

## Impact Assessment of Seasonal Fishing Ban on the Ecology and Livelihoods Associated with Hilsa Fishery in West Bengal, India

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**Abstract:** Hilsa is the most economically important fish species in the Hooghly estuarine system West Bengal, India. Owing to excessive harvest at the local scale, a seasonal fishing ban was imposed on Hilsa catch, prompting to assess the impact in terms of the length-frequency distribution, and the livelihoods of fishers in the region, following the withdrawal of the ban. A comparison of the data on the pre-ban and post-ban period of Hilsa catch of major landing centers of the study along with fish length-frequency composition were recorded for analysis. A socio-economic survey was also conducted among fishers to evaluate their perceptions of the ban and its effects on livelihoods. Results showed no significant difference ( $p > 0.05$ ) in average Hilsa catch between pre-ban and post-ban periods in the riverine-estuarine zone. In contrast, the marine-coastal zone exhibited a significant increase in catch during the post-ban period, with the highest catch recorded at Nischintapur ( $56.13 \pm 18.9$  kg/trawler/day). A total of 364 Hilsa specimens were examined, revealing that smaller-sized fish (10–29 cm) dominated the riverine-estuarine catches during the pre-ban period. Following the ban, the occurrence of larger-sized individuals (50–59 cm) increased in the both zones, indicating improved growth and survival. More than 75% of fishers supported the ban and reported increased Hilsa availability after the closure period. However, over 70% experienced livelihood difficulties due to income loss, inadequate government support, and limited alternative employment opportunities. The findings suggest that the seasonal fishing ban contributes to Hilsa stock conservation and fishery sustainability, particularly in marine-coastal waters. Strengthening livelihood support and alternative income-generating programs is essential for enhancing compliance and ensuring the long-term success of Hilsa management measures.

**Key words:** Hilsa, Fishing ban, Length frequency distribution, Fishers' livelihood, Conservation.

### 1 Introduction

Hilsa, *Tenualosa ilisha* (Hamilton, 1822) is an anadromous fish species of immense economic, ecological, and cultural significance in the northern Bay of Bengal region. The species migrates between marine and freshwater environments during different stages of its life cycle and supports one of the most valuable fisheries in South Asia. In India, the Hooghly River estuary serves as a major migratory pathway and fishing ground for Hilsa, contributing substantially to fish production, employ-

ment generation, and livelihood security of coastal and riverine communities [1, 2]. Owing to its unique taste, high consumer demand, and nutritional richness, Hilsa occupies a prominent position among commercially exploited fish species in the region [3].

Hilsa is highly dependent on the connectivity between marine, estuarine, and freshwater ecosystems. Mature fish migrate upstream for spawning, while juveniles utilize riverine habitats as nursery grounds before gradually returning to coastal waters [4]. Research conducted over several decades

has highlighted the importance of seasonal migration patterns, environmental conditions, and habitat availability in determining the distribution and abundance of Hilsa populations [5, 6]. Any disruption to these ecological processes can adversely affect recruitment success and overall stock productivity.

In recent years, concerns regarding the sustainability of Hilsa fisheries have increased due to fluctuations in catch and indications of stock decline in several parts of its distribution range. Multiple factors have been implicated in this decline, including excessive fishing pressure, indiscriminate harvesting of juvenile fish, degradation of spawning and nursery habitats, pollution, altered river flow regimes, and broader environmental changes [7 - 10]. Among these factors, the capture of immature individuals before they reach reproductive age is considered particularly detrimental because it reduces the future spawning population and limits stock replenishment [11]. The growing market demand for Hilsa has further intensified fishing activities in both marine and inland waters. Consequently, concerns regarding overexploitation have prompted the adoption of various management measures aimed at conserving the resource while maintaining fishery productivity. Studies on Hilsa stock dynamics have emphasized the necessity of regulating fishing pressure to ensure long-term sustainability [11]. Similarly, investigations conducted in Indian waters have indicated that sustainable management of Hilsa requires a combination of biological conservation measures and effective governance frameworks [11 - 14].

Among the management strategies adopted for Hilsa conservation, seasonal fishing bans have emerged as one of the most important regulatory interventions. These temporary restrictions are generally implemented during critical breeding and migration periods to protect spawning adults and allow successful recruitment of young fish into the population. The underlying principle is that a reduction in fishing

mortality during biologically sensitive periods can enhance reproductive output and contribute to stock recovery over time [6]. Such measures have been widely adopted in both India and Bangladesh as part of broader efforts to improve Hilsa fishery management.

