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REVIEW ARTICLE

Contribution and prospect of marine fisheries in the economy of Bangladesh and sustainable blue economy challenges: A review

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ABSTRACT

Marine resources of Bangladesh are abundant, both in terms of huge sea area and its biological richness. The marine water area supports a large number of commercially important fin fish, mollusks, crustaceans, and seaweeds, offering significant economic potential due to their diversified use and high demand in the international market. Therefore, the current review comprehensively examines both the contribution and potentials of marine fisheries resources to the economy, as well as the challenges involved in marine fisheries sectors in attaining a sustainable blue economy in Bangladesh. The study revealed that, the marine fisheries plays an important role in national economy and has huge prospect in employment generation and ensuring food security of Bangladesh. The expansion of mariculture and effective utilization of marine resources will open a new window for the economic development of Bangladesh. Marine fisheries production of Bangladesh has increased over the last two decades, but its relative share in total fisheries production has declined. Despite being rich in marine living resources, commercial mariculture has been developed only for shrimp, prawn, and mud crab. Challenges hindering mariculture expansion includes limited research, technological deficiencies, inadequate skilled workforce, underdeveloped domestic seafood markets, and financial constraints. Concerted efforts including exploring new fishing grounds, conducting stock assessments, implementing scientific management strategies, enacting a national marine fisheries policy, enforcing legislation, and establishing robust surveillance and monitoring mechanisms are required to foster a sustainable blue economy in Bangladesh.

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Introduction

Marine fisheries is an important sector for the economy of Bangladesh. As a leading fish producing country in the world, Bangladesh was positioned 14th among top 30 marine aquatic animal producers in 2021-22 (FAO, 2024). The contribution of the fisheries sector to the gross domestic product (GDP) of the country is 3.57% which is almost one-fourth (26.50%) of the agricultural GDP (DoF, 2022). More than 10 million coastal fishers directly depend on the fisheries sector for their livelihood (Hoque et al., 2021). The coastal and marine environment of Bangladesh is highly productive due to warm climate, heavy rainfall, and abundance of nutrient that supports diverse marine life (Hossain, 2001; Islam, 2003). A large part of the coastal area of Bangladesh is the habitat for commercially important finfish, shrimp, prawn, crab, and seaweed species (Ahmed & Glaser, 2016; AftabUddin et al., 2021). These resources support a vibrant fishing industry that ranges from small-scale artisanal fishing operations to larger commercial enterprises (Hoq et al., 2013). The coastal aquaculture (shrimp/prawn and crab culture) has become a multimillion-dollar industry in Bangladesh due to huge demand in global markets (& and Glaser, 2016). Expansion of mariculture, sustainable utilization of marine fisheries resources, and promotion of blue economy can open a new window for the economic growth of Bangladesh (Hussain et al., 2018).

Blue Economy is a popular term in modern marine and ocean governance (Voyer et al., 2018) however, it is a quite new and emerging concept in Bangladesh. It is a marine-based economic development that increases social and human well-being while preserving the health of the ocean ecosystem (Smith-Godfrey, 2016; Lee et al., 2020). The establishment of a blue economic transformation ensures food and energy security while safeguarding marine ecosystem (Çoban & Ölmez, 2017). The concept of the blue economy was first introduced by Professor Gunter Pauli in 1994 and earned global attention during the United Nations Conference on Sustainable Development held in Rio de Janeiro in 2012 (Roberts & Ali, 2016). Blue economy became an important issue in Bangladesh after the settlement of the maritime boundary with Myanmar and India in 2012 and 2014, respectively (Hussain et al., 2018; AftabUddin et al., 2021). The Blue Economy holds significant potential for boosting economic growth, employment opportunities, food security, and thereby contributing to human welfare (Sarker et al., 2018). It has been estimated that, it will be possible for Bangladesh to obtain 5% of its GDP from marine resources by 2030 (Rashid, 2014). The country has immense potential to be a developed country by 2041, if the expanded coastal and marine resources can properly be explored, extracted, and utilized (Mukit, 2019).

Considering the huge potential, Bangladesh has adopted 17 development goals known as sustainable development goals (SDGs), which have a direct relationship with the development of the blue economy (Bari, 2017). The country has identified 26 sectors to exploit the marine resources where marine fisheries is one of the most promising sectors (Alam, 2019). The government of Bangladesh has embraced the concept of the blue economy (Sarker et al., 2018) and an inter-ministry coordination unit called the "blue economy cell" has also been established to promote blue economy (Patil et al., 2018). Proper planning and development in any production sector need up to date information on available resources, prospect, current states, and problems. The implementation of the developmental program often turns out unsuccessful due to the lack of proper information.

There are studies focusing marine fisheries resources of Bangladesh (Sarkar et al., 2016; Shamsuzzaman et al., 2017a, 2017b; Chakraborty, 2018; Habib & Islam, 2020), their culture potentials (Hoq, 2016; Dhar et al., 2020; Lahiri et al., 2021; Mondal et al., 2021; Chakraborty, 2021; Chowdhury et al., 2022), and constrains of mariculture development (AftabUddin et al., 2021; Sarker et al., 2021) in Bangladesh. There are also studies emphasizing opportunities and limitations in utilizing ocean resources for blue economy development in Bangladesh (Hussain et al., 2017, 2018; Sarker et al., 2018). However, literature focusing contribution of marine fisheries resources as a component of the blue economy, its prospects, and sustainability challenges is still scanty. Therefore, this review aimed to figure out the contribution and prospects of marine fisheries resources in the economy of Bangladesh. This paper also focuses on the challenges involved in marine fisheries sectors in attaining a sustainable blue economy in Bangladesh.

Maritime Area and Marine Fisheries Resource Diversity in Bangladesh

After the settlement of the maritime boundary, Bangladesh now has sovereign rights over 118,813 square kilometers (equivalent to the land mass of Bangladesh) of waters extending up to 12 nautical miles of territorial sea and 200 nautical miles of exclusive economic zone (EEZ) into the Bay of Bengal (BoB) (Figure 1) (Hussain et al., 2017). It is the nursery and breeding ground of a diverse range of marine living organisms such as fishes, shrimps, mollusks, crustaceans, seaweeds, reptiles,

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amphibians, mammals etc. However, there are disagreement in number of existing species in published reports (Table 1). Very little is known about cephalopods (squid, octopus, and cuttle fish), marine mammals (dolphin and whales), and reptiles (turtles and crocodiles) of Bangladesh. In addition, 11 sharks, 24 rays, 3 sponges, 3 starfish's, 10 frogs, 24 snakes, 66 corals, and 3 species of otter have so far been recorded in marine water area of Bangladesh (IUCN, 2015; Sarker et al., 2019). Many of these species are commercially important and have export potential besides having high demand in the domestic market. A detail investigation on species diversity needs to carry out to update the number of different species present and to find out the relative abundance of each of those species in the marine environment of Bangladesh.

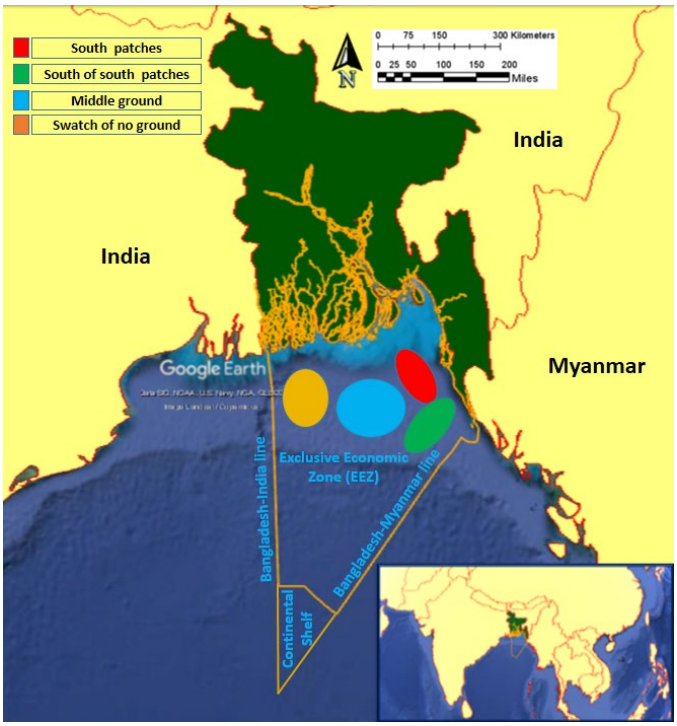

Figure 1. Maritime area of Bangladesh

Contribution of Marine Fisheries to Total Fish Production of Bangladesh

In spite of having a rich biodiversity and a large marine water area, the relative share of marine fisheries in total fish production is very low compared to inland fisheries production. The inland fisheries production of Bangladesh has increased more than double by the last two decades, but marine production has not tumid that much (Figure 2). In 2010-11, the total fish production of Bangladesh was 3261782 MT where inland (capture and culture) fisheries contributed 2683112 MT (82.26%) and marine fisheries from marine capture contributed 578620 (17.74%) MT (Shamsuzzaman et al., 2017a). After 10 years in 2020-21, the total fish production increased to 4621228 MT where the contribution of inland (capture and culture) fisheries was 3939989 (85.26%) MT and marine capture fisheries contributed 681239 (14.74 %) MT (DoF, 2022). Regardless the slow increase in production, the relative share of marine fisheries in total fisheries production has declined (from 17.74% to 14.74%) because no marine aquaculture is currently practiced in Bangladesh (Shamsuzzaman et al., 2017a) and marine fisheries production is completely dependent on marine capture. The reasons behind low marine capture production are lack of modern fishing knowledge and equipment, irrational harvesting of marine resources, inadequate information on pelagic stock, and high levels of capital required to exploit resources of the deep sea (Islam, 2003; Shamsuzzaman et al., 2017b).

