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Fisheries in the Context of Attaining Sustainable Development Goals (SDGs) in Bangladesh: COVID-19 Impacts and Future Prospects

Atiqur Rahman Sunny ^{1,2,*}, Mahmudul Hasan Mithun ³, Shamsul Haque Prodhan ¹, Md. Ashrafuzzaman ¹, Syed Mohammad Aminur Rahman ⁴, Md Masum Billah ⁵, Monayem Hussain ⁶, Khandaker Jafor Ahmed ⁴, Sharif Ahmed Sazzad ⁷, Md Tariqul Alam ⁸, Aminur Rashid ⁸ and Mohammad Mosarof Hossain ⁹

- ¹ Department of Genetic Engineering and Biotechnology, Shahjalal University of Science and Technology, Sylhet 3100, Bangladesh; shamsulhp@gmail.com (S.H.P.); azamanbt@gmail.com (M.A.)
- ² Suchana Project, WorldFish, Bangladesh Office, Gulshan, Dhaka 1213, Bangladesh
- ³ Bangladesh Fisheries Research Institute, Mymensingh 2201, Bangladesh; mithun622bsmrau@gmail.com
- ⁴ Department of Geography, Environment and Population, The University of Adelaide, Adelaide, SA 5005, Australia; syedamin22nd@gmail.com (S.M.A.R.); khandaker.ahmed@adelaide.edu.au (K.J.A.)
- ⁵ Ministry of Education, Bangladesh Secretariat, Dhaka 1000, Bangladesh; masumbahadur@gmail.com
- ⁶ Ecofish-II Project, WorldFish, Bangladesh Office, Gulshan, Dhaka 1213, Bangladesh; hussain.monayem@gmail.com
- ⁷ Pathfinder Agro and Fisheries Consultation Center, Sylhet 3100, Bangladesh; sazzad139@gmail.com
- ⁸ Department of Aquaculture, Sylhet Agricultural University, Sylhet 3100, Bangladesh; talam.aq@sau.ac.bd (M.T.A.); aminur0579sau@gmail.com (A.R.)
- ⁹ Department of Coastal and Marine Fisheries, Sylhet Agricultural University, Sylhet 3100, Bangladesh; mosarofmh.cmf@sau.ac.bd
- * Correspondence: atiksunny@yahoo.com



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Abstract: Fisheries and the aquaculture sector can play a significant role in the achievement of several of the goals of the 2030 Sustainable Development agenda. However, the current COVID-19 situation can negatively impact the fisheries sector, impeding the pace of the achievement of development goals. Therefore, this paper highlighted the performance and challenges of the fisheries sector in Bangladesh, emphasising the impact of COVID-19 and the significance of this sector for achieving the Sustainable Development Goals (SDGs), through primary fieldwork and secondary data. The total fish production in the country has increased more than six times over the last three decades (7.54 to 43.84 lakh MT) with improved culture techniques and extension services. Inland closed water contributions have increased to 16%, while inland open water has declined to 10%, and marine fisheries have dropped to 6% over the past 18 financial years (2000–2001 to 2018–2019). COVID-19, a significant health crisis, has also affected various issues associated with aquatic resources and communities. Transportation obstacles and complexity in the food supply, difficulty in starting production, labour crisis, sudden illness, insufficient consumer demand, commodity price hikes, creditor's pressure, and reduced income were identified as COVID-19 drivers affecting the fisheries sector. The combined effect of these drivers poses a significant threat to a number of the SDGs, such as income (SDG1), nutrition (SDG2), and food security (SDG3 and SDG12), which require immediate and comprehensive action. Several recommendations were discussed, the implementation of which are important to the achievement of the SDGs and the improved management of the aquatic sector (SDG14—life below, and SDG16—life above water).

Keywords: fisheries; aquaculture; food security; COVID-19; SDGs; Bangladesh

1. Introduction

Bangladesh, a nation blessed with diverse aquatic resources, is located in Southeast Asia, between 20°34' to 26°38' N latitude and 88°01' to 92°42' E longitude, and has an

area of 147,570 km² [1]. It is one of the top fish-producing countries globally, with its vast inland, coastal, and marine water resources [2]. The fisheries sector in Bangladesh is one of the most productive and dynamic sectors, which has played an increasingly significant role in the economy for the last few decades [3,4]. Since its independence in 1971, Bangladesh has achieved tremendous progress in the fisheries sector, contributing significantly to the promotion of the dependent community's food security and socioeconomic status [5,6], which are crucially highlighted in the UN's Sustainable Development Goals (SDGs). There are different types of interactions between SDGs and aquatic food production systems and the well-being of the dependent community. Fish from capture fisheries and aquaculture help marginalised people maintain their food supply and livelihoods in terms of nutritional security, good health and well-being, poverty alleviation, and reduced inequalities. Around 12% of the total population of Bangladesh is involved in the fisheries sector directly and indirectly [7], contributing 3.50% to the national GDP, 25.72% to the agricultural GDP [7,8] and providing a significant share of animal proteins.

The diversified fisheries resources of Bangladesh are mainly divided into two groups: inland and marine fisheries [3,9]. Inland fisheries have two sub-sectors, inland capture and inland culture fisheries, covering 3.89 and 0.82 million ha, respectively (Table 1). The inland open water habitats include rivers and estuaries (853,863 ha), the Sundarbans (177,700 ha), beels (114,161 ha), Kaptai Lake (68,800 ha), and floodplains (2,675,758 ha) (Figure 1). On the other hand, inland closed water habitats include ponds (397,775 ha), seasonal cultured water bodies (144,217 ha), Baor (5671 ha), shrimp/prawn farms (258,553 ha), crab farms (9377 ha), pen culture (6330 ha), and 1.76 lakh m³ for cage culture [7]. In 2018–2019, the inland capture, inland culture, and marine fisheries contributed approximately 28.19%, 56.76%, and 15.05% of the country's total fisheries production, respectively [7] (Table 1). Over the last three decades, the total fish production increased more than six times from 7.54 MT in 1983–1984 to BDT 43.84 lakh MT in 2018–2019. In 2018–2019, the country earned BDT 425,031.00 by exporting almost 73.17 thousand MT of fish and fishery products [7].

Table 1. Sector-wise fish production and water areas of Bangladesh in 2018–2019.

Fisheries Types	Fisheries Sector	Water Area (ha)	Production (MT)	Production (%)
Inland Fisheries	Inland open water (capture) rivers, estuaries, Sundarbans, beels, Kaptai Lake, floodplains	3,890,282	1,235,709	28.19
	Inland closed water (culture) pond, seasonal cultured water body, Baor, shrimp/prawn farm, pen culture, cage culture	821,923	2,488,601	56.76
Total (Inland)		4,712,205	3,724,310	84.95
Marine Fisheries	Industrial (trawl) fishing		107,236	2.45
	Artisanal fishing		552,675	12.61
Total (Marine)			659,911	15.05
Total production (Inland + Marine)			4,384,221	100

Data source: Department of Fisheries (DoF) [7].

