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Sustainable Fisheries Management Approach of Bangladesh: A Potential Blue Economy Path

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Authors' contributions

This work was carried out in collaboration between both authors. Author PB designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author CB managed the analyses of the study. Both authors read and approved the final manuscript.

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ABSTRACT

Bangladesh is a land of rivers and numerous waterbody all over the country. Approximately 4.70 million hectares of water sources, including oxbow lakes, floodplains, and numerous canals, are a blessing for Bangladesh. However, issues with food safety in the fisheries industry are a result of urbanization, industrial expansion, high levels of exploitation, habitat degradation, and population growth. It was discovered that many legal shortcomings, a lack of clear strategies and well-considered guidelines, an inaccessible authoritarian framework, authority disputes and non-compliance, a lack of regular legislative review, and a lack of bylaws, rules, and guidelines all contributed to the implementation of regulations, laws, and policies frequently meeting with limited success. The government of Bangladesh has implemented a number of socially conscious initiatives to address the issues, including raising fish productivity, protecting fish stocks, and

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managing fisheries. However, the accumulation of microplastics in the fishing industry is currently one of the main issues from the standpoint of public health.Moreover, Bangladesh's sustainable fisheries management depends on a broad criminal code. As a result, via natural management, fishing privileges have been expanded and promoted well beyond fishing.

Keywords: Fisheries resources; management practice; fisher's livelihoods; Bangladesh.

1. INTRODUCTION

"Fishing enterprise of Bangladesh is one of the most effective and colourful sectors. It performs a key position in assuaging protein deficiency, imparting employment for unemployed teens, foreign-income exchange, and enhancing socio-financial fame—the world debts for 5.00% of national GDP and 30.81% of general agricultural GDP. Fish and fish products were the second ones of the top exporters in 2022–2024, accounting for 3.56% of the total earning rate" [1]. "However, inland fisheries have declined substantially over time, declining and deteriorating wetlands. Bangladesh's fisheries are at risk from overfishing and environmental degradation caused by population oppression" [2,3]. "From 1983-to 1984, inland fishing and traditional fishing contributed 62.59 % and 15.53 % of total fish production, whereas, in 2020-21, inland fishing only contributed 30.50 % while traditional fishing contributed 60.00 % of total fish production" [4]. "The authorities are currently focusing on progressing organic control in public water structures to diminish the loss of resources and increase production. There are both opportunities and challenges in Bangladesh's fishery. Land seizes, inland tradition, and maritime captivity make up the country's fishing sources. The fishery of inland cover five categories of habitats include rive and estuary (853,863 ha), bells (1,14,161 ha), Kaptai Lake (68,800 ha), Sundarbans mangrove rainforests (1,77,000 ha), floods (2,695,529 ha); and an inland fishing endeavor such as six forms, principally lake (three,71,309 ha), regular waterfront (1,30,488), baor (5,488 ha), shrimp / prawn farm (2,75,274 ha), pen culture (6.78 ha), and cage culture (7 ha)" [5-7].

The Bangladesh fishery has several plans to develop the national financial sector. The dramatic decline in fish production over the past two decades may also be due to the current right of access and more that should contribute to overfishing, deforestation and restriction of fish migration during the breeding season [8-10]. Due to their tremendous gains and measurements, climate change conflicts include significant activity and loss of habitat, habitat exchange, disease outbreaks, barriers to migration routes and similarities, and declining fishery production [11-13]. Nonetheless, take a good look at the reputation of the fishery and modern management practices and get a chance to get closer to the fishery management arrangements that can gather more efficiency, equity and sustainability. Small-scale aquatic animals also became popular and contributed to modern fish production. With time some years ago, hatching and kindergarten developed very rapidly, which helped trade in marine animals [14,15].

"In Bangladesh, marine pollution is classified into two types: land-based and sea-based. Land-based sources of pollution include municipal garbage, industrial waste (including ship-breaking activities), and agricultural waste. Land-based marine pollution (LMP) has emerged as the leading source of pollution and contamination in the marine environment. According to the National Program of Action (NPA) for Land-based Marine Pollution Control in Bangladesh, all main rivers in Bangladesh discharge billions of tons of sediments into the BOB. The increasing rate of LMP degrades marine and coastal resources, undermining the country's economic development and impeding achievement of the 'Blue Economy or Blue Growth,' including the Sustainable Development Goals (SDG)"[16-18].

Bangladesh has excellent maritime resources. Despite the abundance of seawater, the most straightforward, about 15.31 per cent of modern fish production in America is supplied with the aid of the sea. More than 255 industrial corporation ports and nearly sixty-eight vessels operate within a closed coastal water belt, with the constant use of a flawed system to make several species diverse. Both commercial and manual vessels are considered one fishery of many species [19,20]. The leading role of authorities in the protection, conservation and biodiversity of marine and coastal ecosystems. As a result, Saint Martin Island and the Sundarbans, a well-known mangrove forest, have been declared a nature reserve and guarding fishery in addition to the biodiversity of the area. The government has also announced a marine reserve (covering an area of 698 square kilometres) and a marine

protected area (MPA) (surrounding 1738 sq. Km) in the Bay of Bengal to defend and preserve plant reproduction grounds and marine animals [20,21].