Evidence from neighboring Bangladesh suggests that conservation programs involving fishing bans, sanctuary establishment, and protection of juvenile Hilsa have yielded encouraging results in terms of increased fish production and improved stock status [9, 15 - 16]. Assessments of conservation initiatives have further demonstrated that protected areas and seasonal closures can positively influence fish abundance when accompanied by effective enforcement and stakeholder participation [17]. These findings indicate that carefully designed management interventions can contribute significantly to the recovery and sustainability of Hilsa populations.

The implementation of fishing bans, although essential for the conservation and recovery of Hilsa populations, is frequently associated with considerable socioeconomic consequences. Fishing communities that rely predominantly on Hilsa harvesting often experience temporary reductions in household income and employment opportunities during the closure period. Such consequences are particularly severe in areas where alternative livelihood options are limited. Previous studies have reported that, although many fishers recognize the long-term benefits of stock conservation, financial hardship during fishing bans remains a major challenge [1]. Consequently, assessing the effectiveness of fishing bans requires consideration of both ecological outcomes and their socioeconomic implications for dependent communities.

Increasing evidence from recent reviews underscores the importance of integrated management strategies for Hilsa conservation that reconcile ecological sustainability with the socio-economic well-being

of fishing communities [10]. Effective fisheries management is now widely regarded as a holistic approach encompassing regulatory interventions, habitat conservation, community participation, and livelihood support mechanisms. Consistent with this perspective, international fisheries assessments advocate ecosystem-based management frameworks that promote the sustainable utilization of aquatic resources while safeguarding the livelihoods and socio-economic interests of fishing-dependent communities [18].

The Hooghly River estuary is a major Hilsa fishing region in India and provides an ideal setting for evaluating the effectiveness of seasonal fishing bans. Although these bans have been implemented to conserve Hilsa stocks, limited information is available on their effects on fish catch, catch per unit effort (CPUE), population size structure, and fishers' perceptions. Assessing these factors is essential for evaluating the effectiveness of the conservation measures and identifying opportunities to improve fisheries management. Therefore, the present study investigates the impact of fishing bans on the Hilsa fishery in the Hooghly River estuary by analyzing fishery performance indicators and the socio-

economic responses of fishing communities. The findings are expected to support evidence-based management strategies for the sustainable exploitation and long-term conservation of this commercially important species.

## 2 Materials and Methods

### 2.1 Study Area

The study was conducted in the lower Hooghly estuary and adjacent coastal waters of West Bengal, India. Sampling locations were selected from both riverine - estuarine and marine - coastal fishing zones that are important centers of Hilsa fishing activity. Major fish landing centers such as Ariadaha, Bagbazar Ghat, Godakhali, Nischinta Pur, Fraserganj were selected for data collection due to their substantial contribution to Hilsa landings (Fig. 1). The region experiences a tropical monsoon climate and supports one of the most productive Hilsa fisheries in India. Seasonal fishing bans are implemented in these areas to protect spawning adults and juvenile Hilsa, making the region suitable for evaluating the biological and socio-economic impacts of fishing restrictions.

### 2.2 Classification of Study Period

Data for the present study were collected over a period of one year (January–December, 2025) from selected Hilsa landing centers located in the Hooghly River estuary and adjacent marine waters of West Bengal, India. For assessing the impact of the fishing ban, the study period was divided into three phases:

**Pre-ban period:** Months immediately preceding the fishing ban.

**Ban period:** Duration during which fishing activities were officially restricted, i.e. April - May month of the respective year.

**Post-ban period:** Months immediately following the lifting of the fishing ban. Catch Per Unit Effort (CPUE), and biological parameters were compared among

these periods to evaluate the effectiveness of the fishing-ban policy.

### 2.3 Data Collection

Both primary and secondary data were used to assess the impact of the fishing ban on Hilsa fishery.