Although inland capture fisheries are an important source of total fish production, they have reduced remarkably due to several anthropogenic interventions and natural causes, e.g., pollution, over-exploitation, destructive fishing, and habitat degradation [10]. In 1983–1984, the total production of inland capture and culture fisheries was 62.59% and 15.53%, respectively, whereas, in 2018–2019, inland capture fisheries sharply dropped to 28.19%, and inland culture fisheries increased to 56.76% [7]. However, in recent years, several socio-eco-friendly programs were implemented to increase the productivity of inland open waters, such as a community-based fisheries management program, the establishment of fish sanctuaries, beel nursery management, the stocking of fingerlings in water bodies, the restoration of the aquatic habitats, and an increase in water area under

cage and pen farming [11]. Bangladesh also has a huge potential for marine fisheries, comprising artisanal (fishing below 40 m depth) and industrial (trawl fishing above 40 m depth) fisheries and coastal sub-sectors. Despite having a long coastline (ca. 710 km) and a large marine water area, the marine fisheries sector is underdeveloped compared to other business sectors in Bangladesh [12]. Nonetheless, the recently settled maritime boundary with Myanmar and India, up to 200 nautical miles from the coastline, comprising 118,813 km² of maritime water, represent a huge blue economy development prospect. The potentiality and challenges of Bangladesh's fisheries and aquaculture sector were reviewed by Ghose (2014) up to 2012 and Shamsuzzaman et al. (2017) up to 2015. The impact of the COVID-19 pandemic on that sector is yet to be explored.

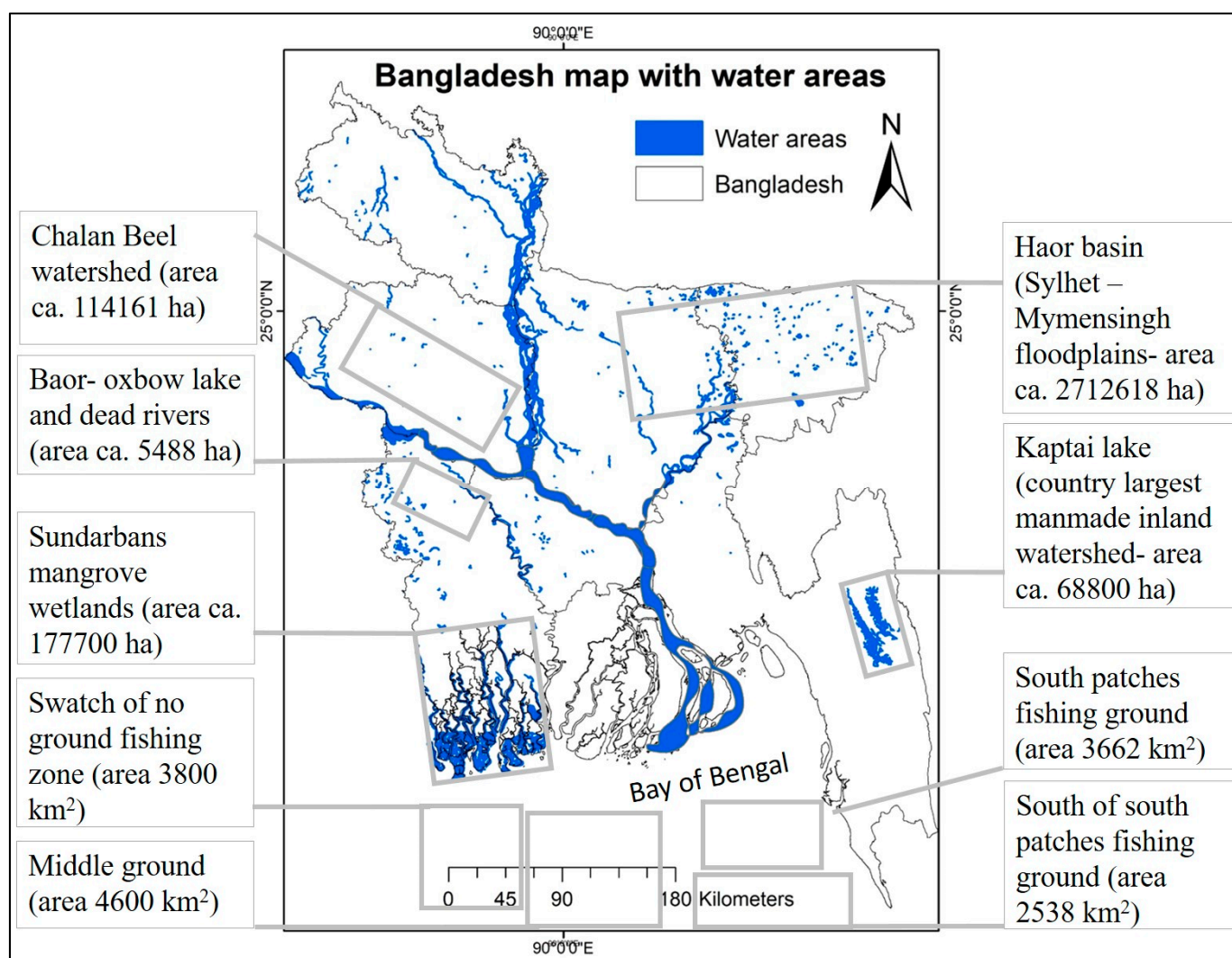


Figure 1. Aquatic resources and focal natural waters in Bangladesh, including major fishing grounds in the Bay of Bengal. This map illustrates the tentative location of major water areas of Bangladesh and does not necessarily reflect any precise administrative and or political boundary line with neighbouring countries.

This aquaculture and fisheries nexus requires observation through the lens of the COVID-19 pandemic because it is likely to impact the aquatic food system and the resilience of the dependent communities in Bangladesh. Bangladesh is struggling to cope with the adverse effects of COVID-19 due to its resource constraints. As of 1 August 2021, the country has confirmed 1,264,328 COVID-19 positive cases, 1,093,266 recovered cases, and the total death toll of 20,916. Bangladesh has adopted so-called preventive measures, such as social distancing, lockdowns, local and international travel restrictions, and work from

home. These initiatives reduce the household income mainly for the wage earners and, as a result, people are facing difficulties managing their living expenses. Indirectly, COVID-19 has affected aquatic food production as well. The restrictions in movement, difficulty in fish and input transportation, low consumer demand, unsold mature fish, low market prices, disruption in the new farming cycle, the labour crisis, limited attendance of the service provider, debt cycle, ban period, and disease susceptibility have all impacted the livelihood of fish farmers, fishers, and associated stakeholders. There are limited studies on the impacts of the COVID-19 pandemic on small-scale fisheries and aquaculture. A more in-depth focus is needed to obtain a general overview of the impacts of this pandemic on the different sub-sectors of fisheries, dependent communities, and associated stakeholders. Aquaculture and fisheries sectors provide crucial provisions to the wider society and have solid linkages for achieving several SDGs within the context of Bangladesh. Nevertheless, literature addressing the linkage of fisheries and the aquaculture sector with relevance to development (e.g., the economic, social, and environmental dimensions of sustainability) and the achievement of the SDGs are also limited. Therefore, this research aimed to highlight the potential and challenges of the fisheries and aquaculture sector in Bangladesh by bridging the gap of the existing situation (e.g., provide an update on the status of the sector, the COVID-19 pandemic impact on the aquatic resource system, and the involved stakeholders and dependent community). This attempt also reflected this sector's potential linkage and significance for achieving several SDGs in Bangladesh because of the COVID-19 pandemic. Finally, this study recommends plans and policies to aid in the recovery of the fisheries sector following the COVID-19 pandemic and analogous inversion in the future.

