Current state and future potential of fisheries in the Mirsarai coastal areas of Chattogram for enhancing Bangladesh's blue economy

Abstract

Aims: This study aims to comprehensively assess the fisheries resources in the Mirsarai coastal area of Chattogram district, focusing on their contribution to both local and national economies. The research seeks to identify challenges and vulnerabilities, particularly those arising from climate change, impacting pond owners, fish farmers, hatchery owners, and nursery owners in the region.

Study Design: The study adopts a cross-sectional design, employing field surveys and interviews to collect data on fish production, climate change impacts, and challenges faced by stakeholders. The cross-sectional approach allows for a holistic understanding of the current state of fisheries resources and their interactions with climatic factors.

Place and Duration of Study: The research is conducted in Mirsarai, a coastal upazila of Chattogram district, Bangladesh. The study encompasses data collected during the January to December 2016, providing insights into the dynamics of fish production, climate change effects, and challenges faced by fisheries stakeholders in Mirsarai.

Methodology: Field surveys are conducted to gather quantitative data on fish production from both capture and culture fisheries. Additionally, interviews with pond owners, fish farmers, hatchery owners, and nursery owners are conducted to qualitatively assess the impact of climate change on their operations and economic well-being. The combination of quantitative and qualitative methods ensures a comprehensive analysis.

Results: The average fish production in capture fisheries is determined to be 63 kg/ha, while culture fisheries, specifically pond aquaculture, yield an average of 1656 kg/ha. The results highlight the significant impact of climate change on the local fisheries sector, revealing

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challenges related to market timing, post-larvae availability, and pricing that affect the economic sustainability of stakeholders.

Conclusion: The findings underscore the vulnerability of Mirsarai's fisheries to climate change, emphasizing economic losses for fish farmers, hatchery owners, and nursery owners. The conclusion calls for urgent adaptive measures and climate-resilient strategies in the fisheries sector to ensure sustainability and viability in the face of evolving climatic conditions.

Implication: This study has implications for fisheries management and policy development, emphasizing the need for proactive measures to address climate-induced challenges and sustain the economic well-being of fisheries stakeholders in the Mirsarai coastal area.

Keywords: Coastal fisheries; culture fisheries; land suitability; aquaculture; resources

1. INTRODUCTION

Bangladesh, a country endowed with abundant inland and marine water resources, has emerged as a global force in fisheries production, ranking 4th in the world for inland fish production by capture and 5th in aquaculture production according to the FAO's State of World Fisheries and Aquaculture 2015 report[1,2]. The fisheries sector holds paramount importance in the social and economic fabric of the nation, contributing significantly to the country's GDP and providing full-time employment to approximately 1.2 million people[3,4]. This robust contribution to the blue economy is underscored by the sector's role in supplying 4.7 percent of the country's GDP and sustaining the livelihoods of around 20 million people, encompassing a diverse range of occupations from full-time fishermen to fish traders, processors, transporters, and packers[5–8].

Over the years, Bangladesh's fisheries sector has witnessed transformative developments, from the discovery of productive fishing grounds in offshore and inshore belts to the introduction of mechanized fishing boats and modern bottom trawling techniques[1,9,10].

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The establishment of processing and export trade industries, coupled with a growing international demand for marine fishes, has propelled the progressive development of the sector[11,12]. The National Fisheries Policy, as a comprehensive sectorial policy, underscores key objectives such as increasing the contribution of fisheries to socio-economic development, poverty reduction, achieving economic growth through fish exports, and preserving biodiversity[13,14,23,24,15–22].

With fish providing 80 percent of the animal protein intake for the people of Bangladesh, the significance of the fisheries sector extends beyond economic contributions to pivotal roles in ensuring food security and nutrition[25–31]. The sector's multifaceted impact is evident in its support for ancillary industries at the rural level and its substantial role in supplying animal protein[2,32,33]. The continued growth and development of the fishery-based economy are anticipated to be even more critical in the future[13,34,35].