#### 2.3.1 Fishery-Dependent Data Collection

Fishery-dependent data were collected directly from commercial fish landings at the selected landing centers. Sampling was conducted twice per month throughout the study period. During each visit, information on Hilsa catch and fishing effort was recorded from randomly selected fishing

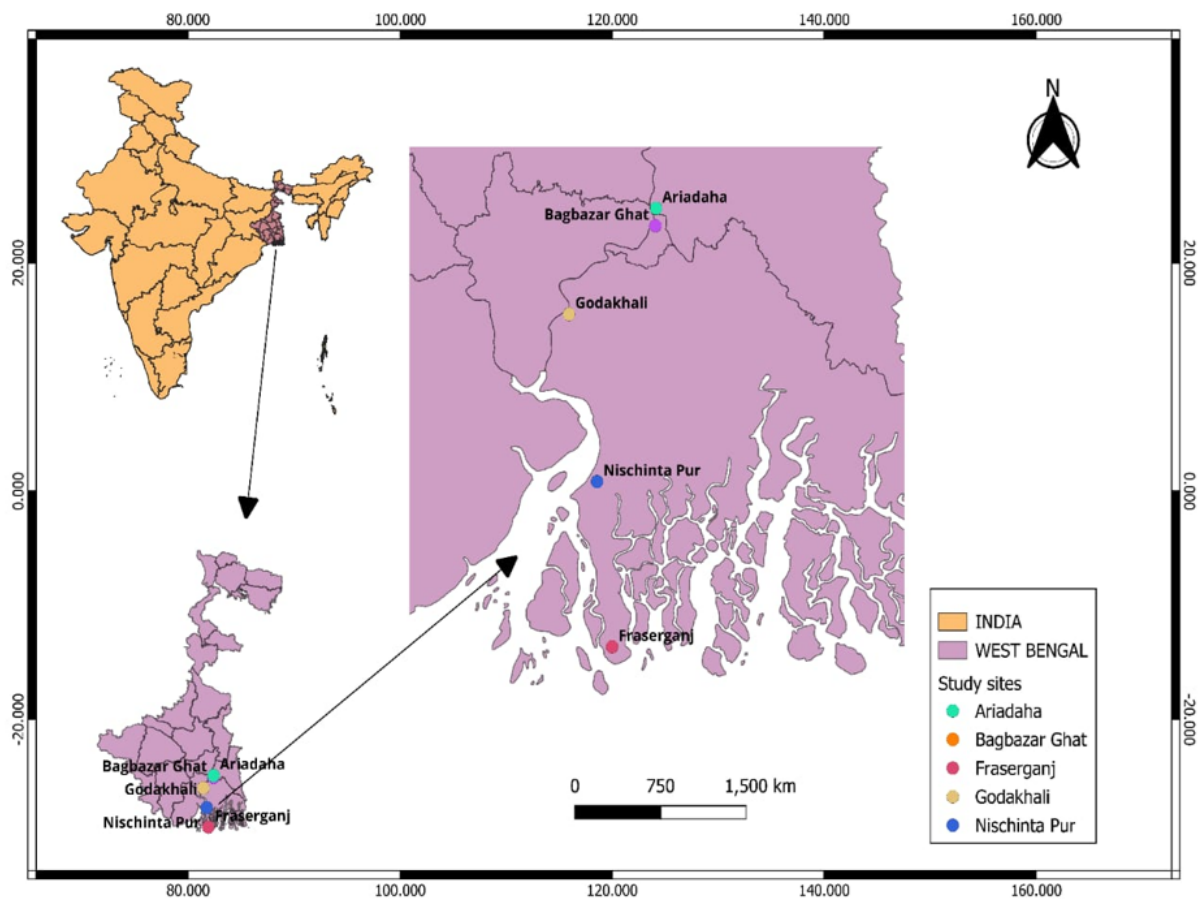


Figure 1: Location map of the study area in the Hooghly River estuary, West Bengal, India, showing the five surveyed fish landing centres: Ariadaha, Bagbazar Ghat, Godakhali, Nischinta Pur, and Fraserganj.

vessels and fishers. The following information was collected:

Total Hilsa catch landed (kg), number of fishing trips, number of operating fishing vessels, duration of fishing trips (hours or days), type of fishing gear used, fishing area and zone (riverine-estuarine and marine-coastal), and date of landing.

The Catch Per Unit Effort (CPUE) was calculated as [19]:

$$\text{CPUE} = \frac{\text{Total catch (kg)}}{\text{Total effort (vessel/day)}}$$

Monthly CPUE values were estimated separately for riverine-estuarine and marine-coastal zones and subsequently compared between pre-ban and post-ban periods. This catch data was obtained using digital weighing balances available at landing centers. Fishing effort was estimated in terms of vessel/day, where one vessel operating for one day was considered one unit of effort.