2. Materials and Methods

2.1. Study Areas

This cross-sectional study was purposively conducted in 15 communities of 10 districts under eight administrative divisions (Table 2).

Table 2. Selected study areas in eight administrative divisions in Bangladesh.

Divisions (n = 8)	Districts (n = 10)	Communities (n = 15)
Khulna	Bagerhat	Chila and Joymonigul
	Chuadanga	Darsana
Rangpur	Gaibanda	Palashbari
Rajshahi	Pabna	Bera
Dhaka	Narsingdi	Polash and Narsingdi Sadar
	Chandpur	Haimchar
Chattogram	Laxmipur	Char Alexandar
Barishal	Barishal	Kawarchar and Laharhat
Sylhet	Sylhet	Osmaninagar and Balaganj
Mymensingh	Mymensingh	Phulpur and Mymensingh Sadar

2.2. Empirical Primary Data Collection

This study on Bangladesh's fisheries and aquaculture fishing communities emerged while the COVID-19 pandemic remained pervasive within the country. Hence, the study was based on field data administrating, such as key informant interviews (KIIs), focus group discussion (FGDs), in-depth interviews, and a primary survey questionnaire. In this case, appropriate ethical consideration was maintained, and the respondents' enthusiastic participation during the field visit, data collection, and preservation was ensured.

2.2.1. In-Depth Tete-a-Tete Interviews

As the COVID-19 scenario of the country was gradually deteriorating and the government was enforcing various restrictions, it was difficult to move across the state for in-depth tete-a-tete interviews. In total, 50 in-depth tete-a-tete interviews were conducted with the aquaculture, fisheries, and coastal communities, hatcheries and fish production

farmers to assess the impact of the pandemic on the fisheries sector. The COVID-19 health protocols and social distancing were strictly maintained during the field site visits.

2.2.2. Key Informant Interviews

We conducted 50 key informant interviews (KIIs) with fisheries-dependent communities (fish, shrimp, crab, snail, and oyster harvesters) to determine the impacts of the COVID-19 pandemic. With strict lockdown and shutdowns, it was challenging to physically meet with eminent and noteworthy officials and various stakeholders for face-to-face interviews. In that case, around 30 telephonic stakeholder interviews were also conducted to cross-check the data accuracy.

2.2.3. Focus Group Discussion

A total of 22 focus group discussions (FGDs) were conducted to understand the context of COVID-19 and the prospects of the fisheries sector tackling the health and food crisis. Respondents provided some exciting information during the FGDs. Participants from diverse departments of aquaculture and fisheries of the selected districts were considered for the FGDs. In every FGD, 6–8 respondents participated, ensuring the World Health Organization's COVID-19 health protocol was followed, face masks were worn, and social distance was maintained.

2.3. Secondary Data Gathering

Secondary data on the COVID-19 pandemic was collected from the Directorate General of Health Services (DGHS), Institute of Epidemiology and Disease Control and Research (IEDCR). Relevant fisheries- and aquaculture-related secondary data, including, but not limited, to fish production, and food demand and supply, was collected from the Department of Fisheries (DoF). Other significant data sources were scientific articles and technical reports.

2.4. Data Analysis

The recording of the KIIs and FGDs were transcribed and analysed. The other content and the summary of the data were analysed to develop a conceptual understanding of this study. MS Excel (version 2016) was used to formulate the quantitative data using descriptive statistics in frequencies and percentages. The data were presented in graphs, bars charts, and tables.

3. Present Status of Inland Fisheries Resources of Bangladesh

3.1. Inland Open Water Fish Production in Bangladesh

Inland fisheries refer to the capturing and culturing of fishes in inland water. Bangladesh ranked third in inland captured fisheries and ranked fifth in world aquaculture production [7]. However, in production from single-species culture, explicitly the monoculturing of Tilapia (*Oreochromis niloticus*), Bangladesh ranked fourth in the world and became third in Asia. The national fish, hilsa (*Tenualosa ilisha*), contributed around 2.15% to the total fish production in the country, with a total production of 5.33 lakh MT, and was awarded the national Geographical Indication Registration Certificate [7,8].

Inland fisheries are sub-divided into inland capture (fishing from inland open water) and inland culture fisheries (aquaculture). The inland capture fishery contains five habitats: the river estuary, the Sundarbans (the world's largest mangrove forest), beels, Kaptai Lake, and floodplains. The inland culture fishery contains seven types of habitats, such as ponds, seasonal culture water bodies, baors, shrimp and prawn farms, crab farms, pen culture, and cage culture [7]. In 2018–2019, the total fish production in Bangladesh was reported as 4.38 million MT, of which 1.23 million MT (28.19%) were from inland open waters, 2.48 million MT (56.76%) from inland closed waters, and 0.65 million MT (15.05%) from marine fisheries (Table 1). Inland open water fisheries are still a significant source of total fish production, but their share has declined from 38.68% in 2000–2001 [13] to only 28.19%

in 2018–2019 [7]. Conversely, inland closed water fisheries contributions have increased from 40.01% in 2000–2001 [13] to 56.76% in 2018–2019 [7]. In recent years, the average yield (annual fish harvest per ha in metric tons) in open inland waters improved sharply (Table 3). The beel fishery has a high productivity of 875 kg/ha compared to the other habitats of inland open water (Table 3). A total of 293 fish species noted by Hossain et al. 2012 [14], and 260 taxa with 12 exotic fish and 24 prawn species, were recorded in Bangladesh [15] and are known to inhabit the nation's freshwaters. Significant carp species, such as catla (*Catla catla*), rui (*Labeo rohita*), mrigal (*Cirrhinus cirrhosus*), and kalbasu (*Labeo calbasu*), along with some exotic carp species, such as silver carp (*Hypophthalmichthys molitrix*), grass carp (*Ctenopharyngodon idellus*), and common carp (*Cyprinus carpio*), are the most available carp species found in the market. About 40–50 small indigenous fish species grow to a maximum length of 25 cm [16]. Some more commonly found species of this variety include titputi (*Puntius ticto*), mola (*Amblypharyngodon mola*), kholisha (*Colisa lalia*), koi (*Anabas testudineus*), and baila (*Glossogobius giuris*). Several small indigenous species of fish are now endangered or critically endangered in Bangladesh [14], although the inland water resources of Bangladesh offer significant potential for the development of freshwater capture and culture fisheries [17,18]. The catch from the inland capture fishery is noteworthy, especially for fish supply and employment in rural areas.

Table 3. Inland open water fish production of Bangladesh in 2018–2019 [7].