Mirsarai, situated in the Chattogram region, stands out as a major contributor to Bangladesh's fish production[36]. Home to a diverse array of fisheries, including inland open water fisheries and freshwater aquaculture, Mirsarai relies on wetlands for fisheries, aquatic vegetation, and navigation[36–38]. However, challenges such as extensive brackish water aquaculture, predominantly shrimp-based, need careful management to ensure sustainable development[2,39,40]. The fisheries practices in Mirsarai have profound implications for food and nutrition, making the formulation of plans and the proper utilization of fisheries resources imperative for sustainable development[41,42]. Moreover, the region's contribution to fish and fish product exports further solidifies its importance in bolstering the country's economy[13]. Bangladesh's extensive river network and proximity to the Bay of Bengal provide a rich tapestry of natural resources, positioning fisheries as a crucial aspect of the nation's agricultural and economic landscape[43].

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Despite its immense potential, the Mirsarai coastal areas grapple with an array of challenges that jeopardize the sustainability of fisheries [42,44,45]. Overfishing, habitat degradation, and the absence of comprehensive spatial planning for both capture and culture fisheries loom large [2,46,47]. A lack of a structured database impedes effective management, limiting our understanding of the intricate interplay between ecological, socio-economic, and cultural dimensions within the region.

This research assessed questions such as, how is the current status of capture and culture fisheries in the Mirsarai coastal areas of Chittagong characterized? What areas within this region exhibit potential for the development of both capture and culture fisheries? What protective measures are deemed necessary for the preservation of wetland habitats, ensuring sustainable fisheries development in Mirsarai? How can a comprehensive database of present wetland areas used by freshwater capture and culture fisheries be effectively developed? Lastly, what strategies and recommendations can be proposed to elevate the contribution of fisheries to the blue economy of Bangladesh?

We posit that a thorough assessment of the current fisheries status, coupled with the demarcation of suitable areas and the identification of protective measures, will form the bedrock for sustainable fisheries development in Mirsarai. The establishment of a database will serve as a critical tool for informed decision-making and resource allocation. Furthermore, implementing the proposed strategies and recommendations will significantly contribute to enhancing the fisheries sector's role in advancing the blue economy of Bangladesh.

The primary objectives of this study encompass a holistic examination of the fisheries dynamics in the Mirsarai coastal areas, aiming to assess the current status and potential of both capture and culture fisheries. Additionally, the study seeks to demarcate suitable areas for the development of these fisheries, identify essential protective measures for the

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preservation of wetland habitats to promote sustainable fisheries development, and create a comprehensive database detailing present wetland areas utilized by freshwater capture and culture fisheries. Furthermore, the study endeavors to propose effective strategies and recommendations with the overarching goal of enhancing the fisheries sector's pivotal contribution to the blue economy of Bangladesh.

2. METHODOLOGY

2.1. Study area

This investigation was conducted in the coastal areas of Mirsarai,Chattogram (Figure 1). The study site, dominated primarily by a specific type of occupation, underscores the significance of the fishery sector as a major economic driver in the region. The research activities spanned the entire calendar year, from January to December 2016, encompassing a comprehensive examination of the ecological, socio-economic, and occupational aspects of this vital coastal area.