### 2.3.2 Biological Data Collection

Biological sampling of Hilsa was carried out at each landing centre immediately after landing. A random sampling approach was adopted to ensure unbiased representation of the landed catch. Fish length was measured using a centimeter measuring scale. Then the collected biological data were used to determine the length-frequency distribution, and mean length of landed fish, which denotes the changes in size composition before and after the fishing ban. Length data were grouped into 10-cm class intervals for frequency analysis.

### 2.3.3 Socio-economic Survey

A total of 287 respondents (148 from riverine-estuarine zone and 139 from marine-coastal zone) were selected using simple random sampling from different landing centers. The respondents included fishers, boat owners, fish traders, and commission agents. To understand fishers' per-

ceptions regarding the fishing ban, a structured questionnaire survey was conducted among fishers and other stakeholders associated with the Hilsa fishery. Information collected through interviews included dependence on Hilsa fishing for livelihood, perceived changes in catch after the ban, changes in fish size and abundance, income loss during the ban period, awareness of conservation measures, opinions regarding continuation of the fishing ban, and availability of government compensation and support schemes. Personal interviews were conducted in the local language to ensure clear communication and accurate responses.

### 2.3.4 Secondary Data Collection

Secondary information was collected from various published and unpublished sources, including different scientific journals, and government notifications regarding fishing-ban regulations.

## 2.4 Data Validation and Quality Control

To ensure accuracy and reliability, field data were cross-verified with landing records and fisher interviews. Measurements were taken using calibrated instruments, and repeated observations were conducted whenever discrepancies were detected. All collected data were entered into different statistical software and checked for transcription errors before statistical analysis.

## 3 Results

### 3.1 Zone-wise Catch Composition

Comparison of pre-ban and post-ban Hilsa catches in the riverine-estuarine zone revealed no statistically significant variation ( $p > 0.05$ ). The riverine-estuarine zone exhibited only a marginal increase in Hilsa catch during the post-ban season compared to the pre-ban season. Among the surveyed landing centers,

Godakhali recorded the highest average catch, increasing slightly from  $5.51 \pm 1.14$  kg/boat/day during the pre-ban period to  $5.71 \pm 1.99$  kg/boat/day in the post-ban period. In contrast, Ariadaha consistently showed the lowest catch levels, with average catches rising from  $0.942 \pm 0.08$  kg/boat/day before the ban to  $1.11 \pm 0.30$

kg/boat/day after the ban (Fig. 2a). Although, the marine-coastal zone exhibited a significant increase in Hilsa catch during the post-ban season compared to the pre-ban season. NischintaPur contributed the highest average catch in the post-ban period, recording  $56.13 \pm 18.9$  kg/trawler/day (Fig. 2b).