Fin Fish

Hilsa (*Tenualosa ilisha*) is the dominant species captured from marine water area (Figure 3). Its production has increased from 339845 MT in 2010-11 to 565183 MT in 2020-21, contributing 46.03% of total marine capture production and 12.23% of total fish production of Bangladesh (DoF, 2022). The declaration of marine protected area (MPA), marine managed areas (MMA), marine reserves, fish sanctuaries, and ban on fishing during the reproduction period under the Protection and Conservation of Fish Act of 1950 has increased hilsa and other fish production in inland and marine water. However, illegal fishing due to lack of alternative income source and insufficient government compensation during the restricted season is undermining the success (Hoq et al., 2013; Talukdar et al., 2022). Despite the high potential for developing commercial mariculture industry in Bangladesh, no marine fin fishes are farmed (Shamsuzzaman et al., 2017a). Only the traditional culture of seabass (*Lates calcarifer*) and mullet (*Chelon subviridis*) is being reported on a small-scale basis in shrimp and prawn *ghers* (modified rice field) that are connected with coastal rivers. Seabass and mullet fry are stocked into the *ghers* collected from the wild or they enter into the *ghers* during water filling from river (Hoq et al., 2014; Chakraborty, 2021; Mondal et al., 2021). Domestication and export oriented commercial culture of high-valued marine finfish species in coastal ponds/enclosures and marine cages have high potential to boost up fish production of Bangladesh (AftabUddin et al., 2021).

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Table 1. Marine fisheries resources in Bangladesh

Category	Sarker et al. (2019)	IUCN (2015)	Rahman (2015)	Hoq et al. (2013)	Islam (2003)	Hossain (2001)
Fish	475	442	442	475	475	475
Shrimp	36	36	36	36	24	25
Crab	50	16	15	15	50	15
Lobster	5	3	3	5	-	5
Mollusk	301	336	336	400	301	301
Seaweed	165	168	168	-	22	56
Squid, octopus, and cuttle fish	9	-	-	7	7	-
Dolphin/whales	11	11	11	11	-	11
Turtles and tortoise	-	7	31	5	-	4
Crocodiles	-	3	3	1	-	1

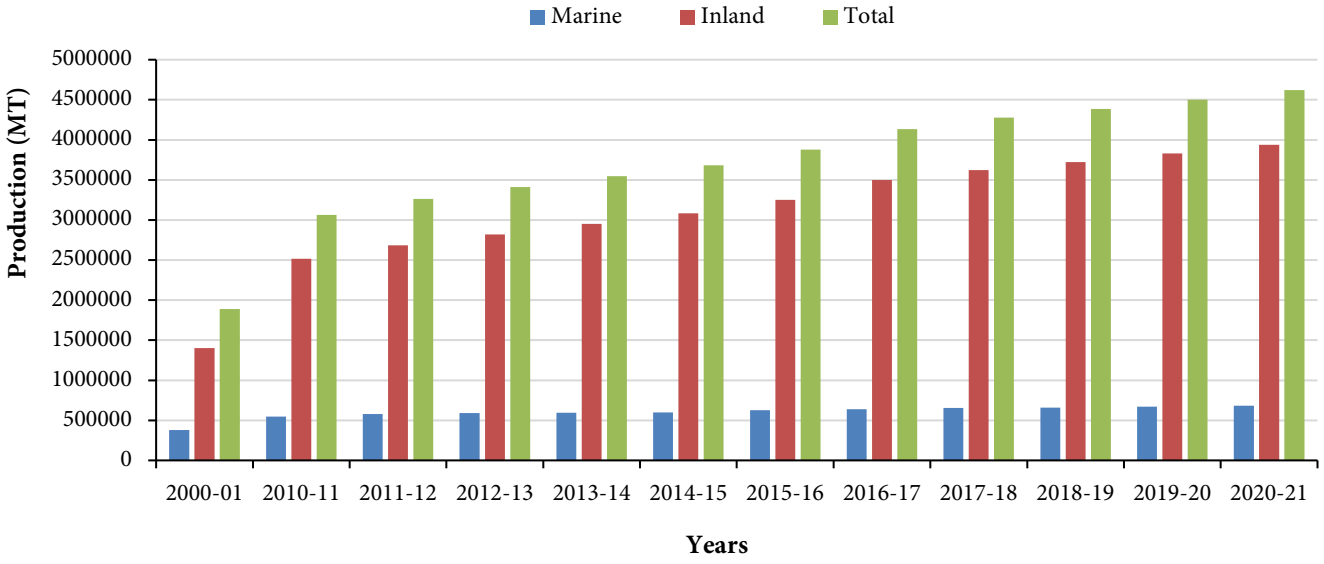

Figure 2. Inland and marine fisheries production in Bangladesh from 2000-01 to 2020-21 (Adapted from DoF (2018))

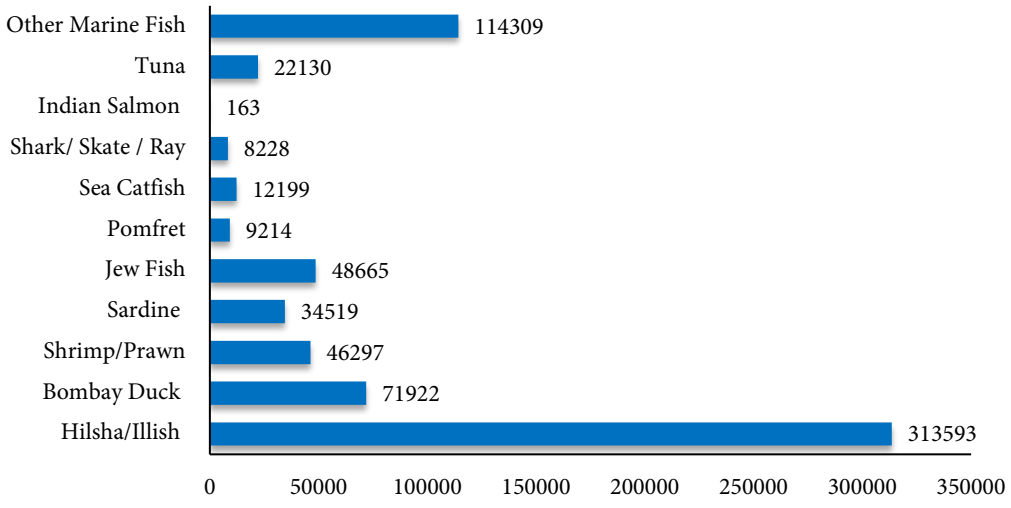

Figure 3. Species-wise annual capture (MT) in marine fisheries in 2020-21 (Adapted from DoF (2022))

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Crustaceans

Shrimp and prawn

Shrimps and prawn are captured from both inland and marine water bodies (rivers, ponds, beels, floodplains, and mangroves etc.); however, commercial culture of shrimp and prawn is only carried out in inland shrimp and prawn farms (*gher*) (Ahmed, 2013; Dhar et al., 2020). The coastal aquaculture of Bangladesh mainly refers to the culture of shrimp (*Penaeus monodon*) and prawn (*Macrobrachium rosenbergii*) (Shamsuzzaman et al., 2017a) and about half of the total production of shrimp and prawn comes from shrimp and prawn farms (Figure 4). The southwest region including Khulna, Satkhira, Bagerhat, and the southeast region including Noakhali, Chattagram, and Cox's bazar cover more than 95% of the shrimp and prawn farming areas of Bangladesh (Ahmed, 2013). Shrimp and prawn farming developed in these areas because of the availability of wild post-larvae and suitable biophysical resources like salinity and low-lying agricultural land (Ahmed, 2013; Dhar et al., 2020). The culture area has expanded in the last two decades from 141352 ha in 2000-01 to 263026 ha in 2020-21 (Figure 4). Many farmers converted their rice fields into *ghers*, because *gher* farming is more profitable than rice cultivation due to its multiple cropping systems (Islam et al., 2017a, 2017b). Moreover, shrimp and prawn have very high demand in national and international market. Country's total shrimp and prawn production has increased from 152520 MT in 2001-02 to 251964 MT in 2020-21; however, the average production of the shrimp farms is 1059 kg ha^{-1} which is still very low compared to Australia (4000 kg ha^{-1}), Thailand (3116 kg ha^{-1}) and Malaysia (1500 kg ha^{-1}) (Kumar et al., 2004; Rahman & Hossain, 2013). The adoption of intensive farming in 30-40% of farms and semi-intensive farming in 60-70% of farms boosted up the production in Australia and Thailand. Bangladesh also needs to introduce intensive culture system, advanced technologies, and proper management strategies to increase per unit yield in shrimp and prawn farms (Rahman & Hossain, 2013).