Recent rulings by international courts insured that Bangladesh's EEZ would be extended to cover an additional 118,813 km2 (MoFA, 2014). Because of this, Bangladesh's conception of the "Blue Economy" has developed, inspiring this coastal nation to investigate marine resources sustainably within maritime boundaries. Since Bangladesh's land-based resources are very constrained in relation to its enormous population, Bangladesh must go one step ahead through efficient maritime spatial design. The coastal and marine habitats are being harmed by human activities in the sea, including overfishing, harmful pollution, habitat destruction, and other effects. In order to maintain productivity, biological variety, and marine ecosystems, current oversight approaches are becoming less effective. The government has suggested marine protected areas as a way to prevent those repercussions and maintain the marine ecology. Aquaculture can be practiced within MPAs to the advantage of the MPAs. With a goal to safeguard marine biodiversity and increase production through the synergistic relationship between MPAs and aquaculture, the creation of new MPAs and the allocation of aquaculture on MPAs have emerged as issues [22-24].

In an initial effort to conserve marine biodiversity, the Bangladeshi government established a marine reserve MPA in 2000. Later, The Swatch of No Ground in the Bay of Bengal, a submerged canyon known as a hotspot for cetaceans, had been officially declared as a "marine protected area" in 2014. The declaration of the Nijhum Dwip Marine Reserve/ Marine Protected Area (MPA) was made on the 1,738 square kilometers area, with an average depth of 900 meters, located south of Dublar Char, through a circular imposed by the Ministry of Environment and Forestry on October 27 in accordance with the Wildlife (Conservation and Security) Act, 2012. This 3,188 square kilometer area has been designated as a protected area, and it is located offshore of the Nijhum Dwip National Park and at the mouth of the Padma-Jamuna-Meghna river system, the third largest river system in the world [25-27].

The creation of MPAs will guarantee habitat restoration, ecological harmony, spawning and nursing grounds for numerous species, and a limit on overfishing in the ocean. On the other side, prospective aquaculture within these MPAs could have a favorable impact on socioeconomic growth, nutritional demand fulfillment, poverty reduction, species restocking, and sustainable food security. By doing this, Bangladesh's blue economic growth will be maximized [28,29].

There's a collection of jobs'(every financially based on the 12 months of July 1-June 30) which is expected to be the last day of 2023. The goal is to increase the contribution of coastal and marine fishers to the economic sector, poverty reduction, and environmental equity. The proposed PDO (proposed development goal) is the primary function of decorating the management of coastal and marine and marine fisheries (world economic centre; Bangladesh Sustainable Coastal and Marine Fisheries (P161568) and the production of marine living resources in intensive coastal fisheries in a secure manner, by defined standards and targeted families with access to subsistence sports that are encouraged to be exported from fishing grounds [30-32].

2. MATERIALS AND METHODS

Data on fish contamination and ingestion were gathered through the use of the following search engines: Google Search, Science Direct, Research Gate online, Scopus, PubMed, SpringerLink, Web of Science, Wiley Online Library, and Springer Nature database. There are different research work has been found in Bangladesh perspsectives about coastal and marine pollution, microplastic problem on fisheries resources in different media.

The article is based on a survey of information gathered from articles, books, and government papers published in various formats. Policy papers, commissioned reports, negotiating documents, and regional and international instruments on marine pollution are analyzed in addition to reviewing secondary literature, primary legal sources, statutory instruments and subsidiary legislation, and marine environmental pollution in Bangladesh. Secondary data was also gathered through newspaper reports, which provided vital information regarding various environmental protection activities undertaken by the Bangladesh government and numerous NGOs. For this study, existing policy papers were evaluated, with occasional revisions considered, focused on land pollution, marine environmental protection, ecosystem

conservation, and marine resource development, among other things.

3. RESULTS AND DISCUSSION

Bangladesh has embraced 17 sustainable development goals (SDGs), which are closely linked to the growth of the blue economy, in light of the great potential. Marine fisheries is one of the most promising sectors of the 26 sectors the nation has identified to use its marine resources. The idea of the "blue economy" has been welcomed by the Bangladeshi government and to further this notion, an inter-ministerial coordination unit known as the "blue economy cell" has been established Any production sector's planning and development must take into account the most recent data regarding resources, prospects, conditions, and issues. When there is insufficient information, the developmental program's implementation frequently fails.

To achieve the sustainable conservation of marine resource, some of newly proposed Marine Protected Areas (MPA) are designed to be declared and take action within 2025 and then following to 2030 for further extended target. In 2025, the current MPAs are proposed to be reach at least 7.5% of the total area. Hence, the SoNG MPA has been proposed to expansion its range by merging the adjacent geological research site from 1789 to 2390 sq. km as it is providing significance habitat for cetaceans and marine turtle. Basis on the ecological degredation in the Moheshkhali island and Saint Martin's Island, these two area are also proposed to declare as MPAs. Kutubdia and Swandip Island's adjacent coast is likely to over exploitation and IUU fishing [33,34]. Following the trend within 2030, further expansion of the MPAs are aimed to reach at least 10% of total areas. It includes the further expansion of SoNG and Saint Martin's MPAs . The following Table-1 expresses the spatial scenario of current and proposed new MPAs within 2030. 4.73% of Bangladesh's total land is currently covered by 5624 sq. km of MPAs. The proposed total preserved area in 2025 is up to 8,992 sq. km, or 7.54% of the total maritime area. Accordingly, MPAs will cover up to 12,092 sq. km of territory by 2030, or more than 10% (10.17%) (Table 1). As of the Aichi biodiversity target-11, current MPAs will cover at least 10% of all marine territory.