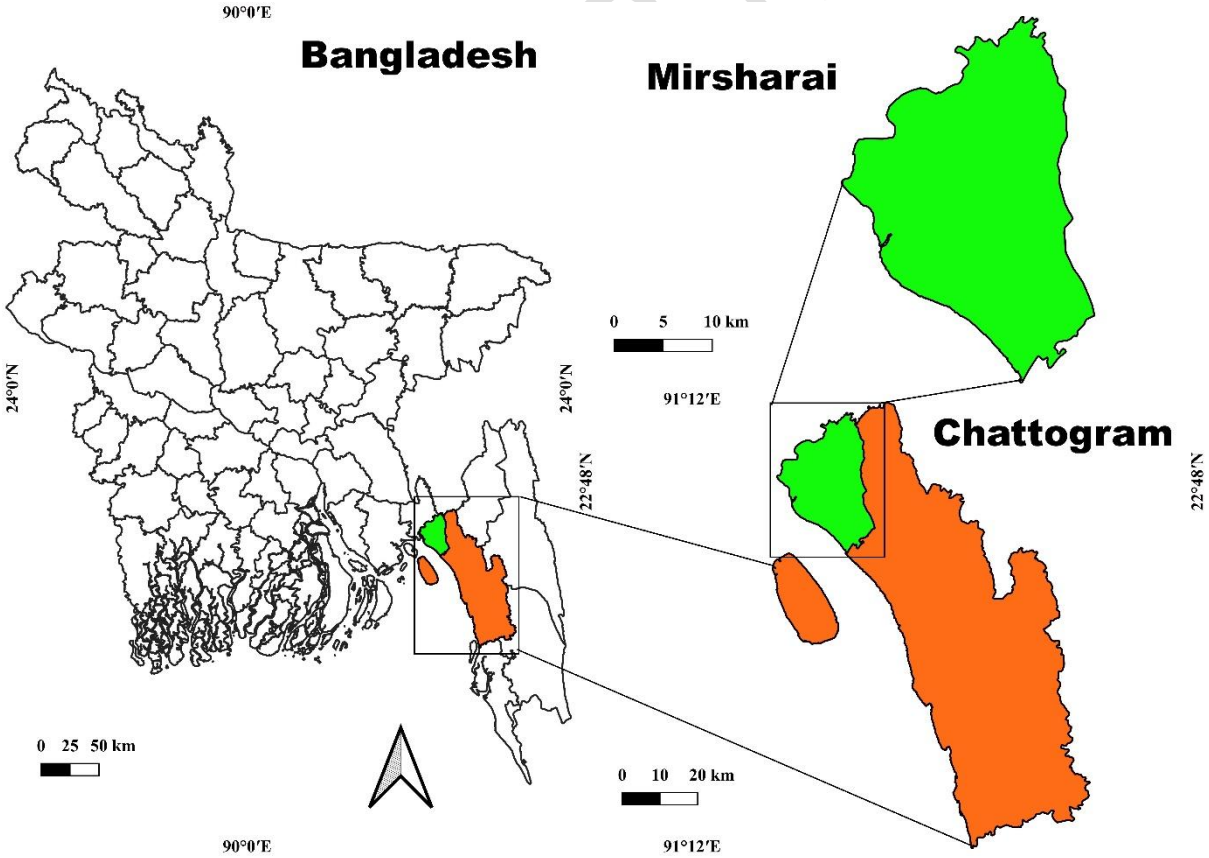

Figure 1. The coastal areas of Mirsarai, Chattogram

2.2. Data collection

Fisheries area was analyzed by using field survey, focus group discussion (FGD), government data and statistics. The detailed fisheries study has been carried out up to union level to collect all kinds of relevant data, maps, reports and information from field survey using proper tools and techniques. The relevant secondary data on fisheries land uses, satellite image classification and information pertinent to present status of fisheries had also been collected from Department of Fisheries (DoF), BBS and CEGIS respectively to develop a data bank for classifying land and water bodies on the basis of fisheries land suitability and assign it to one or a few specific uses for which the land will technically most suitable and economically viable. To determine present fisheries land use situation detailed study has been conducted through PRA tools like Key Informant Interview (KII) with the related fish farmer, local people and Government officials. Information has also been taken mainly from Fisheries Statistical Year Book of Bangladesh of DoF and present field observations and relevant organizations to get feedback from them on different issues of fisheries development and management.

2.3. Data analysis

The collected data underwent a rigorous processing and analysis phase aligned with the study's defined objectives, employing a hybrid approach that encompassed both manual and computer-based methodologies. Microsoft Excel 2013 served as the primary tool for computer-based analysis, ensuring efficiency and accuracy in handling the substantial dataset.

