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ARTICLE

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ASSESSING VULNERABILITY AND PROMOTING SUSTAINABILITY: A STUDY OF HILSA FISHERIES IN WEST BENGAL

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This study investigates the ecological, social, institutional, and technological vulnerabilities affecting Hilsa fisheries in the lower stretch of the Ganga, from Farakka to Gangasagar. Several factors, including sedimentation, overfishing, pollution, habitat loss, unregulated fishing practices, climate change, barrage constructions and ineffective governance, have led to a drastic decline in the Hilsa population, and people depend on the Hilsa fishery. The study revealed that 91% of fishermen agreed that not only there is a significant decline in fish catch but harvested fish are quite smaller (generally <250 g) compared to the average weight of 800 g two to three decades ago and 78.4% of fishermen in Farakka, 85.8% in Godakhali, and 92.2% in Tribeni believe that the use of monofilament small meshed gill nets is the major cause behind this. The study highlights the urgent need for transboundary cooperation, sustainable management practices, strict enforcement, habitat restoration, alternative livelihoods and community-based approaches.

Keywords: *Challenges, Lower Gangetic Stretch, Viability, Transition*

Introduction

The Hilsa fish, scientifically known as *Tenualosa ilisha*, is an anadromous fish species that migrate from the ocean to freshwater rivers for breeding. It belongs to the family Clupeidae[1]. Hilsa is commonly found in Southeast Asia, particularly in the rivers and estuarine waters of Bangladesh, Myanmar, India, Pakistan, Iraq, Kuwait, Iran, Indonesia, Bahrain, Thailand and Malaysia[2,3]. These fish typically inhabit the lower regions of estuaries and coastal areas.

Beyond its status as a premium fish, Hilsa holds significant cultural and culinary importance in various Indian states[4-6]. The primary concentration of Hilsa is in the Hooghly - Bhagirathi section of river Ganga in India[7,8]. According to the most recent FAO[9] data for 2023, Bangladesh's share of global Hilsa production increased to 97.01% from 86% in 2018, while India's share has declined to 2.41% from 8% in 2018[10,9]. In 2021, India's annual Hilsa production was approximately 0.14 lakh tonnes[9].

Hilsa constitutes 12.5% of total fish production in West Bengal[11]. However, West Bengal often falls short of meeting its demand and relies on Hilsa imports from neighbouring Bangladesh. Over a decade from 2001, production in West Bengal dropped significantly, from 80,000 tonnes to 20,000 tonnes[12]. Total Hilsa catch declined from 31.8 to 34.4 tonnes during 1994–1997 to just 6.3 to 6.8 tonnes between 1994–1995 and 2000–2002 at Farakka[13]

Research indicates that Hilsa resources are diminishing across fishing grounds, as evidenced by a sharp decline in catches, particularly in the Hooghly–Bhagirathi river systems over past twenty years[14,15].

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Anthropogenic factors, such as siltation at the estuary of Hooghly–Bhagirathi River hinder Hilsa migration to the estuarine system. The construction of dams and barrages has further reduced Hilsa numbers in upper stretches. Fishing of juveniles and brood fish exploitation, poor enforcement of mesh size regulation, non-functional fish passes, habitat loss, industrialisation, climate change and pollution, have also contributed to the Hilsa catch decline in India[16,12,7].

Methodology

This study examines the Hilsa fishery status in Ganga River in West Bengal, covering the area from Farakka in Murshidabad to Gangasagar in South 24 Parganas. A combination of primary and secondary sources was utilized to gather comprehensive data. Primary data collection took place between January 2022 and November 2024 from 220 fishermen from Farakka, Dhuliyan in Murshidabad; Barrackpore in North 24 Parganas; Mayapur, Nabadwaip and Balagarh in Nadia and Godakhali, Fraserganj and Gangasagar in South 24 Parganas. The data were collected using semi-structured interview methods, including personal interviews, direct observations, and focus group discussions with different stakeholders, i.e., fishermen, fish sellers, and cooperative members, which were employed to collect empirical data. These methods provided insights into experiences, meanings, and perspectives, often from the participants' viewpoints[17-19]. The personal interviews were conducted at the fishermen's house or the landing centre, where they spent most of their time. The collected data were necessary to obtain valuable insights about the Hilsa fishery status and changes over the period. The data on fishing practices, marketing channels, and fish sizes were observed directly by the researcher, and some data was also collected from the local market. The interviews lasted 20 to 30 minutes and were conducted with the Hilsa fishermen, fish sellers and other knowledgeable community members.