The Bay of Bengal, with its extensive coastal communities and diversity, is currently being subjected to many anthropogenic pollution [35]. Heavy metal pollution in our coastal water bodies has come from the rapid rise of industry, posing a serious environmental risk to invertebrates, fish, and humans. Coastal areas are the most polluted areas on the planet. Bangladesh's shoreline is known as a zone of many vulnerabilities due to various forms of pollution that have rendered the entire coastline and marine environment vulnerable. Ships, industrial effluents, sewerage discharge, untreated effluents, e-waste, and open dumping are the main sources of marine and coastal pollution [36, 37].

Sarker et al. [38] determined t"he concentrations of selected heavy metals such as chromium (Cr), copper (Cu), zinc (Zn), arsenic (As), lead (Pb), and cadmium (Cd) as well as the potential human health risk from 9 popular freshwater native edible fishes (*Anabas testudineus, Channa punctatus, Gagata youssoufi, Heteropneustes fossilis, Mastacembelus armatus, Mystus tengara, Ompok pabda, Puntius ticto and Xenentodon cancila*) from Meghna river of Bangladesh during 2019. They found that all heavy elements were higher than the permitted levels set by national and international organizations". However, continuous exposure to heavy metals may pose a risk to people of all ages, particularly children. Furthermore, the measured heavy metals concentration in the selected locations was lower tn in the river's neighboring urban and estuary areas. To interpret the effect of health risk, estimated daily intake, target hazard quotient (THQ), and carcinogenic risk (CR) were calculated. The THQ values were 1, indicating that neither children nor adults were at risk. Furthermore, the CR value for youngsters was 104, whilst the quantity for adults was usually less than 104, indicating that there were no significant negative effects on the consumers. However, continuous exposure to heavy metals may pose a risk to people of all ages, particularly children.

Rahman et al. [39] assess "the heavy metals contamination in selected 5 marine fish species from Kutubdia channel of Nothern Bay of Bengal and their impact on human health. The selected 5 commercially marine fish species (Sillaginopsis panijus, Trichiurus lepturus,

Table 1. Different MPA and their status in Bangladesh

Status of the MPAs	Names of the MPAs	Area of the MPAs
Currently Existing MPAs	1. The marine reserve MPA (designated in 2000)	698 sq. km
	2. Swatch-of-No-Ground MPA (designated in 2014)	1738 sq. km
	3.Nijhum Dwip MPA (designated in 2019)	3,188 sq. km
	Sub-total = 5,624 sq. km	
Proposed new MPAs within 2025	1. Saint Martin's Island MPA	518 sq. km
	2. Moheshkhali Island MPA	354 sq. km
	3. Kutubdia Island MPA	552 sq. km
	4. Swandip MPA	1292 sq. km
	5. Expanded SoNG MPA	2390 sq. km
	Cumulative subtotal (including previous MPA) = 8,992 sq. km	
Proposed new MPAs within 2030	1. Expanded Saint Martin's Island MPA	1096 sq. km
	2. Expanded Moheshkhali Island MPA	1142 sq. km
	3. Further expansion of SoNG MPA	4124 sq. km
	Cumulative subtotal (including previous MPA) = 12,092 sq. km	

Harpadon nehereus, Rita rita, and Coilia dussumieri) were collected throughout the pre- and post monsoon during 2018. They found that The target hazard quotient (THQ) values out of limit than normal ranges and all the trace metal values (Fe, Cr, Cu, Al, Mn) are higher than normal ranges. The values indicated that all the fishes have cancer riskes wher taken by the consumers".

Wang et al. [40] studied "five heavy metals, chromium (Cr), copper (Cu), nickel (Ni), lead (Pb), and zinc (Zn), were studied in surface and core sediments of the Karnaphuli River (KR) estuary in Chittagong, Bangladesh, to reveal the history of heavy metal contamination and its response to catastrophic events and human activities. The surface sediment was primarily consisted of silt and sand, and it was contaminated with Cr and Pb. Because of the fast physical growth of urban and industrial regions in Chittagong, anthropogenic heavy metal inputs have surged. In general, the accumulation pattern of heavy metals in sediments after normalization to Aluminum suggested a faster pace of urbanization and industrialization in the last 30 years and creating the problem of reproductive behavior of fishes of Karnaphuli river".

Hossain et al. [41] found that "trace metals accumulation in 15 commercially important fish species from coastal areas are above the permissible level of fish consumtion according the acceptable limit of WHO and FAO. Furthermore, carnivorous, benthic, and euryhaline species were the largest metal accumulators in that area, demonstrating the influence of habitat preferences and bio-magnification of metals through the food cycle".

Rakib et al. [42] explore "the heavy metal concentration on dried fishes (*H. neherius, T. lepturu, P.chinensis, P. affinis, A. mola, P. microdon, I. megaloptera, C. dussumieri, L. calcarifer, and G. chapra*) were analyzed for Cr, Mn, Fe, Co, Cu, Zn, Se, Rb, Hg, Pb, Ni and As from the coastal areas of Bangladesh. They found that all fish species showed moderate to high pollution, where the species *H. Neherius* and *P. Chinensis* are the most and least polluted ones, respectively. They showed that carcinogenic risk from dried fish samples found values lower than the acceptable limit for cancer risks (10–6 to 10–4)".