3. RESULTS AND DISCUSSION

3.1. Fisheries status

In Mirsharai Upazila, freshwater culture fisheries play a pivotal role in sustaining the local economy, encompassing pond aquaculture, gher, canal activities, among others. The fisheries production in Mirsharai has exhibited a noteworthy upward trajectory, increasing from 6,983 metric tons in 2005-2006 to 12,876 metric tons in 2014-2015. This growth underscores the resilience and adaptability of the community in the face of environmental challenges, positioning the fisheries sector as a crucial contributor to the region's economic sustenance (Figure2).Conversely, the national fisheries production in 2005-2006 stood at 22.84 lakh metric tons, experiencing a gradual rise to 36.84 lakh metric tons by 2014-15. This marks an impressive 84.39% increase over the span of a decade (2005-2014). Notably, the national production witnessed a growth of 61.30% during the same period (2005-2014).

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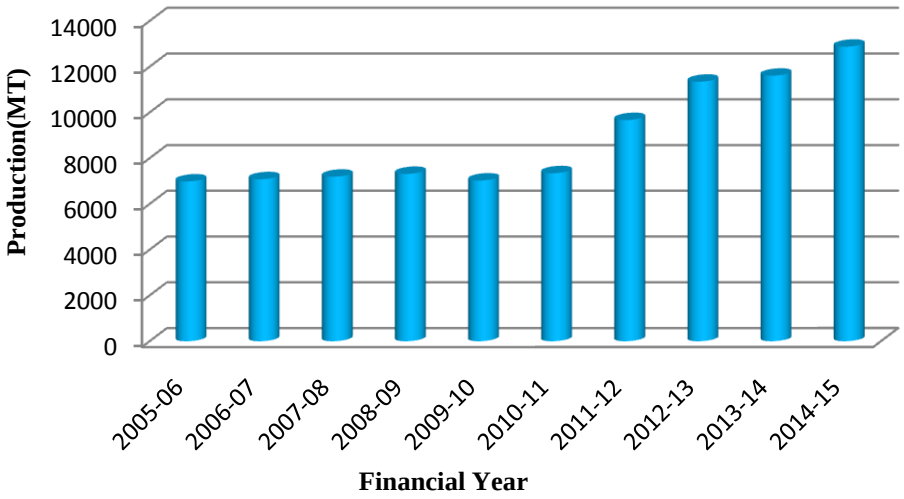

Figure 2. Fisheries production of last 10 years Mirsharai Upazila (combination of primary and secondary data)

The potential for productivity in Mirsharai is promising, attributed to the application of scientific and technical knowledge concerning stock enhancement, seed production, traditional aquaculture methods, and efficient pond management systems[48,49]. Essential resources such as fish seeds, feeds, and other on-farm inputs are readily available to most pond and gher owners[50–55]. However, the expansion of aquaculture faces a significant constraint in the form of limited availability of quality seeds[56,57]. The region faced substantial setbacks between 2007 and 2010, particularly due to the impact of two cyclones, Aila and Sidr, which severely affected the fisheries sector in Mirsharai[58,59]. These natural calamities compounded the challenges faced by vulnerable populations, leading to a decline in fish catches, reduced demand for labor, and subsequent rural-to-urban migration[60,61]. The International Climate Change Strategy and Action Plan of 2008 highlights the anticipated exacerbation of existing problems and hazards due to more frequent and severe tropical cyclones, unpredictable rainfall patterns, riverbank erosion, sedimentation, melting Himalayan glaciers, and rising sea levels[62,63]. In light of these challenges, there is a pressing need to demonstrate aquaculture technologies directly in farmers' fields at the union level, aiming to sustain and enhance the current productivity status[64–66].