Frozen shrimp and prawn is the second largest export earning sector of Bangladesh (Karim et al., 2019). However, in the last couple of years export earnings from shrimp fell both in term of value and volume (Figure 5). Rahman (2019) reported that Bangladesh is falling behind in competition with *Vannamie* shrimp because of its low price and high productivity. Many Asian countries have started *Vannamei* culture; however, not yet been reported in Bangladesh. Moreover, the major importing countries are not satisfied with the quality control and food safety assurance of Bangladesh and imposing difficult conditions to enter into their market. Now, international trade is more regulated and Bangladesh needs to introduce hazards analysis critical control point (HACCP) and traceability to survive the high competition in the international market (Islam et al., 2017b; Rahman & Hossain, 2009).

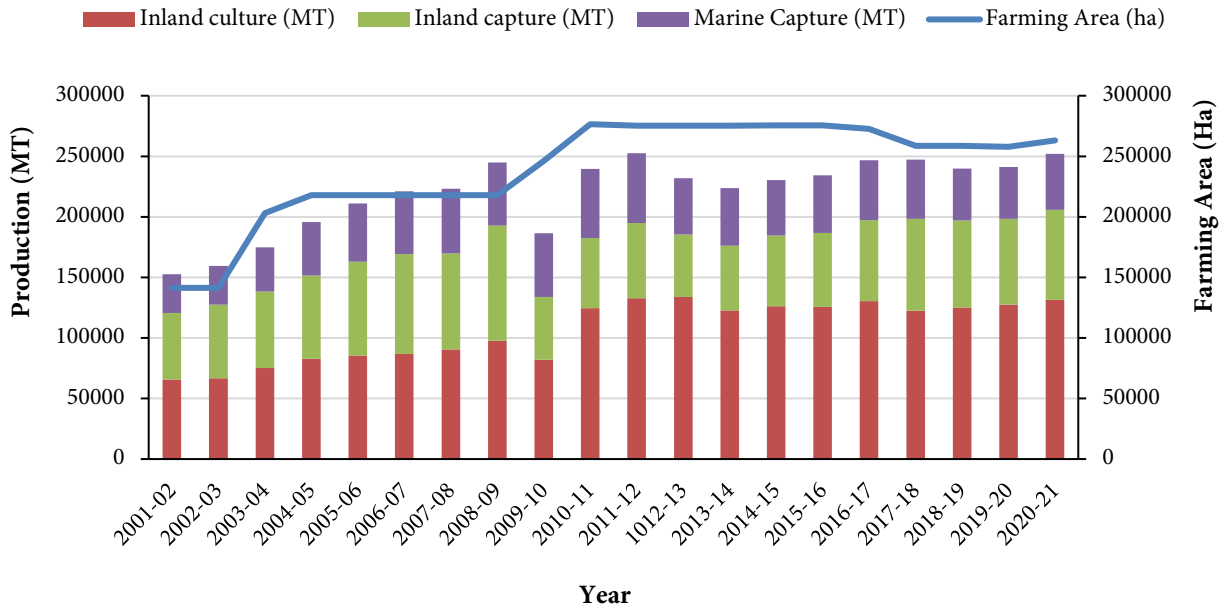

Figure 4. Farming area (Ha) and production (MT) trends of shrimp/prawn from 2001-02 to 2020-21 (Adapted from DoF (2022))

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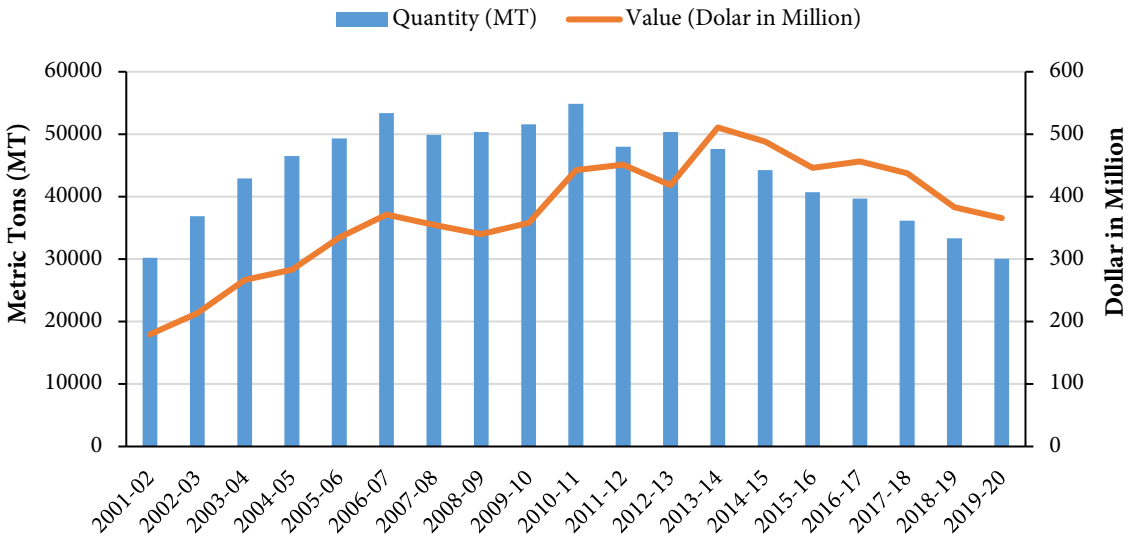

Figure 5. Export earning of frozen shrimp/prawn from 2001-02 to 2019-20 (Adapted from DoF (2020))

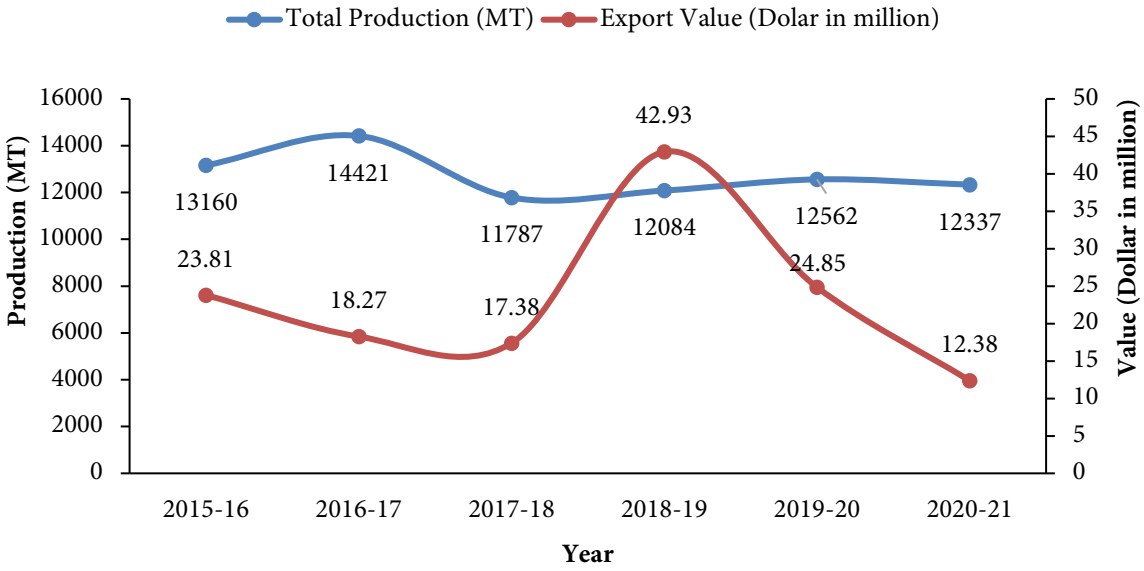

Figure 6. Annual production (MT) and export earnings (USD in million) from crab (Adapted from EPB (2022))