The constraints of the fishing community for Hilsa fishing were assessed by Garret Ranking Technique [22] using the following formula:

Percent position = (100 (Rij-0.5))/Nj

Where; Rij = Rank given for the ith variable by jth respondents; Nj = Number of variables ranked by jth respondents. With the help of this method, the percent position estimated is converted into scores by referring to the Garret table given.

In addition, secondary information was gathered from previous research, websites, and newsletters. The semi-structured interviews are scheduled for open conversations with participants. A list of potential questions was prepared for each stakeholder, focusing on the following main keys aligned with study's research questions:

- Changes in Hilsa fishery over time.
- Drivers and vulnerabilities affecting Hilsa fishery.
- Impact of these driving forces on the well-being of Hilsa fishery stakeholders.
- Potential strategies to enhance the viability of Hilsa fishery.

Results and Discussion

The decline of the Hilsa fisheries in West Bengal, India, has concerned environmentalists and policymakers. The decrease in the Hilsa fish catch also affects fishermen's livelihoods and economic hardships. Several factors contribute to the Hilsa fishery vulnerabilities, namely environmental, social, economic, hydrological, anthropogenic, and emerging issues (Fig. 1).

Ecological Vulnerabilities: Fish need specific riverine and estuarine habitats for breeding and migration. Ecological vulnerability refers to the sensitivity of ecosystems, biodiversity, and habitats to the adverse effects of various drivers.

Hydrological Vulnerabilities: Extreme waterflow of different tributaries and distributaries of river Ganga during monsoon combined with the tidal effect of the brackish water zone, results in significant soil erosion within the river. Continuous soil erosion leads to increased sedimentation, degrading the spawning and feeding habitats of Hilsa and impacting their breeding. Discharging suspended soil particles from the catchment area significantly elevates water turbidity. This resulting water turbidity reduces light penetration and affects aquatic plant photosynthesis and benthic organisms, limiting Hilsa abundance and propagation. Further, it creates physical barriers that disrupt migration routes, reducing their reproductive performance.

The present study of ICAR-CIFRI reflected that 62.6% of fishermen in Maldah, 47.4% in Farakka, and 92.5% in Tribeni agreed that river sedimentation has increased over the last 30 years. According to the fishermen, this is due to reduced water discharge from the Ganges due to the Farakka barrage. This sedimentation on riverbeds and floodplains, forming sandy islands, is perceived as the main factor disrupting the Hilsa's migration route from the Meghna to the Padma to the Ganges and its tributaries. They also reflected that the sedimentation also prevents

Table 1. Constraints of Fishing Communities for Hilsa fishery

Sl. No.	Constraints	Total Score	Avg. Score	Rank
1.	Seasonal availability	6290	62.9	IV
2.	Climate change	6272	62.72	V
3.	Poor marketing channel	5045	50.45	VIII
4.	Ban period	7403	74.03	II
5.	Increased number of fishers	5514	55.14	VI
6.	Illegal fishing practice	6697	66.97	III
7.	CPUE reduction	7684	76.84	I
8.	Non-availabality of Fund	4193	41.93	IX
9.	Overfishing	5245	52.45	VII
10.	Conflict over access	3331	33.31	X

the hatching of eggs. Over 90% of interviewed fishermen reported a significant decline in fish catch since the 1990s, attributing this to increased sedimentation and individual fishing efforts.

Environmental Vulnerabilities: Over the last 37 years, the annual temperature of the air has increased by nearly 1.3°C, with March temperatures rising by 0.4°C[20]. River surface water temperature increased by 0.6–0.8°C for every 1°C air temperature rise, though it can increase by 2 to 3°C as air temperature rises 3 to 5°C[21]. Urbanization is the main cause behind the changing water temperature and also the water quality parameters. Increased water temperatures and CO_2 emissions negatively impact dissolved oxygen levels, ocean acidification, and plankton production, obstructing Hilsa migration, reproduction, and growth. The changes in water temperature also affect on maturity of the fish. Early fish maturity at <40g was noticed by the present researcher.

Social Vulnerabilities: Ganga flows through the major cities of India. Due to that not only affluent discharges but also industrial discharges are the main sources of the anthropogenic contamination of the river water. According to the fishermen's perception, since the early 1960s, water resources development projects like drainage, load control and irrigation programs, river closure, and channel diversion have affected the migration and breeding ground of Hilsa. However, poor drainage system and low inflow from upstream including ecological flow caused the Hilsa fisheries reduction in the past few decades.