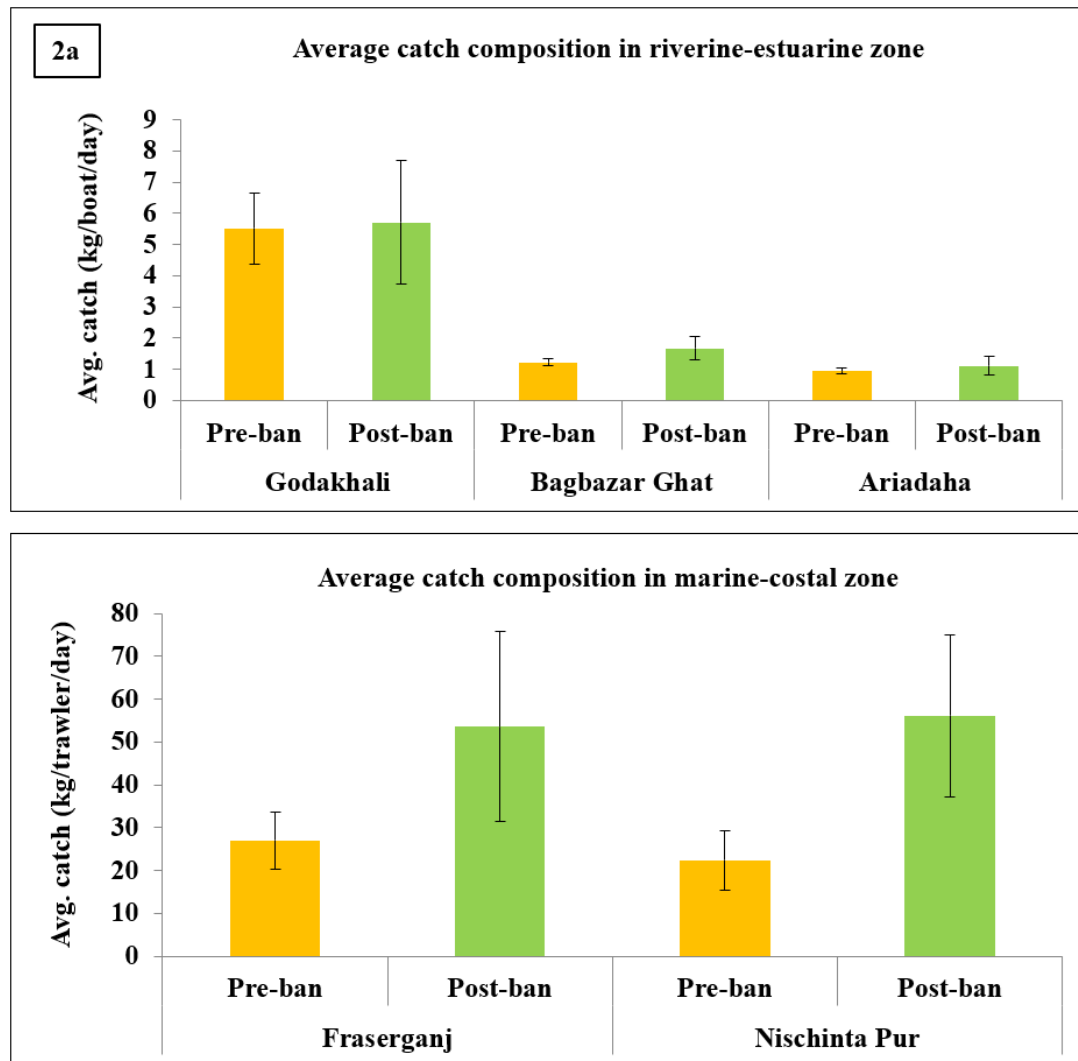


Figure 2: Season-wise average catches composition (2a. in riverine-estuarine zone and 2b. in marine-coastal zone).

### 3.2 Zone-wise Length Distribution

A total of 364 Hilsa specimens (185 from riverine-estuarine zone and 179 from marine-coastal zone) were examined during the study period. The length-frequency distribution of Hilsa varied no-

ticeably between the riverine-estuarine and marine-coastal zones during the study period. In the riverine-estuarine zone, the pre-ban catch was dominated by smaller Hilsa (10–29 cm), which accounted for 63.89% of the total sampled fish. A sig-

nificant difference in the length-frequency distribution was observed between the pre-ban and post-ban periods ( $\chi^2 = 33.63$ ,  $df = 4$ ,  $p < 0.001$ ). In the marine-coastal zone, smaller Hilsa (10–29 cm) accounted for 29.07% of the total sampled fish during the pre-ban period. A significant difference in the length-frequency distribution was observed between the pre-ban and

post-ban periods ( $\chi^2 = 19.10$ ,  $df = 4$ ,  $p < 0.001$ ). Following the fishing ban, a shift towards larger size classes was observed in both zones. Notably, individuals belonging to the 50–59 cm length class constituted more than 5% of the total catch in the post-ban period, whereas the smallest size class (10–19 cm) was absent from the post-ban catch (Fig. 3).