Inland Open Water (Capture Fisheries)	Water Area (ha)	Production (MT)	Productivity (Kg/ha)
Rivers and Estuaries	853,863	320,598	381
The Sundarbans	177,700	18,225	103
Beel	114,161	99,197	875
Kaptai Lake	68,800	10,152	154
Floodplains	2,712,618	768,367	292

Data source: Department of Fisheries (DoF) [7].

3.2. Inland Closed Water (Culture) Fish Production of Bangladesh

The inland aquaculture has generally experienced the fastest growth in the country, with the adoption of advanced culture technologies, species intensification, and improvement of farming systems, particularly in pond aquaculture, among various segments of the fisheries sub-sector [19,20]. However, around half of the fish are provided by aquaculture for direct human consumption and is set to grow further. The aquaculture industry boosts the economy with increasing production capacity and high export opportunities. The average growth rate of the fisheries sector over the last 10 years was about 5.01%, while aquaculture grew by 8.59%. Generally, two types of aquaculture are practised in Bangladesh, namely, freshwater and coastal aquaculture. Marine aquaculture is growing in the country, and the farming of marine fish is significant. Freshwater aquaculture is mainly comprised of pond farming of carps (Indian major and Chinese carps), pangasius (*Pangasius pangasius*) and other catfishes, tilapia (*Oreochromis nilotica*), Mekong climbing perch (*Anabas testudineus*), and several other domesticated fish. Pen and cage culture are two new cultivation approaches in Bangladesh and contributed to 12,361 MT (0.28%) and 3802 MT (0.09%) to the total fish production in 2018–2019, respectively (Table 4). These new methods have the highest potential for increasing fish production in Bangladesh. Total fish production in pen culture declined in the previous years in 2018–2019, but cage culture is becoming more popular and the production rate has increased in recent years. Coastal aquaculture is mainly comprised of shrimp and prawn farming in *ghers* (a coastal pond or enclosures with dug-out soil used to create dykes) and, in 2018–2019, the total production of shrimp and prawn was about 258,039 MT. In Bangladesh, aquaculture production systems are mainly extensive and improved extensive, with some semi-intensive and intensive systems in very few cases [17]. The current aquaculture productions for the pond, seasonal water body, baor (oxbow lake) and shrimp *ghers* are 4.96, 1.50, 1.82, and 0.99 (MT/ha),

respectively (Table 4). Inland pond culture represents the mainstay of aquaculture in Bangladesh, accounting for more than 80% of the total recorded aquaculture production. Pond aquaculture is the most practised type of closed water fishery in Bangladesh and contributed 45.04% (1,974,632 MT) to total fish production in 2018–2019 [7]. The main cultured species in the coastal areas of Bangladesh are giant tiger prawn (*Penaeus monodon*) and giant river prawn (*Macrobrachium rosenbergii*) [21].

Table 4. Inland closed water fish production in 2018–2019 in Bangladesh.

Inland Closed Water	Water Area (ha)	Production (MT)	Productivity (Kg/ha)
Pond	397,775	1,974,632	4964
Seasonal cultured- water body	144,217	217,340	1507
Baor	5671	10,343	1824
Shrimp/Prawn farm	258,553	258,039	998
Crab farm (capture and fattening culture)	9377	12,084	1289
Pen culture	6330	12,361	1953
Cage culture	176,000 m ³	3802	22 kg/m ³

Data source: Department of Fisheries (DoF) [7].

Shrimp and Prawn Production Trends in Bangladesh

Shrimp and prawn are major export items and are mainly produced in coastal districts, such as Khulna, Satkhira, Barishal, Patuakhali, Bagerhat, Bhola, Chattogram, and Cox's Bazar. As a result of increasing demand and prices, shrimp culture began expanding in the 1970s, aiming mainly at the export markets [22]. It was reported that the shrimp and prawn culture area had expanded from 217,177 ha in 2005–2006 to over 258,553 ha in 2018–2019. The production of shrimp has increased from 211,010 MT to 239,855 MT (Figure 2), and the average production of shrimp and prawn is 998 kg/ha [7]. In the Khulna region, shrimp is cultured in a modified rice field (also called *gher*), while in Cox's Bazar, shrimp and salt are produced alternately [23,24]. However, different programs and development projects are also being implemented for the increased production and promotion of shrimp aquaculture. The shrimp cluster farming approach was popularised for enhancing shrimp production and promoting a business-friendly supply chain by adopting good aquaculture practices. The government has maintained standards in all stages of fish and shrimp production, processing, and export. In Bangladesh, shrimp culture technology has intensified in recent years, but the production level has not increased satisfactorily. One of the main reasons for that is the unavailability of good quality post-larvae (PL) and feed. The specific, pathogen-free post-larvae should be supplied broadly to shrimp farms to reduce the different viral and bacterial disease related mortality.

3.3. Marine Fisheries Production in Bangladesh

The Bay of Bengal is blessed with rich coastal and marine ecosystems, hosting a wide range of biodiversity, including fish, shrimp, molluscs, crabs, mammals, reptiles, seaweeds, etc. (Figure 3) [25,26]. It has the potential to contribute to the economy of Bangladesh by the exploration, exploitation, and management of living and non-living resources [27,28]. Most specifically, after the recent decision of the Bangladesh-Myanmar maritime boundary in 2012 and the decision of the India-Bangladesh maritime boundary in 2014, the country established sovereign rights to more than 118,813 km² of territorial sea, 200 nautical miles of Exclusive Economic Zone (EEZ), and an assortment of living and non-living resources under the continental shelf up to 354 nautical miles from the Chittagong coasts.