3.2. Areadistribution

Mirsharai Upazila boasts a total wetland expanse spanning 7,893.60 hectares, with 1,693.84 hectares designated for open water capture fisheries and 6,199.76 hectares allocated to culture fisheries. Table 1 provides a comprehensive breakdown of land distribution, highlighting

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wetland distribution for capture and culture fisheries across various unions and Paurashava. Notably, Dhum, Saherkhali, and Osmanpur unions emerge as significant contributors to the fisheries potential of Mirsharai, encompassing 64.73%, 56.39%, and 44.21% of the total wetland, respectively. This delineation underscores the diverse wetland landscape of Mirsharai, with specific unions exhibiting robust potential for fisheries production, setting the stage for targeted and strategic development initiatives in these high-potential areas.

Table1. Wetland distribution of Mirsharai Upazila (areas in hectare)

Union name	Union area	Culture fisheries		Total culture	*Total capture (In dry season)	Total wetland
		Pond culture	Other fish culture			
Dhum	1340.08	757	00	757	110.42	867.42(64.73%)
Durgapur	1514.98	405	00	405	13.26	418.26(27.61%)
Haitkandi	1324.29	372	00	372	5.09	377.09(28.47%)
Hinguli	1846.96	60	00	60	44.53	104.53(5.66%)
Ichhakhali	4591.50	717	15	732	202.27	934.27(20.35%)
Karerhat	14810.53	160	00	160	328.46	488.46(3.29%)
Katachhara	1395.14	387	00	387	9.88	396.88(28.45%)
Khaiyachhara	600.40	222	00	222	14.62	236.62(39.41%)
Mayani	1858.30	457	00	457	15.65	472.65(25.43%)
Mirsharai	1765.18	237	00	237	11.49	248.49(14.08%)
Mithanala	2161.13	446	00	446	17.92	463.92(21.47%)
Maghadia	1488.66	534	00	534	0.07	534.07(35.88%)
Osmanpur	1346.56	473	2	475	120.26	595.26(44.21%)
Saherkhali	2159.92	448	42	490	728	1218(56.39%)
Wahedpur	1895.55	194.5	5	199.5	12.61	212.11(11.19%)
Zorwarganj	2233.60	176	00	176	20.84	196.84(8.81%)
Baroir Hat	946.62	26.95	00	26.95	12.50	39.45(4.16%)
MirsharaiPaurashava	1560.48	63.31	00	63.31	25.97	89.28(5.72%)
Total	**44839.88**	**6135.76**	**64**	**6199.76**	**1693.84**	**7893.60 (17.60%)**

Of the overall expanse totaling 44,839.88 hectares, 18% is designated as wetland, further subdivided into 21% for capture fisheries and 79% for culture fisheries (Figure 3). This distribution exhibits seasonal variations, particularly during the dry and wet seasons. Notably, the dry season poses challenges as the water level diminishes significantly. Progressive river siltation contributes to a reduction in the water-holding capacity of these bodies. Simultaneously, their location at higher elevations leads to a swift drying up of these water bodies during the dry season. This interplay of factors highlights the dynamic nature of the wetland ecosystem, necessitating careful consideration in the management and sustainable utilization of these vital resources.

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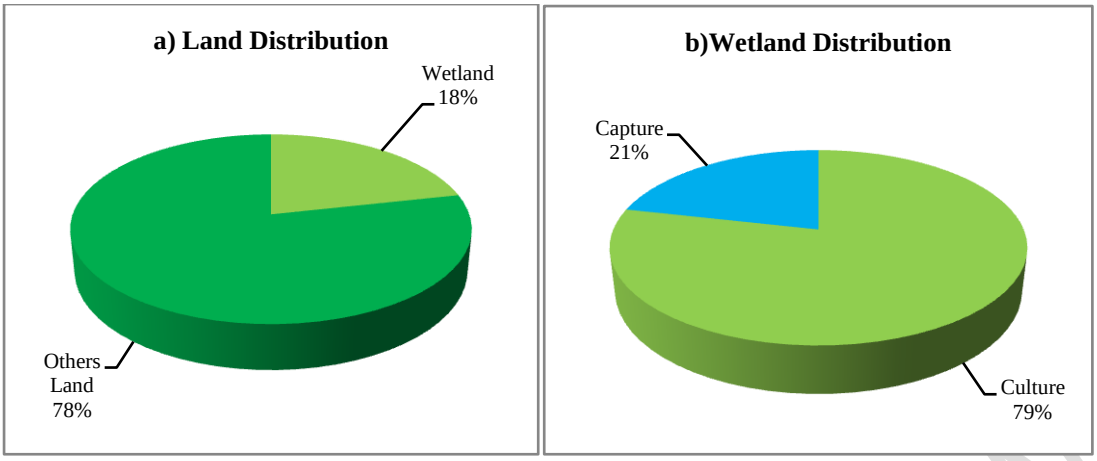