Shipbreaking activities in Chittagong coastal area creating heavy metals pollution in water and sediments in the coastal environment and impacts on aquatic biodiversity. Barua et al. [43] found that 30 fish species now unavailable in the coastal area of Chittagong due to increasing rates of heavy metals abundance in sediments over the 43 years (1975 to 218). The finding also indicated same result for heavy metals accumulation study on water and sediments and its impact on biodiversity due to ship breaking activities in Bangladesh [44,45]. Besides, there are various studies conducted about the heavy metal concentration in the water bodies of the different estuarine rivers of Bangladesh and international countries, which are shown in Table 2.

3.1 Microplastic Accumulation

The Bay of Bengal is today known to be one of the world's most polluted sea by the influence of urban and industrial wastes [81]. In 2017, according to ESDO, 6628.46 billion of microbeads from Dhaka, 1087.18 billion of

microbeads from Chittagong and 212.38 billion of microbeads from Sylhet city are derelict into the water bodies monthly [82,83]. A recent study exposed that, developing economies are the where the position of Bangladesh is in number 10 on the list. Total annual waste generation was mainly determined by population size, therefore the large populations of the 'leading countries' on the list [84,85]. Another study calculated that between 1.15 and 2.41 million tons of plastic waste flows from rivers into the ocean annually, similarly the main drivers were population density, mismanaged plastic waste and most polluting. The study also showed that 83% of the 4.8–12.7 million tons of land-based plastic waste that ends up in the ocean from the 192 coastal countries originates from 20 countries production per country. Whereas, not only plastic waste inputs from land into the ocean in a separated area, but also it can be carried by the oceans across transboundary coastal border and river channels like Ganges from India in Bangladesh. Hence, there is need to supervise and to be documented about the response of the organisms after adopting microplastic [86].

Table 2. Metal concentration(mg/kg) in the estuarine rivers of Bangladesh and international countries

Location	As	Cr	Cd	Pb	Country	References
National						
Rupsha River	5.18	43.2	1.8	29.21	Bangladesh	Hossain et al. (46)
Bhairab River	3.68	31.74	1.44	23.82	Bangladesh	Islam et al. (47)
Kutubdia Channel	9.0	11.0	—	22.0	Bangladesh	Jiang et al. (48)
Feni River Estuary	0.85	35.28	—	6.47	Bangladesh	Karim and Uddin (49)
Pasur River	3.15–19.9	20.67–83.7	0.39–3.17	7.34–55.32	Bangladesh	Karim (50)
Karnaphuli River	81.09	20.3	—	43.69	Bangladesh	Le Gouvello et al. (51)
Karnaphuli River	—	0.76	0.24	4.96	Bangladesh	Lindahl (52)
Karnaphuli River	—	28.17	—	15.49	Bangladesh	Massa et al. (53)
Karnaphuli River coast	—	-	0.43	26.7	Bangladesh	Petersen et al. (54)
Passur river	—	2.80–31.90	0.80–2.70	5.33–18.42	Bangladesh	Pomeroy (55)
Matamuhuri River	—	—	—	26.42	Bangladesh	Radulovich et al. (56)
Moheshkhali River	—	—	—	49.22	Bangladesh	Rice (57)
Bakkhali River	—	—	—	3.12	Bangladesh	Sanchez-Jerez et al. (58)
Sandwip Channel	10.65	50	8	60	Bangladesh	Searchinger et al. (59)
International						
Yangtze River Estuary	—	34.4	0.13	25.8	China	Sharifuzzaman et al. (60)
Yangtze River Estuary	—	69.5–103	0.037–0.212	13.7–23	China	Subrahmanyam et al. (61)
Kallar Estuary	7.30	10.12	3.61	29.11	India	Todinanahary et al. (62)
Korampallam Creek	5.06	26.85	5.29	67.38	India	Troell et al. (63)
Punnakayal Estuary	5.69	9.34	10.40	28.13	India	Wu et al. (64)
Ennmore coast	—	148.6–243.2	4.6–7.5	24.9–40	India	Yang et al. (65)
Vellar estuary	—	38	7	6	India	Chakraborty (66)
Pichavaram	—	141.2	6.60	11.2	India	Chowdhury et

Location	As	Cr	Cd	Pb	Country	References
mangrove						al. (67)
Coleroon Estuary	—	49.6	8.60	4.60	India	Çoban and Olmez (68)
Boston Harbor	—	231.5	—	135	United States	Dhar et al. (69)
Hooghly river estuary	12.50	250.50	5.80	150	India	Habib and Islam (70)
Matla river estuary	15.50	245	6.50	180	India	Hassaan and Shaikh (71)
Tokyo Bay	—	77.3	0.996	50.68	Japan	Hoq (72)
World Average		100		150		Hoq et al. (73)
Average Shale	13	90		20		Hoq et al. (74)
Water Quality Guidelines (Effect range Low)	8.2	81		47		Barua et al (75)
Water Quality Guidelines (Effect range medium)	70	370		220		Hoque et al. (76)
Guideline						
USEPA (2006)	6	26	—	31		Hossain (77)
USEPA (1999)	—	25	0.6	40		Hossain et al. (78)
WHO (2004)	—	25	6	—		Islam (79)
Ayers and Westcot. (1985)	—	0.1	—	5		Islam et al. (80)

While many studies have now proven the abundance of microplastic pollution in the world's oceans, far less research has been done on their presence or impacts in water ecosystems. We know now that plastic pieces are reaching remote and unexpected parts of the planet and it is critical to understand the role that all types of water body are playing in this equation [87,88]. As a result, it is the goal of this exploratory quantitative study to build on the findings microplastic studies by investigating the abundance and types of microplastic pollution in the Bay of Bengal coast in Bangladesh. The results may also provide a clearer picture of how plastic concentrations differ spatially between different locations.