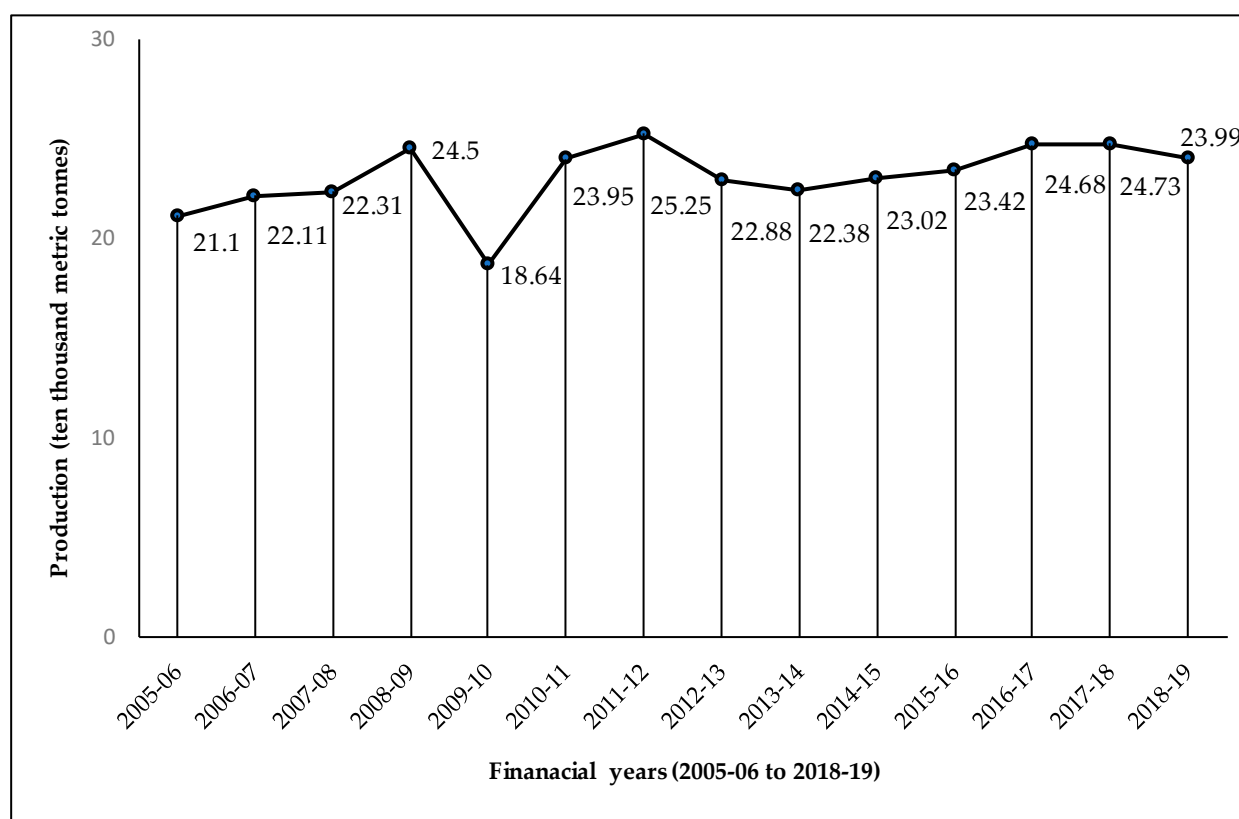


Figure 2. The trend of shrimp/prawn production from 2005–2006 to 2018–2019. Data source: Department of Fisheries (DoF) [7].

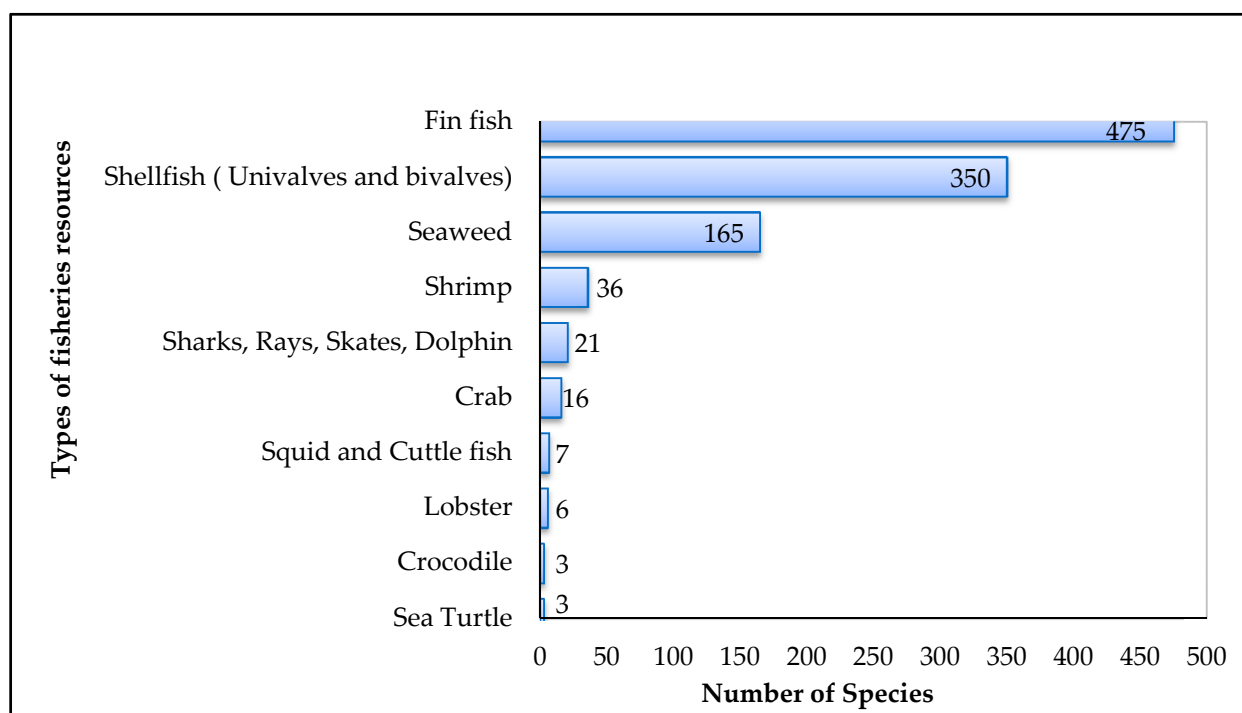


Figure 3. Coastal and marine fisheries resources in Bangladesh [29]. Data source: Food and Agricultural Organization of the United Nations (FAO) [29].

Marine fisheries production contributes only 15% to overall national fish production (Table 1) [29,30]. The coastal fisheries resources are over-exploited, and as a result, the fish stocks and other resources have declined. Numerous surveys examined the status of marine fisheries resources between the 1970s and 1980s, but no current or comprehensive knowledge is available on the fisheries stocks, nor the systematic, biological, and ecological aspects of Bangladesh's coastal and marine fisheries [31,32]. The main commercial fishing zones in the Bay of Bengal are Swatch of no Ground, Middle Ground, South Patches and South of South Patches [33,34]. Artisanal or subsistence fishing is conducted near the coastal areas of Bangladesh. Hilsa shad, sardine, Bombay duck, salmon, pomfret, jewfish, sharks, and rays, among others, are the dominant species captured from marine and coastal water areas [7].

Although the production growth rates fluctuate among the sub-sectors of inland fisheries, the total annual production had gradually increased over the past decade (financial years of 2008–2009 to 2018–2019) and developed a solid ground for stable aquaculture and fisheries production (Table 5).

Table 5. Sector-wise annual fish production from financial years of 2008–2009 to 2018–2019 in Bangladesh.