Crab

Crab is the second most important shellfish species in terms of the export earning in Bangladesh (Hoq et al., 2014). The availability of saline water with temperature condition promoted mud crab farming in the mangrove forests of the Sundarban area and coastal districts in Satkhira, Khulna, Bagerhat, and Cox's Bazar regions. Crab farming has bright prospects due to its low susceptibility to disease, high resistance to environmental conditions, and growing demand in the international market (AftabUddin et al., 2021). Crab species belonging to genera *Scylla*, *Portunus*, *Charybdis*, *Matuta*, *Varuna,* and *Sartorina* are available in the coastal and marine habitats of Bangladesh; however, the mud crab (*Scylla serrata*) is considered the most commercially important species (Rahman et al., 2020). Mud crab is the only species that is cultured in Bangladesh on a small scale. Mud crabs are collected from nature, shrimp farms, coastal pens, and cages. About 70% of mud crab for export comes from Khulna and the rest from Chottagram, Barishal, and Noakhali regions (Istiak, 2018). In Bangladesh, the total production of crab was 12337 MT and the total export value was USD 12.38 million in 2020-21 (Figure 6). Crabs are mainly exported to China, Thailand, the USA, the UK, Australia, Taiwan, Singapore, Hong Kong, Malaysia, and Europe in live and frozen conditions. Despite having huge economic importance due to small market structure, buyer-driven value chains, poor governance, and most importantly inadequate wild seed supply the crab industry is suddenly

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collapsing in Bangladesh (Lahiri et al., 2021). There is no commercial crab hatchery reported in Bangladesh and crab farming is completely dependent on wild stock (Ali et al., 2020). The indiscriminate collection of crab from natural sources is depleting the crab population in the wild (Chakraborty, 2018). Hatchery production of crablet, adoption of advanced culture technologies, introduction of value-added products, expansion of new markets, balance between local and global market, and good governance are possible options for developing a sustainable mud crab industry in Bangladesh (Lahiri et al., 2021).

Lobster

Lobster is a high-valued and popular seafood with an increasing global demand in Asia, Europe, and America. The hatchery technology is yet to be developed and almost the entire global lobster production is from capture fisheries. Recently, the sea cage culture of wild-caught lobster has been expanding in many parts of the world (Petersen & Phuong, 2010). Wild-caught juvenile lobsters are stocked in floating, suspended, and submerged cages and fed with fresh seafood (crabs, mollusks, and fish) (Jones et al., 2019). The total global production of lobster was 308664 ton in 2019 with an estimated value of USD 3920 million (FAO, 2021). Four species of lobster under the families Palinuridae known as spiny lobsters (*Panulirus homarus, P. ornatus, P. polyphagus* and *P. versicolor)* and two species of the family Scyllaridae known as slipper lobsters (*Thenus orientalis* and *Scyllarus depressus*) has so far been identified from Saint Martin's Island and other shallow rocky coastal areas of Bangladesh. Among them, spiny lobsters are the most popular and highly-priced crustacean in the domestic and international market (Ahmed et al., 2022a). The availability of naturally settling lobsters indicates that these areas are suitable for lobster grow-out. The commercial culture of lobster in Vietnam is successful with a production of 1600 tons of premium-grade lobster and the industry is valued at over USD 120 million (Jones et al., 2019). Bangladesh also has a huge prospect in farming lobster using wild collected seed from natural resources. The marine cage culture of lobster can significantly improve the livelihood and socio-economic position of the coastal people.

Seaweed

Seaweeds are marine autotrophic multi-cellular macroalgae that grow attaching to rock or other hard substrates down to the lower limit of the photic marine ecosystem (Sarker et al., 2021). Seaweeds are important due to their nutritive value, bioactive compounds, medicinal properties, pharmaceutical, and industrial uses for human welfare. Moreover, it has the potential to be used as an effective bio-fertilizer and source of renewable bioenergy (AftabUddin et al., 2021; Pradhan et al., 2022). In 2019, the global production of seaweed was 36 million tons (value of USD 14.85 billion) of which 97% was from mariculture and only 3% was from wild exploitation (Sarker et al., 2021). The coastline of BoB, Sundarban, and Saint Martin's Island was found suitable for seaweed culture (Hoq et al., 2013; Hoq, 2016; Sarkar et al., 2016). *Hypnea sp.* was found suitable to culture in Bakkhali River estuary, Inani Beach, and Saint Martin's Island in the winter season (Hoq, 2016). However, still no large-scale commercial culture of seaweed in marine water has been reported yet in Bangladesh. Local collectors collect seaweed from April to May and then exported to China, Myanmar, and Singapore (Ahmed & Taparhudee, 2005). According to Sarkar et al., (2016) about 5000 MT of seaweed biomass is naturally available from the coast of Bangladesh annually. The present production from natural habitat is still very low. Seaweed cultivation could be an alternative source of livelihood for coastal people (Ahmed & Taparhudee, 2005). However, existing seaweed farming is unplanned and farmers are facing problems due to environmental challenges (pollution, turbidity, heavy wave, bio-fouling) due to poor site selection, lack of seed supply and seaweed nursery, lack of technical and financial support for farming, harvesting and processing of seaweed, limited market, and weak supply chain (Ahmed et al., 2022b). A research and development (R&D) based roadmap is required to transform small-scale seaweed culture into a large-scale agribusiness industry. Zoning of seaweed farming areas, seed bank development for commercial seaweed species, integrated and intensive farming practice, value-added product development, post-harvest processing, and seaweed-based industry are the key to developing the seaweed industry in Bangladesh (Chowdhury et al., 2022).

Mollusk

Mollusk, a diverse group including bivalves (oysters, clams, and mussels), gatropods (snails and slugs), cephalopods (cuttlefishes, squids, and octopuses), etc. is available in the marine water of Bangladesh (Islam, 2003). Mollusk meat and shells are used for different purposes like human consumption, poultry and aquaculture diet preparation, lime production, paint making, and ornamental usage (Solaiman et al., 2006). Marine bivalve can produce pearl and a total of 7 species of pearl-bearing oyster has been identified in the BoB which has very high culture potential (Rahman et al., 2015). Marine

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cephalopods are caught by trawl net or set bag net from up to 20 m deep and they contribute 4-5% of total marine fish landing (Siddique et al., 2016). No published report on mollusk catch and stock size is available; however total usage by different stakeholders involved in the mollusk industry was estimated to be 1130 MT per year (Solaiman et al., 2006; Shahabuddin et al., 2010). Mollusk culture is a very low-investment activity with very good returns. Bangladesh earned USD 5.51 million the 2017–2018 by exporting oysters, mussels, and scallops (AftabUddin et al., 2021). Considering water quality, transport, and market facilities the south eastern coast of Bangladesh including Moheskhali channel, Kutubdia, Coxes Bazar, and Teknaf was found to be the most suitable place for mollusk culture while the south western coast was moderately suitable (Salam et al., 2005; Shahabuddin et al., 2010; Hossain et al., 2013). Due to lower salinity and muddy substrate the middle part of the coast was not found suitable for mollusk culture (Salam et al., 2005). Although we have suitable site for marine mollusk culture, no commercial culture of mollusk is reported yet in Bangladesh. Mollusk aquaculture can generate alternative livelihood and employment opportunities in Bangladesh (Hossain et al., 2013). There is considerable potential for future development of the mollusk culture industry in Bangladesh.

Marine Fisheries Products

Marine fisheries products are the important export item in Bangladesh. Producing marine dry and dehydrated fish is a very common practice in the coastal regions and isolated coastal islands (Hoq et al., 2014). About 20% of the total marine catch is dried round the year and marketed in the UK, the US, the Middle East, and domestic markets (Hoq et al., 2014). In the 2017-18 fiscal year, Bangladesh earned USD 4.19 and 2.62 million by exporting 3144 MT of dried and salted fish, and 214 MT of dehydrated fish, respectively (DoF, 2018). Shark and shark products like shark fins, tails, skin, bone, meat, liver, jaw, etc. are other exportable items from Bangladesh. Shark products are mainly exported to Myanmar directly from Cox's Bazar through border. During 2017-18, different shark products exported from Bangladesh were around 0.50 MT with an estimated value of USD 11817 (DoF, 2019). Major shark hunting grounds in Bangladesh include areas of Patuakhali, Barguna, the Sunderbans, Sandwip, Kutubdia, Moheshkhali, and Elephant Point in Teknaf (Roy et al., 2015). There is a good opportunity to earn foreign currency from exporting shark products through proper channels. There is also a high demand for marine mollusk shell especially in Cox's Bazar where there is a mollusk market. The empty shells are used as raw material in making shell craft products, showpieces, ornaments and home decorative item (Rahman et al., 2015). Around 1,000 households were involved in ornament marketing and about 250 MT of mollusk shells were used in this industry annually in Cox's Bazar (Solaiman et al., 2006). Proper planning and government support are required to get more output from these prospective sectors.