Hossain et al. [89] investigated the microplastic abundance in commercial important fishes like Bombay-duck (*Harpadon nehereus*), white Bombay-duck (*H. translucens*) and gold-stripe sardine (*Sardinella gibbosa*) collected from the Northern Bay of Bengal at Bangladesh. They found the 443 microplastic items were found in the intestines of *H. Nehereus*, *H. translucens* and *S. gibbosa*, averaging in the range of 3.20–8.72 items per species. Their finding explored that increasing pattern of microplastics in marine fish might be a major danger to public health via the food chain. Hossain et al. [90] explored the contamination of microplastic in Peaneid shrimp (*Metapenaeus monocerous, Penaeus monodon*) of the Northern Bay of Bengal, Bangladesh. There are 35 and 45 micropalstics items were explored in the shrimp species. The finding indicated potential risk of food safety to the people of Bangladesh for obtained shimp species as delicious food.

This is reality that the fish Hilsa shad (*Tenualosa ilisha*) is major commercial and national fish of Bangladesh providing nearly 13% of the national total fish production. Siddiquee et al. [91] investigated the microplastics in a national fish, Hilsa shad (*Tenualosa ilisha*) from the Bay of Bengal, Bangladesh. Total 287 number of microplastic samples were identified from the gastrointestinal tracts. All the fishes analyzed were contaminated with MPs and indicated the threat of safe food security and nutrition level for the consumers of coastal communities of Bangladesh. Microplastics enter the Bay of Bengal via three major river systems, which transport pollution from hundreds of rivers in Bangladesh and neighboring nations. These plastics are also introduced by the breakdown of lost at sea fishing lines and nets, which are carried to shallow coastal waters by ocean currents. Plastic garbage improperly disposed of in the popular tourist beaches of Cox's Bazar and Kuakata also contributes to pollution in the Bay of Bengal. Jabed et al. [92] detected

microplastics in dried Bombay duck and ribbon fish from 2 coastal region of Bangladesh is really alarming which becoming potentially hazardous microplastics to enter human systems and accumulate in organs.

3.2 Maritime Fisheries Resource Conservation and Management

The government has undertaken projects to expand the vision of the green economy, and Bangladesh has been selected as an initiative to launch the development of green financial instruments in 2014. Modern-day control and evaluation to address the Sustainable Development Goals (SDGs) 14th cause: protection and sustainability of seas, oceans and marine assets for sustainable development aimed at 2020. Correctly handling harvesting and stopping overfishing, unlawful, unreported and out of control fishing practices and dangerous fishing practices and impacting technology-based management structures on fish processing inside the shortest possible time, at least to the quantity that would make the Harvest more sustainable as determined by the source in their natural traits.

The government assumes a lot of responsibility to manage those sectors using the resources of its representatives, especially the Department of fisheries. Nevertheless, several institutions are concerned about developing and managing fisheries in Bangladesh. The MoFL is the main control agency, accountable for drafting, formatting, and imposing fishing tips and recommendations. FL leads one-of-a-kind institutions, including the Department of Fisheries (DoF), which has been concerned with sports-related to expansion, deception, exploitation, training and development of useful human resources, law enforcement and tips, environmental conservation, good governance, control, registration and certificates, fishing licenses, reputation building and promotions, an insurance component manual, and management [93,94]. Bangladesh Fisheries Development Education. Finally, the Department of Fisheries and Cattle Statistics (FLID) has been conducting a campaign to distribute statistics on Fisheries and Cattle. Work of Bangladesh Delta Plan 2100. The Bangladesh Fisheries Development Corporation (BFDC) has been actively involved in marketing, manufacturing, education, etc. In addition, Bangladesh Fisheries Research Institute (BFRI) is actively engaged in fisheries research and related species education. A new amendment to the fish and fish product present coding inspiration was amended on 21 December 2017.

3.3 Policy Regarding Marine Fisheries Management and Pollution Control

The Bangladesh Environment Conservation (BEC) Act, 1995 (amended 2010), was approved by the country government, and it was followed by the Bangladesh Environment Conservation (BEC) Rules, 1997, which is the main umbrella of environmental legislation to prevent overall pollution. The 1995 BEC Act calls for the improvement of environmental standards, the sustainability of environmental conservation, and the mitigation and control of environmental pollution. The draft of the '2004 Marine Environmental Conservation Act' is primarily aimed at conserving the marine environment and preventing marine pollution in Bangladesh by putting MARPOL 73/78 into effect in Bangladesh8. The draft act also directs the government to implement seven other international conventions concerning the marine environment. As a result, the draft will not give these conventions effect. This is a good way to avoid the time-consuming process of ratifying these important conventions in Bangladesh. The Coastal Zone Policy 2005 and the Coastal Development Strategy 2006 are also important legal-based instruments for the development and management of Bangladesh's coastal zone, but these policies have some shortcomings in terms of controlling marine and coastal pollution [95,96].