Figure3. a) Distribution of land b) distribution of capture and culture fisheries wetland of Mirsharai Upazila

Mirsharai contends with recurrent challenges, regularly succumbing to flash floods originating from the Bay of Bengal and Mohouri River[67]. The aftermath of these floods renders affected areas waterlogged for days, causing significant and lasting damage[68,69]. Additionally, the region is frequently battered by cyclones, and landslides become prevalent during the monsoon season[58,70]. The local populace attributes the rise in landslides to factors such as increasing siltation in rivers due to soil erosion, deforestation, and faulty agricultural practices[71,72]. Riverbank erosion further compounds the predicament, resulting in substantial losses to farmlands, homesteads, livelihoods, and assets[73,74]. Beyond the physical toll on infrastructure, encompassing roads, bridges, and market centers, river erosion displaces individuals from their communities and disrupts social networks, amplifying the multifaceted challenges faced by the Mirsharairegion [74–76].

3.3. Present scenario of fishers' community and major captured fishes

The Mirsarai region holds considerable potential in inland open water fisheries, encompassing seasonal water bodies, rivers, natural depressions (beels), and reservoirs. Approximately 21,900 fisheries beneficiaries actively engage in fisheries activities within this area. Despite the absence of recorded inundation of the total land surface during annual flooding in the rainy season, the inland capture fisheries, comprising a wealth of resources, have gradually relinquished their position as the primary fish-producing sources[77,78]. This shift is attributed to the decline and degradation of these resources, prompting aquaculture to emerge as the predominant source[2]. However, recent years have witnessed a decline in aquatic biodiversity, particularly fish species and other aquatic organisms in inland open water, influenced by both natural and anthropological factors[79–81]. Recognizing this

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decline, a paramount focus is now placed on enhanced biological management practices to curb resource degradation and bolster sustainable production in the Mirsarai region.

There are some major native capture fisheriesfound in this area,such asChanda (*Chanda ranga*), Koi (*Anabas testudineus*), Magur (*Clarias batrachus*), Tengra (*Mystustengra*), Taki (*Channa punctatus*), Kholisha (*Colisa* sp.), Shoal (*Chana striatus*), Foli (*Notpterusnotpterus*), Baim (*Mastacembalus spp*.), Mola (*Amblyphayngodon mola*), Sarputi (*Puntius sarana*),Pabda (*Ompokpabda*), Gulsha (*Mystusbleekeri*),Bashpata (*Ailia coila),*Vetki (*Lates calcarifer*), BagdaChingri (*P. japonicus),* Chaga Chingri*(P. indicus),*Rakha *(Datniodespolota),*Balay*(Awaousgrammepomus),*Datina *(Acanthopagrus latus)*etc.Landing centers of different union are also enriched with brackish and marine water fisheries species which have high commercial values in the market.