Non-Conventional Marine Fisheries Resources

Non-conventional marine fisheries resources such as sea cucumber, sea urchin, skates and rays, horseshoe crab, marine sponge, and coral possess huge economic prospect due to their diversified use and high demand in the international market. Sea cucumber and sea urchin collection and culture can also be initiated in Bangladesh. In the Asia-Pacific region (e.g., China, Japan, Korea, Singapore, and Malaysia), sea cucumber and sea urchin have significant importance as a high nutrient food item (AftabUddin et al., 2021). Horseshoe crab has huge prospect in biomedical and pharmaceutical utilization such as endotoxin detection. It is also used for human consumption and as bait for fishing (Gorman, 2020). Skates and rays are not considered as primary food fish; however, are consumed as dietary supplements (cartilage supplement), making traditional Chinese medicine, and used in cosmetics industries (Tiktak et al., 2020). Marine sponges are considered as a treasure house of drugs in response to the potential of their secondary metabolites. Many of these biologically active compounds have shown a wide range of pharmaceutical activities such as antibacterial, antifungal, antitumor, anticancer, antimalarial, antiprotozoal, anti-inflammatory, immunosuppressive, cardiovascular, and antifouling activities (Hassan & Shaikh, 2017). Saint Martin's Island has potential for coral farming, which is better suited to small-scale artisanal production with the help of exporters of aquarium products (AftabUddin et al., 2021). Thus, the exploitation and culture of non-traditional fish, shellfish, mollusk, and crustacean species can significantly contribute to the economy of Bangladesh.

Challenges Toward Sustainable Blue Economy

Challenges in Developing Mariculture

The geographical position and climate condition of Bangladesh is suitable for mariculture however, there have been limited attempts to promote mariculture due to many constraints (Figure 7). The scarcity of seed-producing hatcheries for commercially important marine species is a vital

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constraint for mariculture development in Bangladesh. Wild-caught juvenile and brood stocks need to be domesticated in captive conditions prior to initiating breeding and culture. In this regard, full-fledge technical education and research institutes are required to develop expertise and new technologies. Lack of capital is another vital problem in developing mariculture in Bangladesh. Commercial mariculture infrastructures like inshore coastal ponds and raceways, offshore floating net cages, mollusk and seaweed culture rack and rafts, etc. require a lot of investment. Access to institutional credit operated by commercial banks in Bangladesh is very limited and complicated. Moreover, the country does not have enough domestic consumer for mariculture products like crab, shellfish, seaweed, and others. Hence, modern seafood processing plants are required to export mariculture products to the international markets (Hussain et al., 2019; AftabUddin et al., 2021).

Limited Survey to Identify Fishing Grounds and Stock Assessment

According to Hoq et al. (2013), a total of 26 surveys were carried out in the BoB from 1857 to 2007. Early surveys were for identification of fishing grounds and later surveys were for fisheries stock assessment. Four fishing grounds namely South patches, South-west of south patches, Middle ground, and Swatch of no ground were identified in the BoB (Figure 1) through the survey of Sagar Sandhani and Meen Sandhani (research vessel) from 1968 to 1971 (Hoq et al., 2013; Sarker et al., 2018). Since that, no survey was conducted to find new fishing grounds in the BoB. DoF procured a research vessel from Malaysia in 2016 to conduct survey of demersal fish stock assessment, shrimp stock assessment, and pelagic fish stock assessment in the BoB (Hoq et al., 2013). The stock surveys are about 8 years old and no recent or comprehensive knowledge is available on the fisheries stocks, systematics, biological, and ecological aspects of marine fisheries of Bangladesh (Shamsuzzaman et al., 2017b). Standing stock evaluation and maximum sustainable yield values are necessary knowledge for sustainable resource management (Islam & Shamsuddoha, 2018). Fishing without adequate information on the status of the stock leads to over-exploitation or under-exploitation of fishery resources (Hussain & Hoq, 2010). Several studies reported that the distribution of fish stock shifts over time due to various reasons like climate change or intensive fishing pressure (Katikiro, 2014). Therefore, to identify new fishing ground and assess standing stock for sustainable exploitation, survey needs to be carried out in the extended maritime boundary.

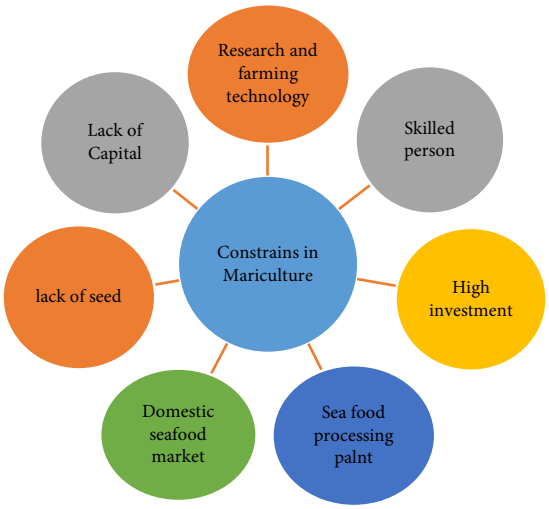

Figure 7. Constraints in developing mariculture in Bangladesh

Fishing Pressure

Bangladesh Fisheries Development Corporation (BFDC) started commercial exploitation of these fishing grounds in 1972 with only 11 fishing trawlers (Islam, 2003). As there is no updated stock assessment report, it is hard to maintain the maximum sustainable yield of our marine fisheries resources. In the last twenty years, industrial (fish and shrimp trawler) and artisanal (mechanized and non-mechanized boat) fishing has increased in the BoB (Figure 8). The number of fish and shrimp trawlers has increased from 21 in 1999-20 to 216 in 2020-21 which is more than ten times higher. At present, 32,859 mechanized and 34,810 non-mechanized boats are exploiting mainly for demersal fishes (DoF, 2022). Pelagic and deep-sea marine fisheries resources are still unexploited (Shamsuzzaman et al., 2017b). Both industrial and artisanal fisheries are exploiting fishery resources without any appropriate management plan due to the unavailability of scientific information and management strategies (Hoq et al., 2013). Therefore, a multidisciplinary baseline research program needs to be developed in the BoB.

Illegal Fishing

The use of illegal fishing gear and illegal fishing by outsider and domestic fishers made the scenario more difficult to maintain responsible fishing. Some destructive fishing gears like estuarine set bag net (ESBN), gill net, and their indiscriminate uses are destroying fry and juveniles of fish and other marine resources (Hoq et al., 2013). Besides, illegal fishing by domestic and foreign fishing trawlers are now a great concern too. Illegal fishers from Myanmar, India, Thailand, and

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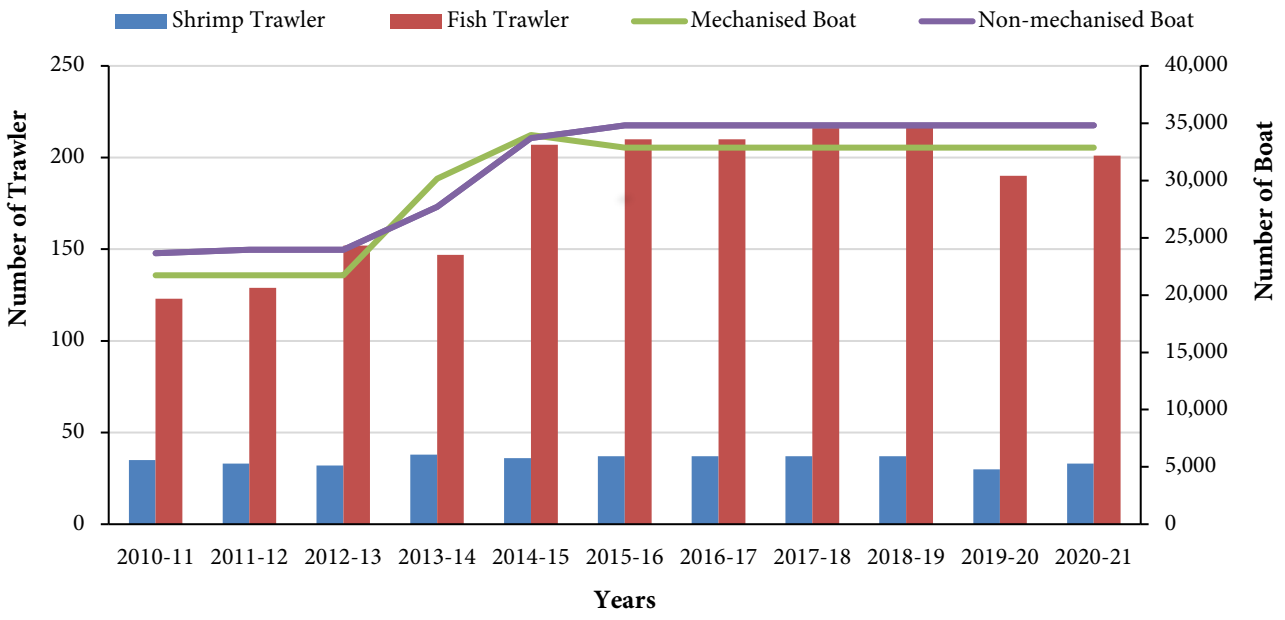

Figure 8. Fishing crafts used in the Bay of Bengal from 2010-11 to 2020-21 (Adapted from Hoq et al. (2013) and DoF (2018))

Sri Lanka trespass the maritime boundary and enter into the Bangladeshi maritime zone (Hussain et al., 2018). An effective surveillance and monitoring system needs to be established to prevent illegal fishing pressure.