Small-scale river fishers have to struggle to compete with larger, more resource-equipped trollers of the deep sea, exacerbating economic vulnerability and reducing their ability to benefit from the fishery. About 91% of respondents reported that harvested fish are quite smaller (generally <250 g) compared to average weight of 800 g two to three decades ago. This size reduction indicates the impact of overfishing. Fishermen stressed their livelihoods are in danger due to extreme overfishing activities.

Economical Vulnerabilities: The price of Hilsa has risen around 2-3 fold (from Rs.500-600/kg to Rs.1500-1800/kg) in the past 10 years. This increasing price and market demand attract more part-time fishers to join the industry to make easy money, which further intensifies fishing pressure. This also increased the intensity of fishing and fishing boats and increase the fishing pressure.

The seasonal nature of Hilsa fishing leads to irregular and inadequate earnings. The market price of Hilsa is also highly unpredictable, creating financial instability for fishermen. Many fishermen rely on informal credit sources with high interest rates, trapping them in a cycle of debt. Middlemen often dominate the Hilsa trade, creating exploitative systems where fishers receive minimal financial benefits. Institutional attempts to regulate this market are largely ineffective. Inadequate cold storage and transportation facilities result in post-harvest losses and reduced market value.

Table 2: Farmers' perceptions of Hilsa catch decline (N=220)

Cause of Hilsa catch decline	Percentage
Climate change	13.67
Farakka barrage	3.16
River siltation and depth reduction	30.67
Unregulated fishing in sea	19.50
Improper enforcement of ban period	15.84
Overfishing and occasional fisher pressure	7.83
Seasonal flow and non-connectivity of river	9.33

Anthropogenic Vulnerabilities: Approximately 78.4% of fishermen in Farakka, 85.8% in Godakhali, and 92.2% in Tribeni believe that the use of monofilament small meshed gill nets (locally known as current jal) at the mouth of estuarine is a major human activity affecting spawning, Hilsa migration, and stock enhancement. Hilsa is generally caught by using set gillnet, drift gillnet and seine nets of different types and sizes of net depends on the season, size of fish, and habitat alteration across the fishing ranges. Juveniles of Hilsa are often caught in small-mesh bag nets, gill nets, shooting nets, seine nets, drag nets, and scoop

nets during the migration towards the sea (Fig 2). Over-trolling in the deep sea also forces the river fishermen to capture the Hilsa juvenile. The ineffectiveness of fish pass in the Farakka barrage caused the Hilsa catch to decline in upper stretch of Ganga. Mono-filament fishing gear, specifically gill nets with a mesh size of 80-85 mm or smaller, is being used by fishers to catch juvenile Hilsa fish weighing smaller than 500 g in the marine zone near mouth of the Hooghly estuary, approximately 30 km from coast. This practice prevents the fish from migrating and breeding in freshwater areas, undermining the goal of developing sustainable Hilsa fisheries.

Emerging Issues: The fisheries sector is distinguished by critical institutional and governance issues, intertwining informal and formal institutions and involving private, public and civil society agents. It connects various sectors and areas of responsibility, making it a vital and intricate part of the economy.

The Hilsa fisheries is regulated by various bodies, including state fisheries departments, local panchayats, and national agencies. The lack of coordinated efforts among these institutions leads to overlapping mandates and conflicting policies. Since Hilsa is a transboundary species, migrating between freshwater and marine ecosystems, collaboration between India and Bangladesh is critical. Weak transboundary governance undermines conservation efforts and shared resource management.

The ban period depends on the southwest monsoon, but Hilsa is one of the numerous fish species whose migration and breeding patterns are significantly impacted by the arrival of the monsoon. The government should take the necessary steps and implement proper legislative actions to enforce the ban period. The government should also provide alternative income sources for poor fishermen to ensure the ban period's success. Proper maintenance of Hilsa Sanctuaries is very much necessary.

Small-scale fishers without modern tools are facing difficulties in locating fish, tracking migration patterns, and managing catches, leading to lower yields and less efficient fishing practices. Without proper training, fishers may not fully utilize or benefit from available technology, leading to suboptimal fishing practices and potential overexploitation of resources. Without advanced technologies for climate change adaptation, such as tools for predicting changes in water temperature and flow patterns, the fishermen are struggling to cope with shifting conditions.