The commonly found fisheries species were*Hilsa ilisha, Lates calcarifer,Harpodonnehereus,Lutianusjohnii,Trichiurushaumela,Polynemus indicus, Aurius platytomus, Stromateuschinencis, Scoliodonsorrakowah, Liza tade, Mugil khorsula, Pomadasys hasta. Lutjanus johni, Mene maculata, Arius* spp.,*E. tetradactylum, Trichanthus*sp, *Scomberomorus guttatus, S. commerson, Rastrellige*sp,*Sphyraena barracuda, Namipterus japonicus, Upeneussulphureus, Sauridatumbil*etc. and shrimp species like *Penaeus monodon, P. japonicus, Peneaus. indicus*etc.The biodiversity of this species could be improved through habitat restoration and establishment of sanctuaries.

3.4. Culture fisheries

Freshwater aquaculture stands as a pivotal element in Mirsharai's fisheries sector. The culture fisheries in this region encompass a diverse range, including ponds, nurseries, ghers, and canals, with an emerging trend towards integrating culture-based capture fisheries practices[48,82]. The seasonal water bodies, aquaculture ponds, and ghers present immense potential for bolstering fish production through the adoption of aquaculture-based enhancement techniques[83]. The implementation of scientific methods in fish culture is anticipated to substantially increase the current production levels. Currently, aquaculture is practiced across an expansive area, totaling approximately 6,199.76 hectares, covering about 79% of the total inland water expanse in Mirsharai. This underscores the significant contribution and growth potential of aquaculture in shaping the fisheries landscape of the Mirsharai region.

Culture fisheries comprise pond aquaculture, fish culture in homestead pond and paddy field etc. Major native culture species are: silver carp (*Hypopthalmichthys nobilis*), pungus

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(*Pungassiussuchi*), Rui (*Labeorohita*), Catla (*Catlacatla*), Bata (*Labeo bata)*, Grass carp, Mrigal (*Cirrhinamrigala*), Tilapia (*Orechromisnilotica*), Grass carp (*Ctenopharyngodonidealla*), Gonia (*Labeoboggut*), BagdaChingri *(Penaeus monodon)*, (*P. japonicus)*, Chaga chingri *(Peneaus indicus)*, etc.

3.5. Land suitability in the study area

The sediment characteristics of the Mirsharai area primarily consist of sandy loam, an optimal soil type for pond preparation in adherence to good aquaculture practices. This soil variant exhibits a commendable water-holding capacity, contributing to its suitability for aquaculture endeavors. A pivotal determinant for fish culture system compatibility is the soil pH, with a reference value above 5.0 deemed suitable. The soil in Mirsharai is categorized based on its nutritional status and pH into three productivity rates (Table 2). An ideal pond depth of 2 meters and a pH level ranging from 6.5 to 8.5 are considered optimal for fish production. Notably, the soil pH value, water quality, and land type, particularly Medium Low Land (MLL) in different unions of Mirsharai, are predominantly suitable for both capture and culture fisheries, aligning with the prerequisites for successful aquaculture practices[84,85].

Table2.Land suitability matrix for fresh water fish culture[86]

Productivity Rating	pH Level	Nutrition component level (mg/kg Soil)		
		Nitrogen	Phosphorous	Carbon
High	7.5-6.5	> 50	6-12	> 1.5
Medium	6.5-5.5	25-49	3-5	0.5-1.4
Low	< 5.5&>8.5	< 25	< 3	< 0.5

3.6. Wetland status

Progressive river siltation is a major contributor to frequent floods during the rainy season, reducing the water-holding capacity and leading to adverse consequences[87]. Conversely, in the dry season, the swift drying up of water bodies impedes fish growth throughout the season. The construction of flood protection embankments, while aimed at preventing floods, has inadvertently obstructed rivers and canals, adversely impacting the natural abundance of fisheries[88]. The combined ecological changes in the wetland have significantly lowered the average production from these water bodies[89,90]. The wetland status varies between capture fisheries and culture fisheries areas, with capture fisheries seeing minimal change from 47,850 hectares in 2005-2006 to 46,950 hectares in the last decade. In contrast, the area

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under culture fisheries has steadily increased from 5,922 hectares in 2005-2006 to 6,012 hectares in 2014-2015 (Figure 4). This positive trend in culture fisheries is attributed to effective coordination and communication among government bodies, research institutions, and non-governmental organizations[41]. The decreasing trend in inland capture fisheries area is likely to persist due to climate change, environmental hazards, and competition with other non-fisheries land uses[34,91,92].