A. Inland Fisheries	Year-Wise Fisheries Production (Metric Tonnes)										
	2008–2009	2009–2010	2010–2011	2011–2012	2012–2013	2013–2014	2014–2015	2015–2016	2016–2017	2017–2018	2018–2019
(a) Inland (Capture)											
1. River	138,160	141,148	144,566	145,613	147,264	167,373	174,878	178,458	271,639	320,598	325,478
2. The Sundarbans	18,462	20,437	22,451	21,610	15,945	18,366	17,580	16,870	18,086	18,225	18,282
3. Beel	79,200	79,209	81,564	85,208	87,902	88,911	92,678	95,453	98,117	99,197	99,890
4. Kaptai Lake	8590	7336	8980	8537	9017	8179	8645	9589	9982	10,152	10,578
5. Floodplains	843,671	781,807	797,024	696,127	701,330	712,976	730,210	747,872	765,782	768,367	781,481
(b) Inland (culture)											
1. Pond	912,178	1,140,484	1,219,736	1,392,412	1,446,594	1,526,160	1,613,240	1,719,783	1,833,118	1,900,298	1,974,632
2. Seasonal culture	35,842	46,902	51,230	132,163	200,833	193,303	201,280	207,658	215,547	216,353	217,340
3. Baor	5038	8727	4864	5186	6146	6514	7267	7729	8002	8072	10,343
4. Shrimp	145,585	155,866	184,939	196,306	206,235	216,447	223,582	239,798	246,406	254,367	258,039
5. Crab	-	-	-	-	-	-	-	13,160	14,421	11,787	12,084
6. Pen culture	-	-	-	-	-	13,054	13,070	13,364	13,368	10,285	12,361
7. Cage culture	-	-	-	-	-	1447	1969	2062	2490	4253	3802
B. Marine Fisheries											
1. Marine Industrial	35,429	34,182	41,665	73,386	73,030	76,885	84,846	105,348	108,479	120,087	107,236
2. Marine Artisanal	479,215	483,100	504,668	505,234	515,958	518,500	515,000	521,180	528,997	534,600	552,675
Total (MT)	2,701,370	2,899,198	3,061,687	3,261,782	3,410,254	3,548,115	3,684,245	3,878,324	4,134,434	4,276,641	4,384,221
Growth rate (%)	5.39	7.32	5.6	6.54	4.55	4.04	3.84	5.27	6.6	3.44	2.52

Data source: Department of Fisheries (DoF) [7].

4. Fish Production Trends in Bangladesh from 1983–1984 to 2017–2018

Bangladesh's total inland open water fish production in 2003–2004 was 732,067 MT, which slowly increased and reached 1,235,709 MT in 2018–2019 (Figure 4) [7]. Whereas inland closed water fish production in Bangladesh has doubled in the last decades, inland open water production has been slower to increase. It was reported that the country's total inland closed water fish production was 914,752 MT in 2003–2004 and had become 2,405,415 MT by 2017–2018. The country's total marine water fish production was 455,207 MT in 2003–2004 and had become 654,687 MT by 2017–2018. However, during the last three years, a slight increase in marine water fish production was observed, while it remained more or less constant in 2015–2018.

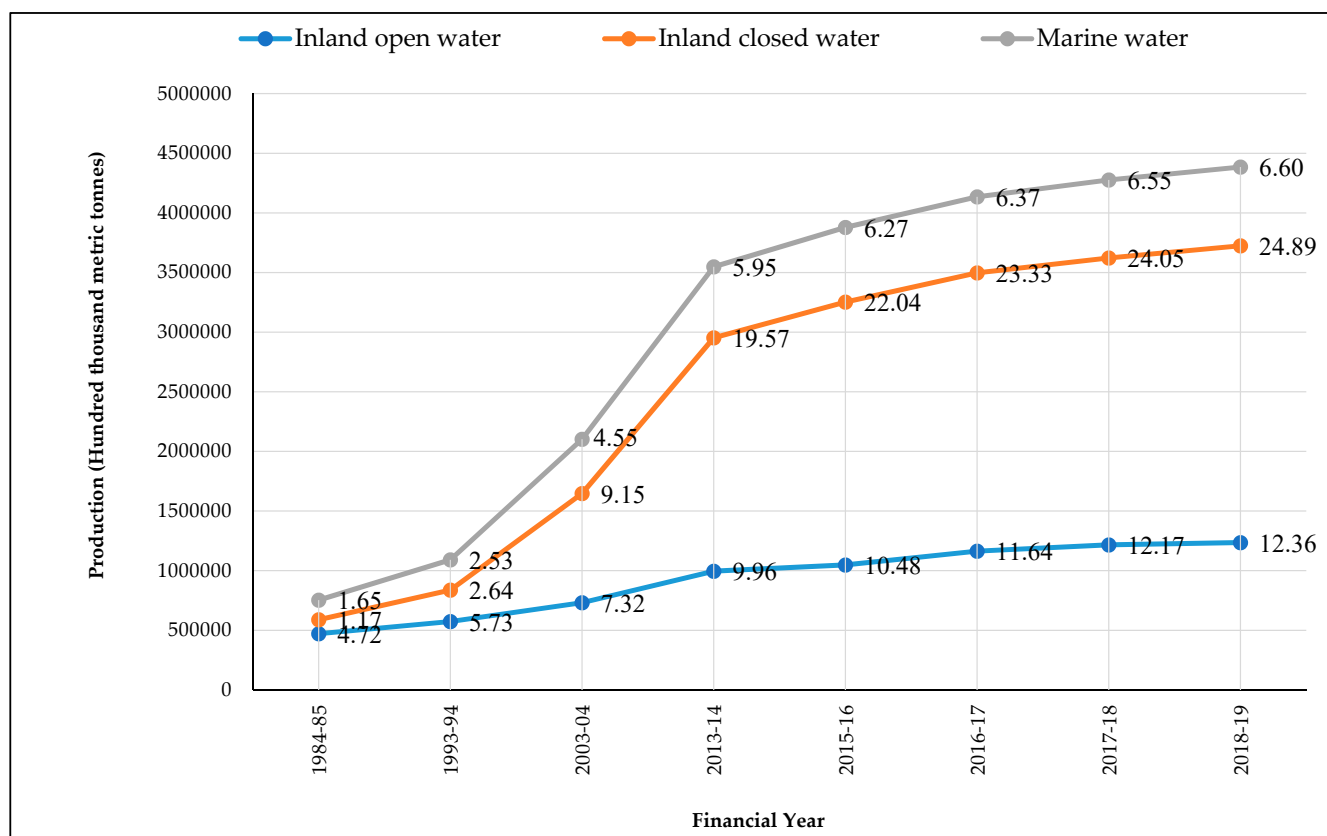


Figure 4. The trend of fish production in Bangladesh (1983–1984 to 2018–2019). Data source: Department of Fisheries (DoF) [7].

5. Export of Fish and Fishery Products

The fisheries sector of Bangladesh has emerged as the second most essential contributor to export earnings. Ten categories of fishery products (frozen freshwater fish, frozen marine water fish, frozen shrimp, chilled fish, live fish, dry fish, salted and dehydrated fish, kuchia (*Monopterusuchia*) and crab (*Scylla* sp.) in live condition, and fish scales/shrimp skulls) are exported from Bangladesh to more than 55 countries. The shrimp export destinations are highly concentrated in the European Union (EU). More than 45% of fishery exports (by quantity) were exported to the EU in 2015. The remaining 55% were exported to the USA, Japan, Russia, China, Thailand, Vietnam, India, Malaysia, Philippines, and Saudi Arabia [11,35,36]. The year-wise annual export value was highest in 2013–2014, but during the last three years (2015–2019), the export value and quantity sharply decreased compared to previous years (Figure 5) [7].