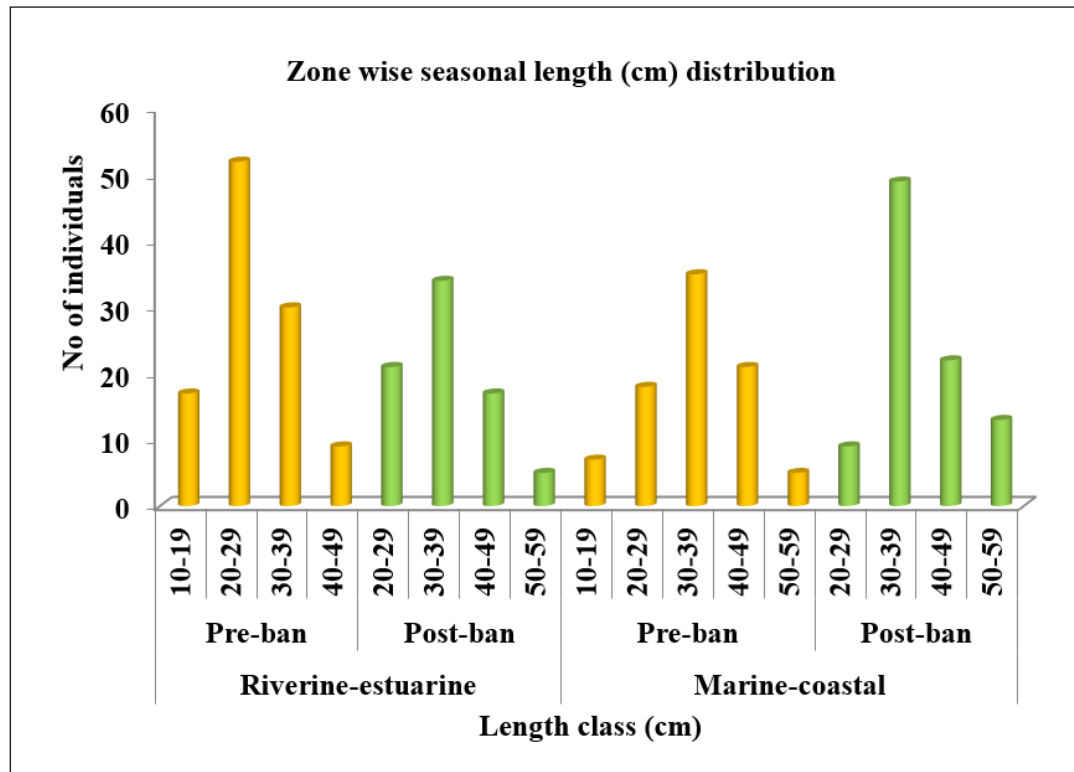


Figure 3: Seasonal length-frequency distribution of Hilsa (*Tenuklosa ilisha*) in the riverine–estuarine and marine–coastal zones during the pre-ban and post-ban periods.

### 3.3 Zone-wise Fishers' Response on Fishing Ban

The survey revealed strong support for the Hilsa fishing ban among fishers from both the riverine-estuarine and marine-coastal zones, with more than 75% of respondents acknowledging its positive impact on Hilsa catches and stock replenishment (Table 1). Most fishers reported an increase in Hilsa availability following the ban period. Despite recognizing its ecological benefits, over 70% of the respondents indicated that the ban adversely affects

their livelihoods, as income from fishing is completely or substantially interrupted during the closure period. Many fishers also expressed concerns regarding the inadequacy and irregular distribution of government assistance. To cope with the loss of fishing income, fishers engage in various alternative livelihood activities during ban period (Fig. 4). Net repairing emerged as the most common occupation in the riverine-estuarine zone, involving nearly 23% of respondents, whereas fish trading was the predominant alternative activity

in the marine-coastal zone, engaging approximately 23% of fishers. Additionally, around 12% of marine-coastal fishers reported migrating to other states for temporary employment as migrant laborers during the ban period. A notable find-

ing of the survey was that a considerable proportion of fishers (15% in the riverine-estuarine zone and 13% in the marine-coastal zone) remained without any alternative source of income, highlighting their vulnerability during the fishing closure.

Table 1: Percentage analysis of different responses of fishers regarding fishing ban in two zones.

| Sl. No. | Parameters                            | R-E |       | M-C |       | R-E 1 |       | M-C 1 |       |
|---------|---------------------------------------|-----|-------|-----|-------|-------|-------|-------|-------|
|         |                                       | f   | %     | f   | %     | f     | %     | f     | %     |
| 1       | Total count of respondents            | 67  | 46.85 | 81  | 53.15 | 63    | 43.75 | 81    | 56.25 |
| 2       | Support fishing ban                   | 53  | 79.10 | 62  | 81.58 | 50    | 79.36 | 64    | 79.01 |
| 3       | Do not support fishing ban            | 14  | 20.90 | 14  | 18.42 | 13    | 20.63 | 17    | 20.99 |
| 4       | Observed catch increase after ban     | 53  | 79.10 | 62  | 81.58 | 50    | 79.36 | 64    | 79.01 |
| 5       | Support income loss during ban        | 48  | 71.64 | 56  | 73.68 | 45    | 71.43 | 59    | 72.84 |
| 6       | Do not support income loss during ban | 19  | 28.36 | 20  | 26.32 | 18    | 28.57 | 22    | 27.16 |
| 7       | Received Govt. assistance             | 20  | 29.85 | 18  | 23.68 | 19    | 30.16 | 23    | 28.40 |
| 8       | Do not received Govt. assistance      | 47  | 70.15 | 58  | 76.32 | 44    | 69.84 | 58    | 71.60 |