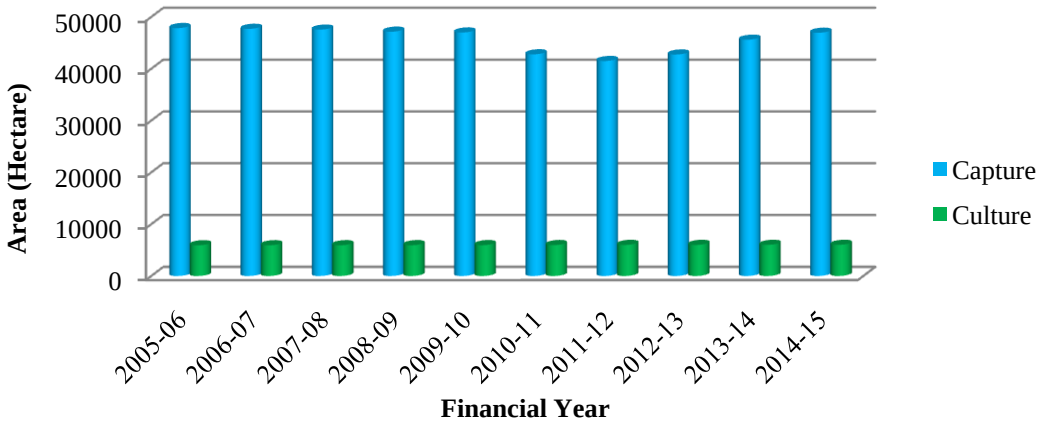

Figure 4. Wetland status of capture and culture fisheries area in Mirsharai Upazila

3.7. Fisheries contribute on the local economy as well as blue economy

The blue economy encompasses marine-based economic activities, envisioning oceans and seas as developmental spaces integrating spatial planning for conservation, sustainable utilization of living resources, extraction of oil and mineral wealth, bio-prospecting, sustainable energy production, and marine transport[93,94]. Marine ecosystems and resources play a pivotal role in supporting global food security, fostering sustainable livelihoods, creating economic opportunities, and promoting social inclusion for billions of people[3,95]. While the coastal and marine environment gains increasing importance for a country's social, economic, and strategic objectives, this study primarily focuses on aquaculture and fisheries resources[6,13,64]. The fisheries industry in Bangladesh, with significant male and female participation, is a crucial contributor to blue economy development[14]. Ensuring gender

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equality in labor participation, fair remuneration, and equitable decision-making is essential for a sustainable trajectory[96]. Effective management is critical, as overexploitation and poor resource stewardship lead to lost opportunities, heightened food insecurity, and diminished economic prospects, particularly impacting some of the world's most vulnerable populations[97,98].

4. CONCLUSIONS

The findings underscore the vast potential of aquaculture in Bangladesh, particularly in Chattogram district, as a key contributor to the fisheries sector. The study identifies challenges in small-scale marine and coastal fisheries, emphasizing the crucial role of fisheries in supplying animal protein, employment, foreign exchange earnings, and rural industrial support. Given the limitations in capture fisheries and the expansive potential for aquaculture, future fish production, crucial for domestic consumption and export, must be primarily derived from aquaculture. Moreover, the sector offers an avenue to absorb surplus labor productively. In Mirsharai, the study reveals rich fisheries resources, with habitat degradation, fishing pressure, and wetland conversion identified as challenges. Fisheries land zoning and wetland protection are crucial for optimizing fish productivity, and administrative measures are essential for sustainable fisheries development in Mirsarai, contributing significantly to the socio-economic upliftment of the region.

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