Marine Pollution

Marine pollution is another concerning issue in BoB that pollutes the marine environment and degrades marine biodiversity. Industries, ship-breaking yards, sewage, tourism, and trans boundary depositions are the main sources of pollution. Moreover, major river systems (Ganges, Meghna, Jamuna, and Brahmaputra) of Bangladesh carry land-based wastes from urban areas (Biswas et al., 2021). Ocean acidification also threatens blue economy and causes adverse biological effects on marine organism (Tayyar, 2023). Without appropriate control measures, coastal and marine ecosystems are largely unprotected and pollution can cause devastating impact on marine biota including human health (Alam & Xiangmin, 2019). Being a maritime nation, as well as one of the top biodiversity-rich country, Bangladesh needs to take the marine pollution issue seriously. At present, Bangladesh has no act or law to protect the coastal and marine resources from pollution. To conserve and protect the ecosystem and environment Bangladesh has enacted a number of conservation and protection laws but they do not have any direct relation with marine pollution (Alam & Xiangmin, 2019; Alam et al., 2021). Bangladesh can draw lessons from international marine pollution control regulations and set up marine pollution protection law in the present context of blue growth.

Inadequate Government Rules, Policies, Regulations, and Poor Implementation

Economic activities in the ocean may cause threats to the biodiversity and the environment, therefore it is important to implement environmentally compatible policies (Suluk, 2022). There are about twelve old-fashioned fisheries regulations for the management of fisheries resources in Bangladesh. Major features of these regulations are protection, conservation, restriction, management, exploitation, monitoring, supervision, quality control, licensing, and development (Shamsuzzaman et al., 2016). Unfortunately, most of the laws are not implemented properly and surveillance in the coastal and marine areas is very poor. The implementation of these laws and policies often faces conflicts among the stakeholders due to coastal poverty, the inadequate and improper distribution of incentives, insufficient logistic support, limited alternative occupations, political interference, and a lack of awareness regarding fishery regulation (Islam et al., 2017c). Moreover, the lack of clear policy guidelines and strategy and the absence of regular law review and updating mechanisms are also limiting the success in the implementation of these laws (Shamsuzzaman et al., 2016). There is a need to adjust the existing laws and legislation of the country to achieve the goal of sustainable coastal and marine fisheries resource

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management. An integral, coherent, and comprehensive legal framework is required to formulate consulting with all the fishery stakeholders (Islam et al., 2017c).

Conclusion

The marine fisheries resources in Bangladesh hold immense potential for boosting fisheries production and driving economic growth. Expansion of mariculture and effective utilization of marine resources can play a part in developing a sustainable blue economy in Bangladesh. To increase marine fisheries production, it is imperative to address the existing challenges comprehensively. This entails not only conducting further scientific investigations for stock assessment, exploring new fishing grounds, and advancing culture technologies but also prioritizing the development of skilled personnel, leveraging advanced technology, expanding the domestic seafood market, enhancing the supply chain, and implementing effective management strategies. Moreover, to overcome the limitations hindering marine fisheries performance, it is crucial to strengthen policy interventions. This includes formulating specialized government policy for marine fisheries, and ensuring their robust implementation. By strengthening policy frameworks, Bangladesh protects its marine fisheries resources efficiently, drive the blue economy forward, and make a substantial contribution to sustainable development.

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Compliance With Ethical Standards

Authors' Contributions

MRI: Conceptualization, Data analysis, Writing - Original Draft, Writing-Review and Editing
TA: Conceptualization, Data analysis
AH: Writing - Original Draft
ATT: Writing - Original Draft
SSM: Writing - Original Draft
MAH: Writing-Review and Editing
MMH: Writing-Review and Editing
All authors read and approved the final manuscript.

Conflict of Interest

The authors declare that there is no conflict of interest.

Ethical Approval

For this type of study, formal consent is not required.

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Data Availability Statement

The authors confirm that the data supporting the findings of this study are available within the article.

References

AftabUddin, S., Hussain, M. G., Abdullah, Al. M., Failler, P., & Drakeford, B. M. (2021). On the potential and constraints of mariculture development in Bangladesh. *Aquaculture International*, *29*, 575–593. https://doi.org/https://doi.org/10.1007/s10499-020-00643-9

Ahmed, M. S., Barua, A., Datta, S. K., Saha, T., Antu, D. R., & Ahmed, S. (2022a). Characterization of spiny lobsters from Bangladesh waters using morphology, COI and 16S rRNA sequences. *Heliyon*, *8*(2), e08846. https://doi.org/10.1016/j.heliyon.2022.e08846

Ahmed, N. (2013). Linking prawn and shrimp farming towards a green economy in Bangladesh: Confronting climate change. *Ocean & Coastal Management*, *75*, 33–42. https://doi.org/10.1016/j.ocecoaman.2013.01.002

Ahmed, N., & Glaser, M. (2016). Can "Integrated Multi-Trophic Aquaculture (IMTA)" adapt to climate change in coastal Bangladesh? *Ocean & Coastal Management*, *132*, 120–131. https://doi.org/10.1016/j.ocecoaman.2016.08.017

Ahmed, N., & Taparhudee, W. (2005). Seaweed cultivation in Bangladesh: Problems and potentials. *Kasetsart University Fisheries Research Bulletin*, *28*, 13-21.

Ahmed, Z. U., Hasan, O., Rahman, M. M., Akter, M., Rahman, M. S., & Sarker, S. (2022b). Seaweeds for the sustainable blue economy development: A study from the south east coast of Bangladesh. *Heliyon*, *8*, e09079. https://doi.org/10.1016/j.heliyon.2022.e09079

Alam, M. W., & Xiangmin, X. (2019). Marine pollution prevention in Bangladesh: A way forward for implement comprehensive national legal framework. *Thalassas*, *35*, 17–27. https://doi.org/10.1007/s41208-018-0078-x

Alam, M. W., Xiangmin, X., & Ahamed, R. (2021). Protecting the marine and coastal water from land-based sources of pollution in the northern Bay of Bengal: A legal analysis for implementing a national comprehensive act. *Environmental Challenges*, *4*, 100154. https://doi.org/10.1016/j.envc.2021.100154

Alam, M. K. (2019). *Blue Economy –Development of Sea Resources for Bangladesh*. Ministry of Foreign Affairs. Retrieved on November 22, 2022, from https://mofa.gov.bd/site/page/8c5b2a3f-9873-4f27-8761-2737db83c2ec/OCEAN/BLUE-ECONOMY--FOR-BANGLADESH

Ali, M. Y., Hossain, M. B., Sana, S., Rouf, M. A., Yasmin, S., & Sarower, M. G. (2020). Identifying peak breeding season and estimating size at first maturity of mud crab (*Scylla olivacea*) from a coastal region of Bangladesh. *Heliyon*, *6*, 6. https://doi.org/10.1016/j.heliyon.2020.e04318

Bari, A. (2017). Our oceans and the blue economy: Opportunities and challenges. *Procedia Engineering*, *194*, 5–11. https://doi.org/10.1016/j.proeng.2017.08.109

Biswas, J. C., Haque, M. M., Maniruzzaman, M., & Kalra, N. (2021). Coastal and marine pollution in Bangladesh: Pathways, hotspots and adaptation strategies. *European Journal of Environment and Earth Sciences*, *2*, 26–34. https://doi.org/10.24018/ejgeo.2021.2.4.133

Chakraborty, B. (2018). Present status of mud crab population in Bangladesh. *International Journal of Oceanography & Aquaculture*, *2*(2), 00134. https://doi.org/10.23880/ijoac-16000134

Chakraborty, B. K. (2021). Status of sea bass farming in the coastal area of Bangladesh. *Journal of Natural Resource and Development*, *16*(2), 1-13.

Chowdhury, M. S. N., Hossain, M. S., AftabUddin, S., Alamgir, M., & Sharifuzzaman, S. M. (2022). Seaweed aquaculture in Bangladesh: Present status, challenges and future prospects. *Ocean & Coastal Management*, *228*, 106309. https://doi.org/10.1016/j.ocecoaman.2022.106309

Çoban, M. N., & Ölmez, Ü. (2017). Blue economy and blue growth. *Turkish Studies*, *12*(3), 155-166. https://doi.org/10.7827/turkishstudies.11122

Dhar, A. R., Uddin, M. T., Roy, M. K. (2020). Assessment of organic shrimp farming sustainability from economic and environmental viewpoints in Bangladesh. *Environmental Research*, *180*, 108879. https://doi.org/10.1016/j.envres.2019.108879

DoF. (2018). *Yearbook of Fisheries Statistics of Bangladesh, 2017-18*. Fisheries Resources Survey System (FRSS). Department of Fisheries, Bangladesh. 129 pp.