Besides, there are some rules and strategies in Bangladesh for marine fisheries conservation and management which are as follows:

a) The Fish and Fish Product (Inspection and Quality Control) Ordinance, 1983

b) The Marine Fisheries Ordinance, 1983

c) The Marine Fisheries Rules, 1983

d) The Fish and Fish Product (Inspection and quality control) Rules, 1997 (amended in 2008, 2014 & 2017)

e) The Fish Hatchery Act, 2010

g) The Fish Hatchery Rules, 2011

In addition to the regulations, the following policies and guidelines are also in place for official control of fish products-

1. National Fisheries Policy-1998
2. National Residue Control Plan Policy Guidelines, 2011 (amended in 2012)
3. National Shrimp Policy, 2014
4. Fish and Fishery Products Official Control Protocol, 2015
5. Guidelines for the Control of Aquaculture Medicinal Products-AMPs, 2015
6. Manual on Good Aquaculture Practice-Trainer Manual
7. Compliance Guidelines for Fish Feed Production, Import & Marketing
8. Guidebook on Waste Management in Fish and Fishery Industries
9. Good Aquaculture Practice – A Farmer's Guide
10. Compliance Guidelines for Shrimp Hatchery
11. ISO/IEC 17025:2005 General Requirements for Competence of Testing Laboratory Enacting Acts, Rules and Policies.
12. Marine fisheries sector is governed by the Marine Fisheries Ordinance, 1983, Marine Fisheries Rules, 1983.
13. All industrial trawlers and mechanized fishing boats must have a license for fishing.
14. Industrial fishing trawlers must take sailing permission (SP) from Marine Fisheries Office under the Department of fisheries (DoF).
15. Trawlers can catch fish/shrimp in an area of not shallower than 40 meters depth. Mechanized fishing boats are allowed to fish below 40 meters in depth.
16. The Fish and Fishery Products (Fish Inspection and Quality Control) Rules,
17. 1997 provides guidelines for the production of safe seafood in trawlers.
18. Currently, 63 freezing trawlers have been licensed by the Fish Inspection and Quality Control Office as their factory vessel complied with sanitary and hygienic standards.

3.4 Adaptive Management based Fisheries Strategy

The Bangladesh government has taken initiatives to regulate the fishery primarily due to climate change. The fishery is said to be pushed by weather change, which incorporates loss of habitat, rotation, ailment outbreaks, restrictions on migration and copy routes, and declining fishery production. Ministry of Environment and Forests (MoEF) with a technical guide from IUCN Bangladesh USA workplace. 2009. For this reason, they have now installed another large Rustic Climate Fund, which was initially valued at 45 million USD and was later raised to 100 million USD, with a strong focus on different weather effects. They closed the fishing grounds because of the fundamental truth of Bangladesh's climate change system and movement system. The fishing industry has developed appropriate methods to maintain normal yields and widespread habitat in fishing communities. As well they have decided on fishery management strategies to capture fisheries based on appropriate flexibility, the popularity of the strategies used and the development of operational talent. single version strategies are used for areas such as aquaculture development and biodiversity management and biodiversity conservation to improve the fishery [96-98] development and expansion of fully community-based water resources. The framework uses a framework for rivers, canals, floodplains, valleys and lakes, to improve and re-dig connecting drainage ditches where it is necessary to keep the water intact with flow, improve water pressure in our bodies, and ensure that it is uninterrupted passage of fish.(BanDuDeltAS. Fisheries. Bangladesh Delta Plan 2100 formulation mission).

3.4.1 Significance of coastal blue carbons

According to a study, the ocean offers excellent potential to support global efforts to reduce greenhouse gas emissions and improve climate resilience. Mangroves and seagrass are examples of blue carbon ecosystems (BCE) that have the potential to store ten times more carbon annually per hectare than terrestrial ecosystems [99,100]. Ocean-based mitigation strategies could reduce global greenhouse gas (GHG) emissions by more than 4 billion tonnes of carbon dioxide equivalent (CO_2e) annually in 2030 and by more than 11 billion tonnes annually in 2050 compared to predicted emissions under business as usual (BAU). These reductions exceed the emissions from all coal-fired power plants currently in operation worldwide [101,102]. For their economic well-being, more than 3 billion people rely on the fisheries and tourism that the oceans provide [103,104]. Nevertheless, as the World Meteorological Organization's State of the Global Climate report dated May 18, 2022,

confirmed, greenhouse gas concentrations, sea levels, ocean temperatures, and acidity all reached new highs in 2021. These affect how resilient marine and coastal ecosystems are on a social and economic level. Currently, coastal flooding threatens over 250 million people [105,106]. Additionally, the cost of climate change impacts on fisheries and marine tourism could reach US$146 billion year by 2050. For sustainable marine and coastal management, an integrated vision of ecological preservation, economic activity, and equal prosperity is required [107]. There are several opportunities for ocean-based climate action, which also has more comprehensive socioeconomic benefits. One is altering one's diet to include low-carbon and sustainably derived forms of ocean-based protein. The protection, rehabilitation, and preservation of marine and coastal habitats are among the others. By 2030, coastal and marine ecosystem conservation and restoration have the potential to reduce CO2 emissions by 0.32 to 0.89 GtCO2e annually [108]. Every dollar spent on mangrove conservation and restoration initiatives returns benefits to the environment, the economy, and society (Konar & Ding, 2020). There is the potential to further reduce emissions by 0.34 to 0.94 GtCO2e through the production of foods derived from the ocean and dietary changes toward sustainably produced and low-carbon ocean-based proteins. 2019 (Hoegh-Guldberg and associates) Gains from boosting ocean-based protein production sustainably can reach $10 for every $1 invested (Konar & Ding, 2020). Less than 17% of land and 8% of the ocean are protected globally compared to the Aichi Biodiversity Target 11, which was endorsed by many countries [108].