Future Way for Hilsa Fishery Viability: The prospects of the Hilsa fishery in West Bengal depend on various factors, including conservation efforts, management strategies, environmental conditions, and socio-economic factors. Implementing sustainable fishing practices and conservation measures can help ensure the long-term sustainability in Hilsa fisheries and related communities. This includes regulating fishing gear, establishing protected areas, and promoting community-based fisheries management approaches. The transformation from vulnerabilities to viabilities is a transition process that takes time and effort by every stakeholders related with the fishery including the final consumers (Fig. 3). Here are some potential future scenarios for the Hilsa fisheries sustainable viability in West Bengal:

Habitat Restoration: Restoring and protecting critical Hilsa habitats, such as riverine and estuarine ecosystems, can enhance breeding and spawning grounds and facilitate the fish's natural lifecycle. Dredging in rivers is also a necessary factor for restoring river velocity and depth. Protect breeding and nursery grounds to re-establishment of the fish stock by the introduction of seasonal closures as well as Hilsa sanctuaries.

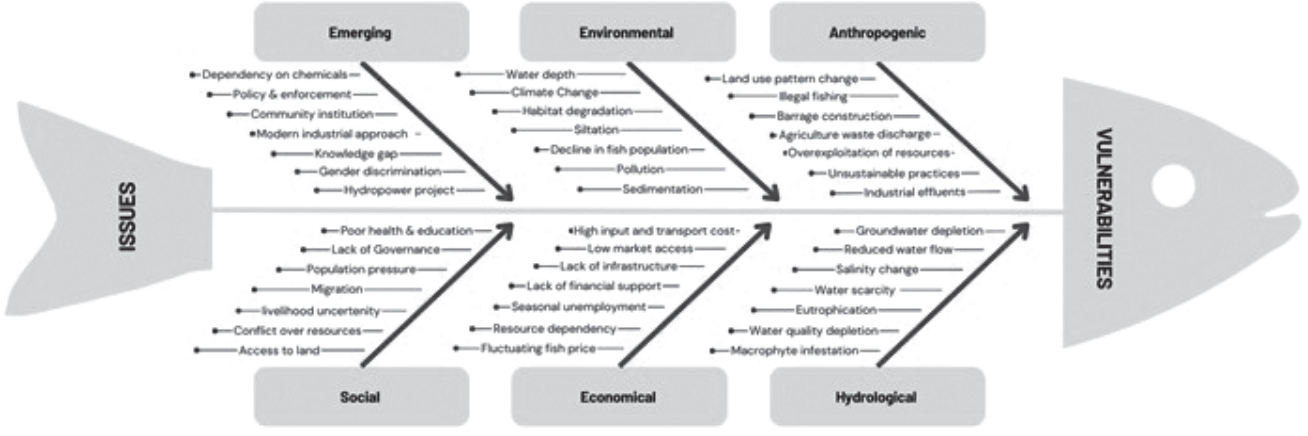

Fig. 1: Different areas of Vulnerability

Fig. 2: Hilsa fishing with different types of net

Climate Change Adaptation: The impact of climate changes, like sea level rising, altered rainfall patterns, and changing ocean temperatures, are essential for the resilience of Hilsa fishery. Adaptive management strategies may include adjusting fishing seasons, improving water management practices, and promoting alternative livelihoods for fishing communities.

National and International Collaboration: Collaborating with neighbouring countries, such as Bangladesh and Myanmar, which share Hilsa populations and fisheries, can help manage transboundary Hilsa stocks effectively and sustainably. Establishment of corelation and collaboration with the water management institution and land use institution to create clear understanding of fisheries requirements, riverine habitat water flow and improve water quality parameters.

Research and Innovation: Investing in research and innovation to improve understanding of Hilsa biology, ecology, and fisheries dynamics can inform evidence-based management decisions and support the development of