DoF. (2019). *Yearbook of Fisheries Statistics of Bangladesh, 2018-19*. Fisheries Resources Survey System (FRSS). Department of Fisheries, Bangladesh. 135 pp.

DoF. (2020). *Yearbook of Fisheries Statistics of Bangladesh, 2019-20*. Fisheries Resources Survey System (FRSS). Department of Fisheries, Bangladesh. 132 pp.

DoF. (2022). *Yearbook of Fisheries Statistics of Bangladesh, 2020-21*. Fisheries Resources Survey System (FRSS). Department of Fisheries, Bangladesh. 138 pp.

EPB. (2022). *Annual Report 2020-21*. Export promotion bureau, Bangladesh. Retrieved on November 11, 2022, from http://www.epb.gov.bd/site/view/annual_reports/Annual-Report

FAO. (2021). *FAO Yearbook. Fishery and Aquaculture Statistics 2019/FAO annuaries*. FAO, Rome, Italy. https://doi.org/https://doi.org/10.4060/cb7874t

FAO. (2024). *Fishery and Aquaculture Statistics – Yearbook 2021*. FAO Yearbook of Fishery and Aquaculture Statistics, Rome, Italy. https://doi.org/10.4060/cc9523en

Gorman, R. (2020). Atlantic horseshoe crabs and endotoxin testing: Perspectives on alternatives, sustainable methods, and the 3Rs (replacement, reduction, and refinement). *Frontiers in Marine Science*, *7*, 582132. https://doi.org/10.3389/fmars.2020.582132

Habib, K. A., & Islam, M. D. J. (2020). An updated checklist of Marine Fishes of Bangladesh. *Bangladesh Journal of Fisheries*, *32*, 357–367. https://doi.org/10.52168/bjf.2020.32.40

Hassan, S. S. U., & Shaikh, A. L. (2017). Marine actinobacteria as a drug treasure house. *Biomedicine & Pharmacotherapy*, *87*, 46–57. https://doi.org/10.1016/j.biopha.2016.12.086

Hoq, E. (2016). Feasibility of Seaweed Culture in Inani and Bakkhali Coast of Cox's Bazar, Bangladesh. *Pakistan Journal of Marine Science*, *25*, 27–36.

Hoq, M. E., Haroon, A. K. Y., & Chakraborty, S. C. (2013). *Marine fisheries of Bangladesh: prospect & potentialities*. Bangladesh Fisheries Research Institute, Bangladesh. 120 pp.

Hoq, M. E., Sein, A., Khan, M. S. K., Debnath, P. P., Kudrat, E., & Kabir, Q. A. 2014. Captive breeding of mud crab *Scylla serrata* (Forskål, 1975) in Bangladesh. *Bangladesh Journal of Zoology*, *42*, 295–299. https://doi.org/10.3329/bjz.v42i2.23372

Hoque, M. S., Bygvraa, D. A., Pike, K., Hasan, M. M., Rahman, M. A., Akter, S., Mitchell, D., & Holliday, E. (2021). Knowledge, practice, and economic impacts of COVID-19 on small-scale coastal fishing communities in Bangladesh: Policy recommendations for improved livelihoods. *Marine Policy*, *131*, 104647. https://doi.org/10.1016/j.marpol.2021.104647

Hossain, M. S. (2001). Biological aspects of the coastal and marine environment of Bangladesh. *Ocean & Coast Management*, *44*, 261–282. https://doi.org/10.1016/S0964-5691(01)00049-7

Hossain, M. S., Rothuis, A., Chowdhury, S. R., Smaal, A., Ysebaert, T., Sharifuzzaman, S. M., Van Sluis, C., Hellegers, P., Van Duijn, A., Dankers, P., Chowdhury, S. N., & Sarker, S. (2013). Oyster aquaculture for coastal defense with food production in Bangladesh. *Aquaculture Asia*, *18*, 15–24.

Hussain, M. G., Failler, P., Karim, A. A., Alam, & M. K. (2017). Review on opportunities, constraints and challenges of blue economy development in Bangladesh. *Journal of Fisheries and Life Sciences*, *2*, 45–57.

Hussain, M. G., Failler, P., Karim, A. Al., & Alam, M. K. (2018). Major opportunities of blue economy development in Bangladesh. *Journal of the Indian Ocean Region*, *14*, 88–99. https://doi.org/10.1080/19480881.2017.1368250

Hussain, M. G., Hoq, M. E. (2010). *Sustainable management of fisheries resources of the bay of Bengal*. Bangladesh Fisheries Research Institute, Bangladesh. 122 pp.

Hussain, M. G., Uddin, S. A., & Failler, P. (2019). Potentials for the development of blue economy: Prospects and challenges of mariculture in Bangladesh. *Journal of Bangladesh Agriculture*, *9*, 1–14.

Islam, M. M., & Shamsuddoha, M. (2018). Coastal and marine conservation strategy for Bangladesh in the context of achieving blue growth and sustainable development goals (SDGs). *Environmental Science & Policy*, *87*, 45–54. https://doi.org/10.1016/j.envsci.2018.05.014

Islam, M. M., Shamsuzzaman, M., Mozumder, M., Xiangmin, X., Ming, Y., & Jewel, M. (2017c). Exploitation and conservation of coastal and marine fisheries in Bangladesh: Do the fishery laws matter? *Marine Policy*, *76*, 143–151. https://doi.org/10.1016/j.marpol.2016.11.026

Islam, M. R., Haque, M., & Rahman, M. (2017a). Studies on seafood production systems in the South-west Region of Bangladesh. *Journal of Bangladesh Agricultural University*, *15*, 123–132. https://doi.org/10.3329/jbau.v15i1.33537

Islam, M. R., Rahman, M., & Haque, M. (2017b). Strength and weakness of existing traceability system of seafood production in Bangladesh. *Progressive Agriculture*, *28*, 156–166. https://doi.org/10.3329/pa.v28i2.33477

Islam, M. S. (2003). Perspectives of the coastal and marine fisheries of the Bay of Bengal, Bangladesh. *Ocean & Coastal Management*, *46*, 763–796. https://doi.org/10.1016/S09645691(03)00064-4

Istiak, S. M. (2018). Study for assessing mud crab (*Scylla serrata*, Forskal, 1755) market chain and value-added products development in Bangladesh. *Bangladesh Journal of Zoology*, *46*, 263–273. https://doi.org/10.3329/bjz.v46i2.39066

IUCN. (2015). *Red List of Bangladesh Volume 2: Mammals*. International Union for Conservation of Nature (IUCN), Bangladesh Country Office, Dhaka, Bangladesh. 223 pp.

Jones, C. M., Anh, T. L., & Priyambodo, B. (2019). Lobster aquaculture development in Vietnam and Indonesia. Radhakrishnan, E., Phillips, B., Achamveetil, G. (Eds.), *Lobsters: Biology, Fisheries and Aquaculture* (pp. 541–570). Springer. https://doi.org/10.1007/978-981-32-9094-5_12

Karim, M. F., Zhang, X., & Li, R. (2019). Dynamics of shrimp farming in the southwestern coastal districts of Bangladesh using a shrimp yield dataset (SYD) and Landsat satellite archives. *Sustainability*, *11*, 4635. https://doi.org/10.3390/su11174635

Katikiro, R. E. (2014). Perceptions on the shifting baseline among coastal fishers of Tanga, Northeast Tanzania. *Ocean & Coastal Management*, *91*, 23–31. https://doi.org/10.1016/j.ocecoaman.2014.01.009

Kumar, A., Birthal, P. S., & Badruddin, A. (2004). Technical efficiency in shrimp farming in India: Estimation and implications. *Indian Journal of Agricultural Economics*, *59*, 413–420.

