provide the statutory basis for protection in India, limiting activities that jeopardize ecological integrity. Sustainable management approaches should prioritize: • The protection of breeding and larval habitats; • The maintenance of natural water cycles; • The reduction of pollutant loads; • The regulation of harvest volumes; • The control of non-native species; • The restoration of degraded wetland sites; and • The inclusion of local stakeholders in management processes.

3.5 Marine and Brackish Water Resources India's maritime zones encompass estuaries, mangrove forests, seagrass beds, coral reefs, and open ocean waters, which support significant populations of fish, crustaceans, and mollusks. Estuarine environments are especially critical as nurseries and feeding grounds. Swetha et al. (2024) analyzed 84 estuaries on the western coast, identifying a lack of comprehensive data regarding their productivity and community dynamics. These researchers suggested the establishment of integrated monitoring systems involving scientists and local communities. However, marine biodiversity remains threatened by overharvesting, habitat loss, and climate change. The National Wildlife Action Plan emphasizes the need for enhanced assessment and protection of these coastal zones.

3.6 Primary Threats to Aquatic Ecosystems

3.6.1 Environmental Degradation The deterioration of physical habitats represents a major challenge. The drainage of wetlands, modification of riparian zones, dam construction, and mining activities diminish the availability of suitable habitats. Fragmentation is particularly detrimental to migratory taxa, as it prevents movement between essential life-cycle locations.

3.6.2 Aquatic Contamination The influx of industrial effluents, untreated municipal waste, agricultural chemicals, and microplastics adversely affects aquatic organisms. These pollutants can lower dissolved oxygen, shift pH levels, and introduce toxins, resulting in impaired growth, reproductive failure, and increased susceptibility to disease and mortality.

3.6.3 Excessive Harvesting Intensive fishing activities deplete stocks and alter community structures. Destructive practices, such as the use of explosives or small-mesh nets that capture immature fish, lead to recruitment failure. Devaraj (2010) stressed that biological research is essential to inform management actions like seasonal fishing bans and gear limitations.

3.6.4 Non-Native Species Invasive organisms compete for ecological niches and disrupt trophic structures. Singh (2024) examined these effects in inland waters, highlighting the importance of prevention, surveillance, and habitat safeguarding to protect indigenous biodiversity.

3.6.5 Climatic Shifts Changing climates affect thermal profiles, rainfall patterns, and oceanographic variables, influencing fish physiology, reproduction, and survival. These environmental changes often interact with other stressors, such as pollution and overexploitation, to accelerate population declines. 3.6.6 Reduction in Genetic Variation Small, isolated populations are vulnerable to the loss of genetic diversity. Overfishing and unscientific stocking practices can undermine the genetic health of native populations. Kumar et al. (2010) emphasized that scientific policy and community participation are necessary to safeguard these genetic assets.

3.7 Conservation of *Ichthyological* Genetic Assets Maintaining genetic diversity is a fundamental requirement for modern fisheries management, as it allows populations to adapt to environmental changes. In-situ Conservation: The protection of species within their natural habitats through the establishment of sanctuaries, protected river reaches, and regulated zones. Ex-situ Conservation: The preservation of genetic material through captive breeding programs, gene banks, and cryopreserved germplasm. Sarkar et al. (2024) suggested that a combined approach is required for high-priority species, noting significant gaps in current biological and genetic knowledge. Additionally, Pathak et al. (2025) introduced the Aquatic Genetic Resource Information System of India (AqGRISI) to consolidate data for various stakeholders.

3.8 Stakeholder Involvement in Conservation Local fishing communities often possess extensive traditional knowledge concerning fish ecology and behavior. The effectiveness of conservation efforts is improved when these groups participate in management decisions. Community-based strategies may include seasonal closures, the management of sanctuaries, gear restrictions, and habitat rehabilitation. Research by Debnath (2026) in northeastern India indicates that participatory frameworks lead to more successful conservation results.

3.9 The Application of Modern Technology Technological innovations offer new possibilities for conservation, such as: • Geospatial applications (Remote Sensing/GIS) for mapping habitats; • Molecular tools (DNA barcoding, eDNA) for species identification and genetic monitoring; • Hydroacoustic techniques for assessing biomass; • Artificial intelligence and machine learning for predictive analysis; • Centralized digital platforms for monitoring conservation status.

ICAR has identified geospatial mapping, genetic improvement, and sustainable management models as priority research areas

Source	Threat	Major Impact	Recommended Conservation Measure
Habitat destruction	Loss of breeding and feeding grounds	Habitat restoration and protection	
Water pollution	Fish mortality and reduced reproduction	Pollution control and wastewater treatment	

Overfishing	Decline in fish stocks	Closed seasons, mesh-size regulation and catch limits	
Dams and barriers	Disruption of migration	Fish passages and environmental-flow management	
Invasive species	Competition with native species	Prevention, monitoring and control	
Climate change	Distribution and reproductive changes	Climate-resilient fisheries management	
Wetland conversion	Loss of fisheries habitat	Wetland protection and restoration	
Genetic erosion	Reduced adaptive capacity	Gene banks, captive breeding and genetic monitoring	
Unsustainable aquaculture	Disease, pollution and genetic impacts	Best-management practices	
Lack of data	Weak conservation planning	Long-term biodiversity monitor	

4. Research Deficiencies and Future Outlook Despite progress in documenting India's aquatic life, major knowledge voids persist. Initially, data distribution remains uneven. While major wetlands and rivers are well-documented, smaller bodies of water are neglected. Das et al. (2021) emphasize that Indian rivers require consistent, systematic fish diversity evaluations. Additionally, long-term tracking of endangered and commercial species is essential. For many, information on population size, reproduction, migration, and genetics is lacking. Furthermore, fisheries management must incorporate climate change factors, including shifts in temperature, precipitation, water levels, sea-level rise, and weather extremes. Fourthly, strategy should shift from individual species to ecosystem-based models, protecting spawning sites, nurseries, migratory paths, and food webs. Fifthly, merging indigenous ecological wisdom with science is vital, transforming local residents into active conservation partners. Finally, digital databases like AqGRISI (Aquatic Genetic Resource Information System of India) should be expanded to better support research and resource management.

5. CONCLUSION

India's water ecosystems, including rivers, wetlands, reservoirs, estuaries, and oceans, constitute vital biological assets offering essential ecological and economic benefits while supporting fishing-dependent livelihoods. Research indicates these resources face growing threats from habitat loss, pollution, excessive fishing, non-native species, altered river flows, and climate change. Preserving these assets necessitates merging biodiversity protection with sustainable fishery practices. Prioritizing habitat preservation is crucial, alongside managing fishing intensity, restoring damaged environments, and safeguarding indigenous species and genetic variety. Managing invasive species and utilizing both in-situ and ex-situ methods for endangered fish are also necessary. Tools like molecular analysis, GIS, remote sensing, and digital databases can improve management, provided local communities and traditional insights are integrated. Ultimately, the longevity of India's fisheries relies on ecological health and regenerative capacity rather than just harvest volume. Sustainable resource use must be built upon community-backed, ecosystem-focused conservation strategies.

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