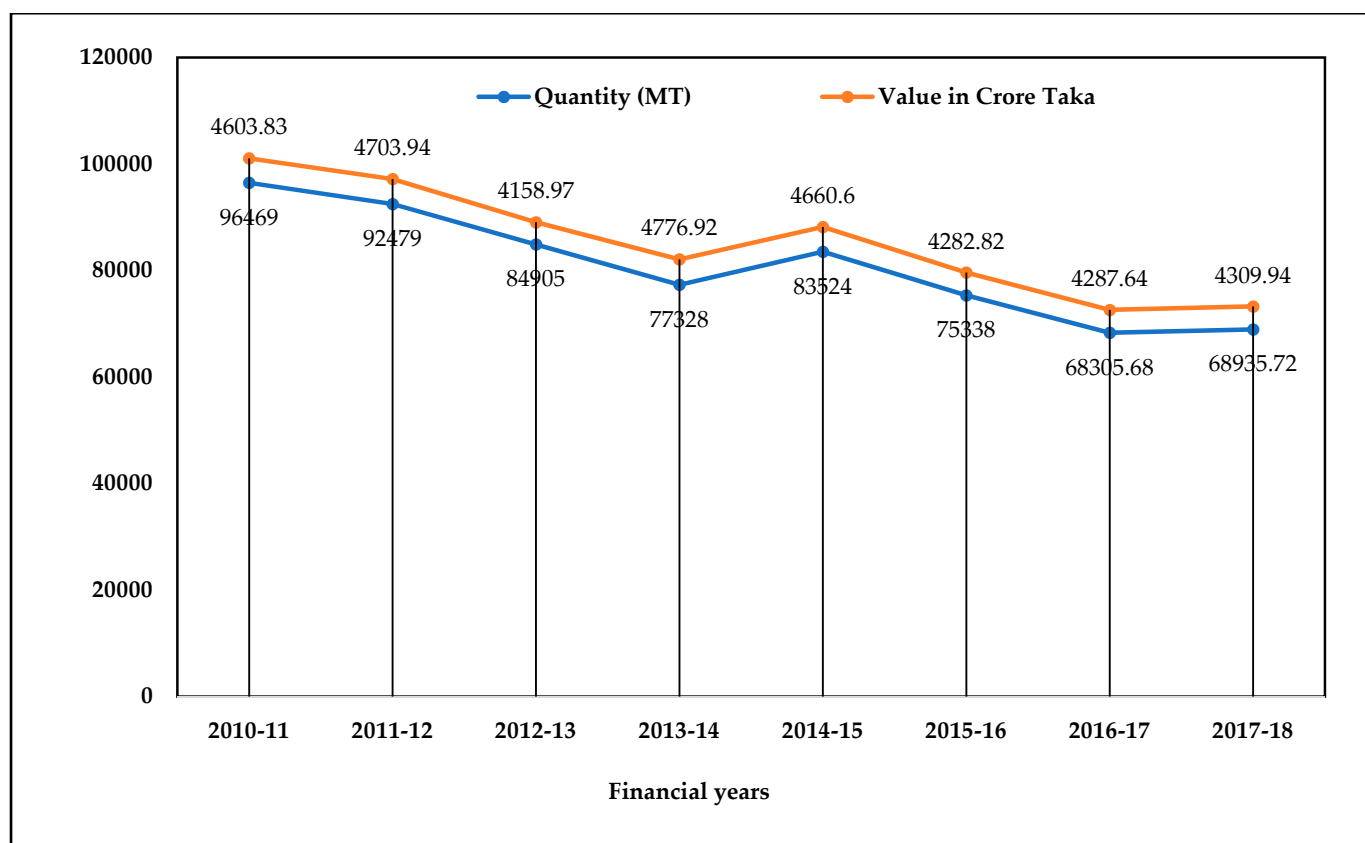


Figure 5. Year-wise annual export value of fish and fisheries product in BDT. Data source: Department of Fisheries (DoF) [7].

6. Fisher's Livelihood and Vulnerabilities: Observations from Fieldwork

The research findings showed that most fishers had inadequate income and poor housing facilities, which is concordant with other studies' findings in Bangladesh [37,38]. Fishers were identified as having not received proper institutional education and bearing the responsibilities of large family sizes [39,40]. They, in turn, cannot afford to send their children to school, which is relevant to SDG 4 which addresses access to quality education. However, most fishers reported having sanitary latrine facilities (related to SDG 3: good health and well-being) and using solar power as a primary source of electricity.

The fishers were not concerned about the nutritional value of foods and consumed fish as it was all they could afford fish. Fishers reported a reliance on loans to maintain their family during hard times and for the purchase of fishing equipment (e.g., net, fishing pot, boat, etc.). They faced several constraints, as outlined in Figure 6. The significant constraints included natural calamities, a reduction in fish catches, an unsatisfactory law and order situation, a lack of access to credit, ban periods, environmental degradation in coastal areas, a lack of alternative income-generating activities (IGAs), lack of community-based organisation, lack of infrastructure, the burden of *Dadon* (rent money), inadequate market facilities, and the loss of fishing equipment. Dependency on a single livelihood option, namely, fishing, increases their vulnerability. Conflicts between stakeholders, such as boat owners and moneylenders, also hampered financial stability and made illegal fishing an attractive option [41,42]. The livelihood status of the fishing communities was also affected by various types of seasonal stress. The ban period and the seasonal shifts in the fish availability make the fishers more vulnerable.

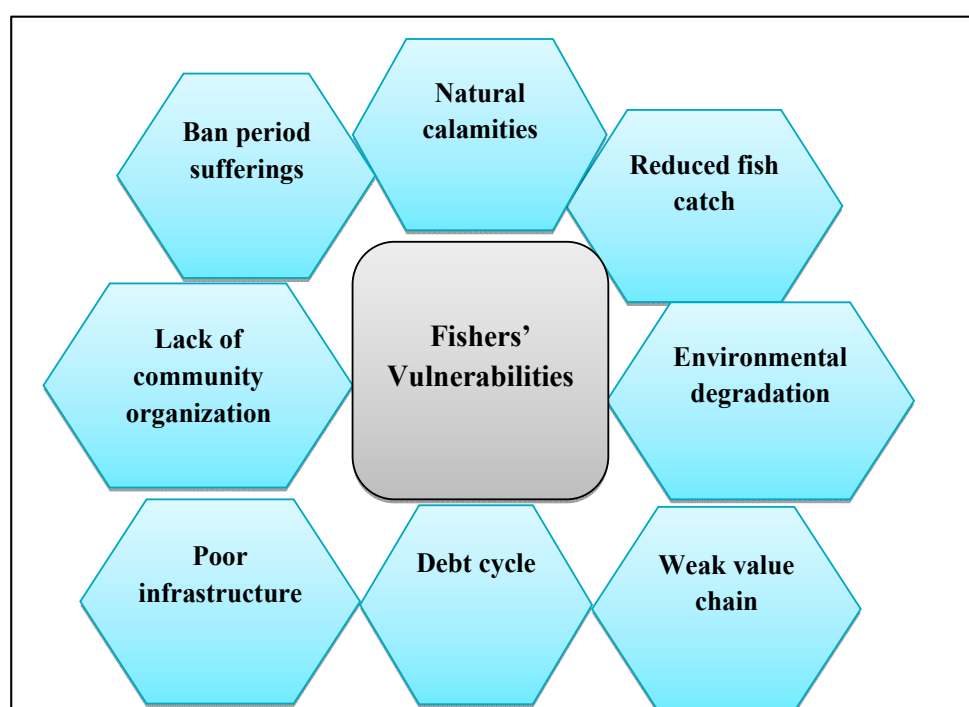


Figure 6. Fishers' vulnerabilities (contextually modified after Sunny et al., 2021 [8]).