Lahiri, T., Nazrul, K. M. S., Rahman, M. A., Saha, D., Egna, H., Wahab, M. A., & Mamun, A. Al. (2021). Boom and bust: Soft-shell mud crab farming in south-east coastal Bangladesh. *Aquaculture Research*, *52*, 5056–5068. https://doi.org/10.1111/are.15377

Lee, K. H., Noh, J., & Khim, J. S. (2020). The Blue Economy and the United Nations' sustainable development goals: Challenges and opportunities. *Environment International*, *137*, 105528. https://doi.org/10.1016/j.envint.2020.105528

Mondal, D. K., Begum, N., Rahman, S. L., & Islam, M. L. (2021). Culture potential of fresh water giant prawn (*Macrobrachium rosenbergii*) with tiger shrimp (*Penaeus monodon*) and green back mullet (*Chelon subviridis*) in poly culture. *International Journal of Fisheries and Aquatic Studies*, *9*, 230–234. https://doi.org/10.22271/fish.2021.v9.i1c.2408

Mukit, M. (2019). Blue Economy: A new economic frontier of Bangladesh. Pressenza. Retrieved on November 6, 2022, from https://www.pressenza.com/2019/11/blue-economy-a-new-economic-frontier-of-bangladesh/

Patil, P. G., Virdin, J., Colgan, C. S., Hussain, M. G., Failler, P., & Vegh, T. (2018). *Toward a Blue Economy: A pathway for Bangladesh's sustainable growth*. World Bank. https://doi.org/10.1596/30014

Petersen, E. H., & Phuong, T. H. (2010). Tropical spiny lobster (*Panulirus ornatus*) farming in Vietnam-bioeconomics and perceived constraints to development. *Aquaculture Research*, *41*(10), e634-e642. https://doi.org/10.1111/j.1365-2109.2010.02581.x

Pradhan, B., Bhuyan, P. P., Patra, S., Nayak, R., Behera, P. K., Behera, C., Behera, A. K., Ki, J. S., & Jena, M. (2022). Beneficial effects of seaweeds and seaweed-derived bioactive compounds: Current evidence and future prospective. *Biocatalysis and Agricultural Biotechnology*, *39*, 102242. https://doi.org/10.1016/j.bcab.2021.102242

Rahman, M. (2015). Causes of biodiversity depletion in Bangladesh and Their consequences on ecosystem services. *American Journal of Environmental Protection*, *4*(5), 214-236. https://doi.org/10.11648/j.ajep.20150405.13

Rahman, M. A., Parvej, M. R., Rashid, M. H., & Hoq, M. E. (2015). Availability of pearl producing marine bivalves in south-eastern coast of Bangladesh and culture potentialities. *Journal of Fisheries*, *3*(3), 293-296. https://doi.org/10.17017/jfish.v3i3.2015.108

Rahman, M. M., & Hossain, M. M. (2009). Production and export of shrimp of Bangladesh: Problems and prospects. *Progressive Agriculture*, *20*, 163–171. https://doi.org/10.3329/pa.v20i12.16868

Rahman, M. M., Haque, S. M., Galib, S. M., Islam, M. A., Parvez, M. T., Hoque, M. N., Wahab, M. A., Egna, H., & Brown, C. (2020). Mud crab fishery in climate vulnerable coastal Bangladesh: An analysis towards sustainable development. *Aquaculture International*, *28*, 1243–1268. https://doi.org/10.1007/s10499-020-00523-2

Rahman, M., & Hossain, M. (2013). Production and export of shrimp of Bangladesh: Problems and prospects. *Progressive Agriculture*, *20*, 163–171. https://doi.org/10.3329/pa.v20i1-2.16868

Rahman, R. (2019). *Drastic Fall in Shrimp Export Earning*. The Financial Express. Retrieved on November 17, 2022, from https://thefinancialexpress.com.bd/trade/drastic-fall-in-shrimp-export-earnings-1567226650

Rashid, H. U. (2014). *Blue Economy - Are we ready for it?* The Daily Star. Retrieved on November 17, 2022, from https://www.thedailystar.net/opinion/economics/blue-economy-are-we-ready-it-1575823

Roberts, J. P., & Ali, A. (2016). *The Blue Economy and small sates*. Commonwealth Blue Economy Series, No. 1. Commonwealth Secretariat.

Roy, B. J., Singha, N. K., Rhaman, M. G., & Ali, A. (2015). Status and recorded of sharks and rays in the Bay of Bengal of Bangladesh Region. *Brazilian Journal of Biological Science*, *2*, 343–367.

Salam, M. A., Hossain, M. S., & Tareque, A. (2005). Studies on the present status and future potential of molluscs, dry fish and crab in Bangladesh coast: A GIS methodological perspective. Islam, M. A., Ahmed, K. & Akhteruzzaman M. (Eds.), *Value Chain and Market Assessment of Coastal and Marine Aquatic Products of Bangladesh* (pp. 192–210). Bangladesh Fisheries Research Forum.

Sarkar, M. S. I., Kamal, M., Hasan, M. M., & Hossain, M. I. (2016). Present status of naturally occurring seaweed flora and their utilization in Bangladesh. *Research in Agriculture, Livestock and Fisheries*, *3*, 203–216. https://doi.org/10.3329/ralf.v3i1.27879

Sarker, S., Akter, M., Rahman, M. S., Islam, M. M., Hasan, O., Kabir, M. A., & Rahman, M. M. (2021). Spatial prediction of seaweed habitat for mariculture in the coastal area of Bangladesh using a generalized additive model. *Algal Research*, *60*, 102490. https://doi.org/10.1016/j.algal.2021.102490

Sarker, S., Bhuyan, M. A. H., Rahman, M. M., Islam, M. A., Hossain, M. S., Basak, S. C., & Islam, M. M. (2018). From science to action: Exploring the potentials of Blue Economy for enhancing economic sustainability in Bangladesh. *Ocean & Coastal Management*, *157*, 180–192. https://doi.org/10.1016/j.ocecoaman.2018.03.001

Sarker, S., Hussain, F. A., Assaduzzaman, M., & Failler, P. (2019). Blue economy and climate change: Bangladesh perspective. *Journal of Ocean and Coastal Economics*, *6*(2), 6. https://doi.org/10.15351/2373-8456.1105

Shahabuddin, A. M., Wahab, M. A., Miah, M. I., & Salam, M. (2010). Abundance, distribution and culture potentials of three commercially important mollusks species along the coast of Bay of Bengal. *Research Journal of Agriculture and Biological Sciences*, *6*, 754–762.

Shamsuzzaman, M. M., Islam, M. M., Tania, N. J., Abdullah Al-Mamun, M., Barman, P. P., & Xu, X. (2017a). Fisheries resources of Bangladesh: Present status and future direction. *Aquaculture and Fisheries*, *2*, 145–156. https://doi.org/10.1016/j.aaf.2017.03.006

Shamsuzzaman, M. M., Xiangmin, X., & Islam, M. M. (2016). Legal status of Bangladesh fisheries: Issues and responses. *Indian Journal of Geo-Marine Sciences*, *45*, 1474–1480.

Shamsuzzaman, M. M., Xiangmin, X., Islam, M. M., Alam, M. W., & Karim, E. (2017b). Sustainable marine fisheries resources of Bangladesh: A strategic response for economic security. *Indian Journal of Geo-Marine Sciences*, *46*, 757–765.

Siddique, M. A. M., Khan, M. S. K., Habib, A., Bhuiyan, M. K. A., & Aftabuddin, S. (2016). Size frequency and length–weight relationships of three semi-tropical cephalopods, Indian squid *Photololigo duvaucelii*, needle cuttlefish *Sepia aculeata*, and spineless cuttlefish *Sepiella inermis* from the coastal waters of Bangladesh, Bay of Bengal. *Zoology and Ecology*, *26*, 176–180. https://doi.org/10.1080/21658005.2016.1190523

Smith-Godfrey, S. (2016). Defining the blue economy. *Maritime Affairs*, *12*, 58–64. https://doi.org/10.1080/09733159.2016.1175131

Solaiman, M., Huq, K. A, Faruk, M. A. R, & Hossain, M. A. R. (2006). *Mollusc marketing system through value chain analysis with special emphasis on livelihood of the poor fishermen.* Bangladesh Fisheries Research Forum.

Suluk, S. (2022). Colors of the Economy: An evaluation of Turkey in the context of the sustainable Blue Economy. *Dumlupınar University Journal of Social Sciences*, 74, 132-150. https://doi.org/10.51290/dpusbe.1123257

Talukdar, A., Schneider, P., Begum, A., Kawsar, M. A., Sultana, M. A., Sumon, T. A, Rashed-Un-nabi, M., Mozumder, M. M. H., & Shamsuzzaman, M. M. (2022). The premium of Hilsa sanctuary: A socio-economic and ecological evaluation from the Meghna estuary, Bangladesh. *Sustainability*, *14*(13), 7782. https://doi.org/10.3390/su14137782

Tayyar, A. E. (2023). *Küresel ısınmanın kötü ikizi – Mavi ekonomi ve endüstri-içi ticaret: Türkiye için ARDL analiz* [The evil twin of global warming – blue economy and intra-industry trade: ARDL analysis for Türkiye]. *Pamukkale University Journal of Social Sciences Institute*, (57), 21-36. https://doi.org/10.30794/pausbed.1228128

Tiktak, G. P., Butcher, D., Lawrence, P. J., Norrey, J., Bradley, L., Shaw, K., & Megson, D. (2020). Are concentrations of pollutants in sharks. rays skates a cause concern? A systematic review. *Marine Pollution Bulletin*, *160*, 11170. https://doi.org/10.1016/j.marpolbul.2020.111701

Voyer, M., Quirk, G., McIlgorm, A., & Azmi, K. (2018). Shades of blue: what do competing interpretations of the Blue Economy mean for oceans governance? *Journal of Environmental Policy & Planning*, *20*(5), 595–616. https://doi.org/10.1080/1523908X.2018.1473153