**Abbreviations:** **R-E** = Riverine-estuarine zone in pre-ban season; **M-C** = Marine coastal zone in pre-ban season; **R-E 1** = Riverine-estuarine zone in post-ban season; **M-C 1** = Marine coastal zone in post-ban season; **f** = Frequency; **%** = Percentage.

## 4 Discussions

The fishing ban had a limited immediate effect on catch rates. The slight increase in average catch observed after the ban may indicate some improvement in stock availability; however, the magnitude of change was insufficient to produce a significant difference. This could be attributed to factors such as variable environmental conditions, fishing effort, river flow, salinity fluctuations, and the migratory behavior of Hilsa, which can strongly influence catch levels in riverine-estuarine habitats. In contrast, the marine-coastal zone showed a significant increase in Hilsa catch during the post-ban period, indicating a positive response of the fishery to the seasonal closure. The higher catches after the ban may reflect reduced fishing pressure during the breeding and nursery periods, allowing more fish to survive, grow, and recruit to the fishable stock. Such improvements in catch rates following fishing restrictions have been reported in several

Hilsa fisheries and are often considered evidence of the effectiveness of conservation measures [13, 20-21]. In Bangladesh the 22-day seasonal fishing ban (14th October – 4th November) significantly improved Hilsa reproductive success, with breeding success reaching 51.2% (a 102% increase over the 2001 – 02 baseline), an estimated 758,075 kg of fertilized eggs produced, female dominance (62 – 96% of the catch; 88 – 100% in spawning grounds), and spent Hilsa increasing from 8% to 51.2%, confirming the effectiveness of the ban in enhancing spawning and recruitment [22]. The predominance of smaller-sized Hilsa (10–29 cm) in the riverine-estuarine zone during the pre-ban period suggests that these areas function as important nursery and juvenile habitats where young fish spend a significant portion of their life cycle. In contrast, the relatively lower proportion of small-sized fish in the marine-coastal zone indicates the presence of a more diverse size structure, including a greater number of sub-adult and adult in-