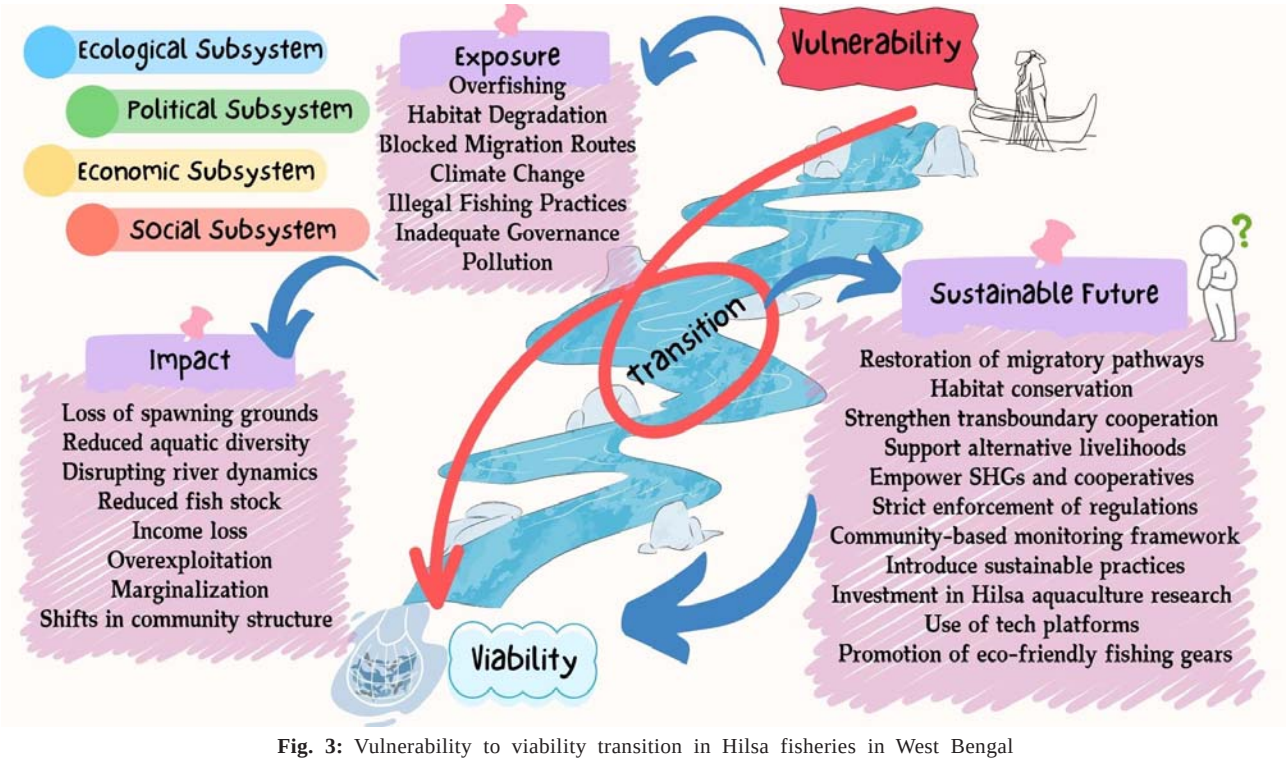

Fig. 3: Vulnerability to viability transition in Hilsa fisheries in West Bengal

innovative fishing technologies and practices. This delicacy fish species has been introduced into aquaculture to replenish the demand. Research should focus on captive maturation, breeding and fingerling rearing of Hilsa.

Community Engagement and Livelihood Diversification: Engaging fishing communities in Hilsa conservation efforts and restricted poison fishing can reduce pressure on the fishery and enhance community resilience. About 80 to 90 percentage of Hilsa are captured during the month of monsoon season coinciding with the movement towards upstream of rivers and estuaries. Strict regulation of ban period during this time is very essential. During the fishing ban period, the government should focus on the alternative livelihoods of full-time fishers. Fishers also can include identifying and protecting the Hilsa.

Family Involvement for Fishing: The Hilsa fishery now a days become to family occupation. The women and men of the family went for fishing with an optional hired person. So, the division of the income becomes lower which make the fishery more profitable.

Market Development: Developing markets for sustainably caught Hilsa and promoting proper marketing chain can create economic incentives for conservation and support the fishery's long-term viability. Developing cooperatives to reduce dependency on middlemen will ensure fair pricing. Building cold storage facilities and improve transportation for better post-harvest management.

Institutional and Policy Framework for Hilsa Fishery: The Indian government has established various acts, ordinances, and rules to regulate the utilization, development, and preservation of its fisheries industry as well as aquatic resources. The West Bengal State government has implemented specific directions for the conservation of Hilsa fish. However, the Hilsa conservation regulations outlined in the Government of West Bengal notification and order under West Bengal Inland Fisheries Rules and Marine Fishing Regulation Act, both issued in April 2013, require significant improvement.