Additionally, there still needs to be efforts to create marine protected areas (MPAs) to protect BCE, marine, and coastal habitats. Even though the level of actual protection these areas provide varies, now 42% of the remaining mangroves are found within these officially declared protected zones These ecosystems can thrive if at least 30% of biologically relevant maritime and coastal areas are conserved [107, 108]. While marine reserves cannot resolve all of the ocean's issues, they provide exceptional ecological and economic advantages both within and outside their boundaries. Blue carbon habitats are highly valued in many coastal cities because of their many benefits. The advantages of mangroves are illustrated in the following graphics: Blue carbon ecosystems provide healthy fisheries, shoreline protection, employment generation, and enhanced water quality in addition to helping to store carbon. Mangroves serve as natural barriers that protect shorelines and absorb wave energy to lessen the risk of floods that storm surge. Seagrass meadows promote light attenuation, enhanced water quality, and other benefits while reducing erosion by storing suspended sediments in their roots. By absorbing pollutants, including heavy metals, fertilizers, and suspended particles, coastal wetlands contribute to maintaining water quality and preventing eutrophication. These ecosystems provide habitat for essential fisheries, breeding grounds, nursery areas, and various recreational activities (e.g.,snorkeling, fishing, boating, and ecotourism). Blue carbon helps the environment store carbon and enhances water quality, supports healthy fisheries, safeguards coasts, and boosts the local economy by generating jobs [107].

3.4.2 Knowledge gaps

Although research different projects and, initiatives are taken nationally and globally, there are a lot of knowledge gaps to promote blue carbon. The following key knowledge gaps are summarized below;

3.4.3 Blue carbon management and global initiatives

By preserving and regenerating blue carbon ecosystems, nations are attempting to lower their greenhouse gas (GHG) emissions and contribute to the mitigation and adaptation to climate change. Over the past ten years, progress has been achieved in encouraging the inclusion of blue carbon ecosystems in national and subnational strategies. The Paris Agreement allows for the inclusion of mitigation and adaptation measures in each nation's nationally determined contribution (NDCs). An examination of the 163 submitted NDCs revealed that 59 nations include coastal ecosystems and the coastal zone in their adaptation strategies, and 28 countries mention coastal wetlands in mitigation. Several methods are provided by the United Nations Framework Convention on Climate Change (UNFCCC) for nations to submit their planned responses to climate change and their advancements in doing so. Countries may also incorporate blue carbon ecosystems in their National Adaptation Plans (NAPs), National and Nationally Appropriate Mitigation Actions (NAMAs) in addition to the NDCs (NAMAs).

Table 3. Summary of key knowledge gaps

A. Geographical extent	While mangroves are fairly well mapped, large areas containing seagrass meadows remain largely unsurveyed, (e.g., Southeast Asia, eastern and western South America and the west coast of Africa). Similarly, the global extent of tidal salt marsh and rates of marsh and seagrass meadow loss are currently undocumented.
B. Sequestration and storage	Limited data are available in the scientific literature on the carbon sequestration and storage rates of blue carbon ecosystems in Africa, South America, and Southeast Asia.
C. Emissions and removals	Additional mapping of converted, and degraded and revegetated blue carbon ecosystems and the quantification of emissions from exposed organic soils, and from disturbed or degraded seagrass meadows as well as quantification of removals to restored coastal ecosystems, is needed to enable inclusion in relevant databases (e.g., the IPCC Emission Factor Database).
D. Human drivers	Emission rates associated with specific human activities over time for various drivers of ecosystem degradation, or loss (e.g., drainage, burning, harvesting, or clearing of vegetation at different intensity levels) are limited at the moment, especially for seagrasses. Removal rates to restored coastal ecosystems are also currently lacking
E. Coastal Erosion	A significant amount of eroded coastal carbon is thought to be dissolved in the ocean water where it enters the ocean-atmosphere system. The remaining eroded carbon is deposited in offshore sediments and sequestered. The fate of carbon eroded from blue carbon ecosystems is an ongoing topic of scientific research.