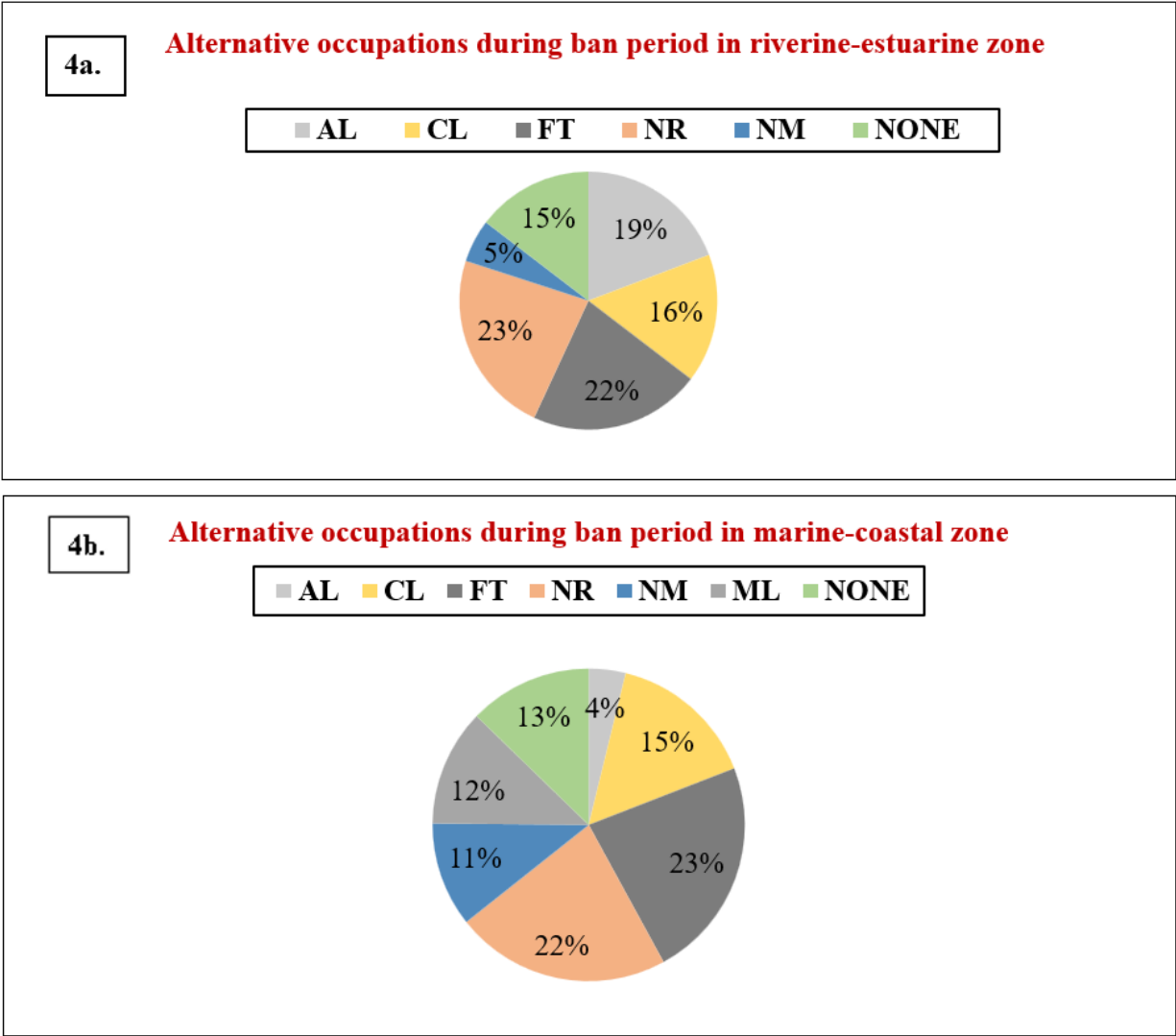


Figure 4: Pie charts showing the percentage distribution of alternative occupations adopted by fishers during the fishing ban period in (4a) the riverine-estuarine zone and (4b) the marine-coastal zone. **Abbreviations:** **AL** = **A**griculture **L**abor; **CL** = **C**onstruction **L**abor; **FT** = **F**ish **T**rading; **NR** = **N**et **R**epairing; **NM** = **N**et **M**aking; **ML** = **M**igrant **L**abor.

dividuals. Following the fishing ban, the length-frequency distribution shifted towards larger size classes in both zones, with fish measuring 50–59 cm comprising more than 5% of the catch. This increase in larger-sized individuals may reflect the positive effects of reduced fishing pressure during the ban period, allowing Hilsa additional time to grow and survive before being harvested. The presence of more large-sized fish after the ban is particularly important because larger Hilsa generally contribute more to spawning and stock replenishment.

Majority of fishers support the Hilsa fishing ban and recognize its role in increasing Hilsa abundance and improving catches after the closure period. This positive perception suggests that fishers are aware of the long-term benefits of conservation measures and their contribution to sustaining Hilsa stocks. Similar observations have been reported in other Hilsa-producing regions, where seasonal fishing restrictions have been associated with improved fish availability and recruitment [13].

Concerns regarding the adequacy and timely distribution of government assistance further emphasize the financial insecurity experienced by many households [23, 24]. These findings highlight the gap between conservation objectives and livelihood support mechanisms.

The migration of a section of coastal fishers to other states for temporary employment further reflects the economic pressure created by the ban. Importantly, the presence of fishers without any alternative source of income underscores the vulnerability of certain households and their dependence on fishing activities.

## 5 Conclusion

The study demonstrates that the Hilsa fishing ban has contributed positively to stock conservation, as evidenced by increased post-ban catches in the marine-coastal zone, the occurrence of larger-

sized individuals after the ban, and the positive perceptions of most fishers regarding stock replenishment. However, the riverine-estuarine zone showed only marginal changes in catch rates, indicating habitat-specific responses to the ban. Despite its ecological benefits, the ban imposes significant economic hardships on fishing communities due to loss of income and inadequate support mechanisms. Therefore, effective conservation of Hilsa requires not only seasonal fishing restrictions but also strengthened livelihood assistance and alternative income opportunities for fishers.

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