Restrictions in Fishing Gear and Vessels: Management and conservation rules concerning Hilsa fisheries must be strictly enforced. This includes the regulation of mesh sizes for fishing nets. On April 9, 2013, the Kolkata Gazette issued a specific notification that regulates the use of nets with designated mesh sizes for catching Hilsa. The use of *current jal* which is a specific gillnet made of monofilament synthetic nylon fiber, with a mesh size below 90 mm is strictly prohibited. Additionally, there is a ban on using scoop nets, bag nets and small-meshed gill nets throughout the migratory routes from February to April. It is crucial to prioritize efforts to minimize the impact of mechanized fishing activities in the northern Bay of Bengal. Government regulations also include bottom trawling ban within 12 nautical miles of the Indian continental shelf and a reduction in the number of deep-sea fishing vessels targeting Hilsa to help increase stock numbers.

Government Policies Relevant to Hilsa Fishery: Every year, from April 15th to June 14th, the East Coast of India is closed to fishing. A Hilsa fishing ban is enforced for ten days depending on lunar cycles during September and October. There is also a prohibition on catching juvenile Hilsa with a body size less than 23 cm and restrictions on fishing within 5 square kilometers of the Farakka Barrage year-round. Other aspects of the ban include prohibitions on the catching, marketing, transporting, and possessing of juveniles with less than 23 cm size.

Resource Conservation: The six-months fishing ban in the estuarine and freshwater areas of designated Hilsa Sanctuaries (extending approximately 318 km) is very much important for protecting Hilsa population in future. The fisheries department has identified Hilsa sanctuaries along the stretch of the Hooghly River in between Diamond Harbour to Nischindapur in South 24-Parganas, Katwa to Hooghly Ghat (covering Burdwan, Nadia, North 24-Parganas, and Hooghly), and Lalbagh to Farakka Barrage in Murshidabad and Malda, as well as five square kilometres around sandbars on the Matla, Raimangal, and Thakuran rivers in the Sundarbans. Many fishermen continue to practice bottom trawling in foreshore areas, targeting Hilsa and jeopardizing ichthyo-diversity in those regions. The widespread use of bag nets further impedes juvenile Hilsa from contributing to the fishery. There is virtually no regulation over these irresponsible fishing activities, and compliance with the closed season is minimal. Furthermore, there is a lack of efforts to raise social awareness or implement surveillance measures for fishery conservation.

Present Scenario of Hilsa Fishery in West Bengal: Catch trends of the Hilsa fishery in the Hooghly-Matlah estuary have been documented over time. Many researchers, including those from the ICAR-Central Inland Fisheries Research Institute (CIFRI), have studied the impact of the Farakka Barrage on the Hilsa fishery since 1980. In 2012, the Indian Council of Agricultural Research (ICAR) initiated a comprehensive study to understand the population structure of Hilsa in the estuarine waters and assess the feasibility of controlled breeding and rearing for aquaculture. A CIFRI study revealed a 92% reduction in Hilsa catch upstream of the Farakka Barrage since its

construction. The non-operation of the Fish Pass at the Farakka Barrage since 1989 has impeded the migration of Hilsa upstream. In response, CIFRI and the National Mission for Clean Ganga (NMCG) have been working on a project since 2018 to rehabilitate the Hilsa fish upstream of the barrage. CIFRI has released over 110,435 live juvenile and brooder Hilsa from downstream to upstream. They have also conducted migration studies using Floy Tags, tracking tagged Hilsa as far as 516 km upstream in Mirzapur, Uttar Pradesh. Additionally, ICAR-CIFRI is increasing the Hilsa population upstream by artificially breeding Hilsa, collecting wild brooders, fertilizing eggs, and releasing reared spawn upstream of the barrage. More than 5.5 million fertilized eggs and 734,000 spawn have been released into the Ganges. The recovery of juvenile Hilsa in Jharkhand, Bihar, and Uttar Pradesh demonstrates the success of these initiatives.

There is a need to develop alternative livelihood options for Hilsa fishermen, especially those living along the riverine areas. This region includes several districts: Malda, Murshidabad, Nadia, Bardhaman, Hooghly, Howrah, Purba Medinipur, North 24 Parganas, and South 24 Parganas. Following the Gazette notification in 2013 and under the West Bengal Fisheries Policy of 2015 aimed at Hilsa fishery conservation, a provision was made to establish an institutional mechanism. In line with this, the department has set up the "Hilsa Conservation and Research Centre." The West Bengal government has also declared sanctuaries in the spawning areas, but the enforcement of these measures will need to be gradual due to human considerations and economic issues involved.

Conclusion

Effective management requires protecting critical spawning grounds, commitment of local fishermen, and strategically managed river. Governmental and non-governmental organisations should expand formal education facilities and provide vocational and technical education to equip fishing community and their next generations with skills for alternative employment, thereby reducing fishing intensity.

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