Blue carbon ecosystems must be included in official GHG inventories submitted by nations under the UNFCCC to generate practical policy and management solutions and deliver accurate data into national and global greenhouse gas accounts. Incorporating coastal wetlands into national carbon inventories is a significant potential for nations (for guidance, see the IPCC 2013 Wetlands Supplement, which provides GHG accounting methodologies for inland and coastal wetlands and supports the inclusion of emissions and removals from these ecosystems in national GHG inventories). The mitigation potential of blue carbon ecosystems will be considered when evaluating global progress toward reaching the objectives of the Paris Agreement through the Global Stocktake process by incorporating these habitats in national inventories. If a government considers mangroves to be forests, mangrove conservation and restoration efforts can be included in REDD+ and LULUCF activities, two UNFCCC forest mechanisms. Soil carbon will also be considered in the REDD+ or LULUCF accounting procedures where soils are a substantial source or sink as determined by IPCC fundamental category analysis, such as in mangrove forests. The new window provides access to worldwide mangrove blue carbon data, made available by Global Mangrove Watch, and can be used to report in these two ways. Developing nations have the opportunity to carry out climate mitigation projects that also have a focus on social benefits through NAMAs (Nationally Appropriate Mitigation Actions). Blue carbon initiatives in land-use change, conservation, and restoration activities in coastal environments are included in NAMAs. Coastal wetland ecosystems have a lot of social and economic benefits that make them a good fit for this list.To address the urgent and immediate needs of least-developed countries (LDCs) to adapt to climate change, national adaptation programs for action (NAPAs) are provided. The development and implementation of policies and programs to meet medium- and long-term adaptation needs are made possible by national adaptation plans (NAPs), which parties can use to identify those needs. Many parties have already considered coastal wetlands in their NAPs and NAPAs. Adding blue carbon opens a new window to national initiatives to mitigate climate change, including: Conduct national carbon assessments and evaluations of blue carbon ecosystems' ecological and socioeconomic conditions.

- Conduct a nationwide cost-benefit analysis and incorporate blue carbon into national policies for reducing climate change.
- Identify the advantages of carbon-related investments and activities in coastal areas.
- Enhance technological, policy, and institutional capabilities for emissions from blue carbon sinks and reservoirs and removal of those emissions
- Engage in community outreach initiatives
- Seagrasses are now excluded from any reporting, accounting, or NDC framework, which is one of the current problems of integrating blue carbon ecosystems into national policy.

Another challenge is the incomplete carbon stock data, emissions, and removal. However, with assistance from organizations like the opens in a separate window Blue Carbon Initiative and its website, Blue carbon ecosystems are being more thoroughly included in national policy thanks to the International Partnership for Blue Carbon.

4. CONCLUSIONS AND RECOMMENDA-TIONS

Some of the climatic concerns can be overcome by managing blue carbon ecosystems. The rate of open ocean sequestration caused by the biological and solubility pumps is expected to decrease due to climate change. Mangroves, salt marshes, and seagrass meadows should all be protected and restored as tools in the fight against climate change. Actors in the policy, advocacy, and especially scientific communities urgently need to support biodiversity conservation based on its merits rather than just considering it valuable for its potential to sequester carbon. Ocean-based approaches to climate change must be solid and trustworthy, offer numerous advantages at various scales, and show additionally.

This article makes recommendations for how these varied ocean ecosystems, when sustainably maintained across sectors, could support the mitigation plans and the preservation of carbon stocks. A transparent and reliable framework for operating such a market is necessary to secure funding from stakeholders who would profit from ecosystem services as well as from carbon credits. Despite the fact that "climate bandwagoning" frequently uses the justification of climate mitigation to justify political and economic action, it now needs to be translated into useful and quick-acting governance practices and policies, beginning with partnerships with the private sector as well as the broadening of the tax base. Local communities must be involved in the decision-making process for these conservation efforts to be successful since they will immediately benefit from the meaningful jobs and stable income that will assist secure ownership of these initiatives.

Al though International Organizations like The Blue Carbon Initiative, Blue Carbon Scientific Working Group, and International Blue Carbon Policy Working Group are doing research and necessary measures to restore coastal ecosystem to combat climate changes the following measures may be taken to get more benefits from Blue Carbon system and control land based pollution:

- Control Water and Air Pollution specially in the Marine Environment
- Control Pollution from Shipping Sectors
- Promote Marine Protected Area
- Promote Marine Spatial Planning System
- Protecting & restoring blue carbon ecosystems.
- Protecting coral reefs.
- Restore Tidal Salt Marshes and Wetlands
- Restore Mangrove Forest
- Restore Seagrasses
- National legal frameworks should be taken for restoring Coastal Ecosystem
- International legal frameworks should be taken for restoring Coastal Ecosystem
- International Data Sharing of Coastal Ecosystem should be promoted
- Long period and resilience project should be taken Globally for restoring Coastal Ecosystem
- Carbon Marketing or Carbon Financial System should be promoted Globally

The Bangladesh fishing industry has all the opportunities and challenges. Gambling has been a significant growth activity within the economic device over the past few decades and contributes significantly to the development of economic well-being, and deserves the potential for future development within Bangladesh's agricultural financial system. There may be a strong desire to recognize the capacity to change practical legal guidelines and procedures for the country's sustainable management and conservation of fishery resources. Fishers, suppliers, processors, buyers and consumers

alike should hold on to these topics so that they can be concerned with the procurement control systems and enjoy a complete system. But a lack of access to finance, there may be a growing financial gap between bad fishers, boat owners, and fishermen. Fisheries are the most vulnerable to poverty due to the high exposure to drug failure and economic shock. Control measures should include managing the depth of fishing, driving the gadget selection, category of equipment and duration of the fish season, closed start-up, deprived fishing ban, closed fishing area, and allocation of fishing resources including staff, funding, funding and so on. Following fisheries insurance, Bangladeshi authorities need to legislate the entire criminal system to properly manage and use their assets for sustainable development and the well-being of its people.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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