Shocks, including natural disasters such as floods, droughts, cyclones, earthquakes, landslides, disease epidemics, and sudden economic changes, affect the livelihood of fishers. In the fishery context, cyclones and floods have a devastating effect on life and property (SDG 13: climate action). Loss of life (loss in human capital), physical infrastructure, and assets, such as the loss of fishing gear, roads, bridges and transport linkages, limit the access to health and education services and employment opportunities in other sectors. Compared with farming communities, coastal fishing communities are more susceptible to inclement weather conditions [43,44].

7. COVID-19 Scenario and Responses in Bangladesh

Bangladesh is facing momentous challenges in tackling the COVID-19 pandemic after confirming the first COVID-19 case within its borders on 8 March 2020 and the first death shortly thereafter on 18 March 2020. The media and some academics believe that COVID-19 may have been present in Bangladesh earlier, but not remained unidentified due to insufficient monitoring and inadequate testing [45]. While the number of infected cases remained low until the end of March 2020, in April, the suspected case rate showed a sharp rise with the new suspected rate in Bangladesh reaching 1155% in mid-April when 186% was the highest in Asia, placing the country ahead of India, Indonesia, Thailand, and Sri Lanka [8]. On 31 May 2020, a total of 312,061 suspected cases were tested, of which 47,153 cases were confirmed positive; there were also 9781 recovered cases, and the total number of deaths increased to 650. As time passed, the country experienced an increase of COVID-19 in all divisions. As of 1 August 2021, the highest increase in cases was observed in the Dhaka division (760,062 cases), followed by the Chattogram division (181,832 cases), Khulna division (93,644 cases), Rajshahi division (83,558 cases), Rangpur division (44,875 cases), Sylhet division (39,966 cases), Barishal division (33,870 cases), and Mymensingh division (26,521 cases). The number of recovered and death cases has also increased simultaneously (Figure 7).

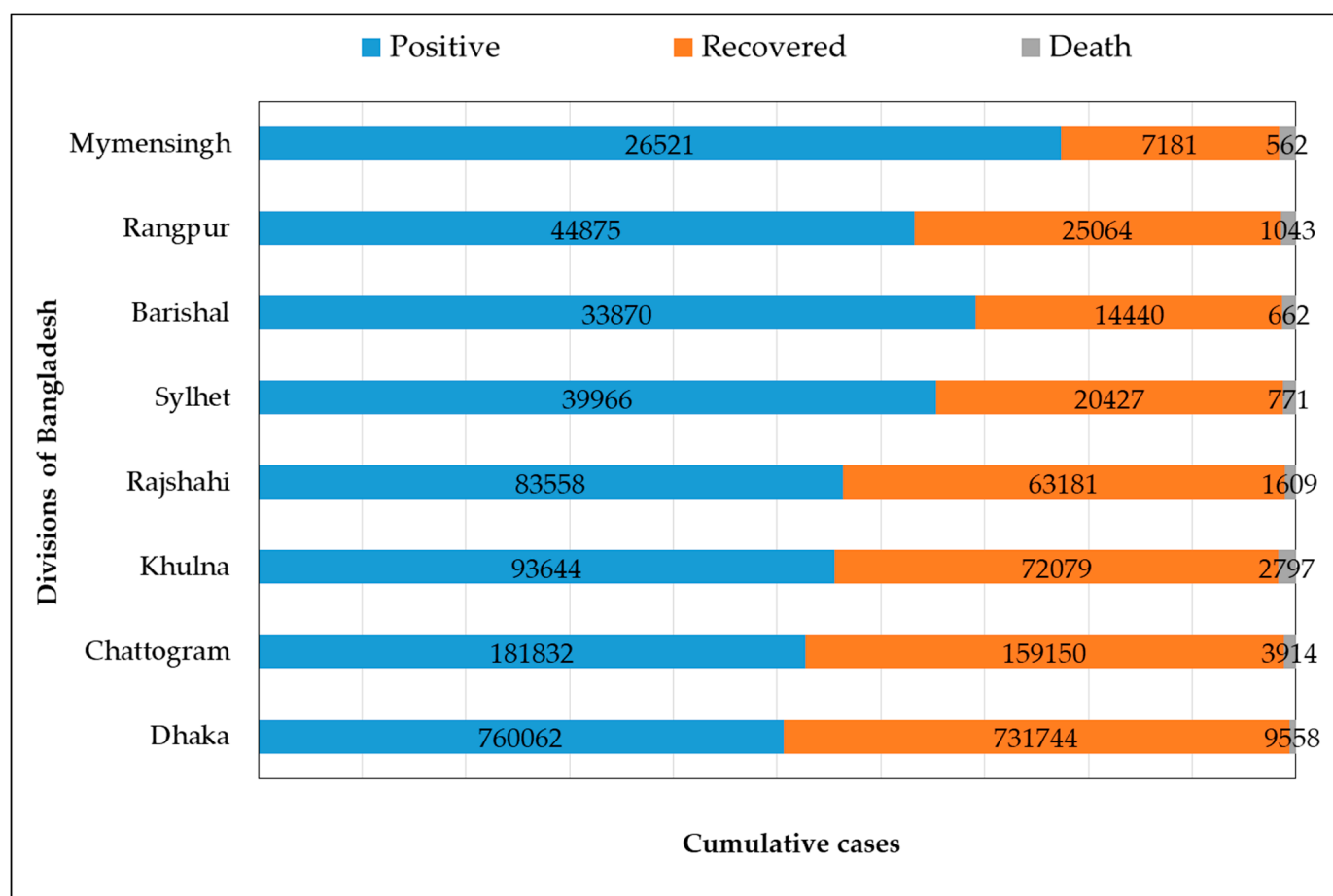


Figure 7. Positive, recovered, and death statistics of COVID-19 in Bangladesh.

In the early stages of COVID-19 in Bangladesh, there were no strict protocols nor lockdowns. To control the transmission of the virus, the Bangladesh government suspended on-arrival flights from all European countries on 14 March 2020, shut down all educational institutions on 17 March 2020, and deployed troops for quarantine supervision on 19 March 2020. The government of Bangladesh declared a ten-day nationwide lockdown for the first time on 23 March 2020, effective from 26 March to 04 April 2020. On 1 June 2020, the restrictions were eased despite the growing number of COVID-19 cases and associated deaths. All offices, shops, and public transportation were restricted, following the strict health guidelines. On 25 October 2020, the Bangladesh government implemented a new policy to wear face masks as “no mask, no service in government and private offices” (Table 6). In the second wave of the coronavirus outbreak in Bangladesh, seven days of controlled movement was imposed all over the country on 5 April 2021. On 14 April 2021, a strict lockdown was imposed until 21 April and later extended to May, closing all government and non-government organisations, except emergency services. The government imposed another lockdown, to control the spread, from 1 July until 07 July, but it was later extended until further notice.

Table 6. Snapshot of COVID-19 response in Bangladesh.

COVID-19 Response	
8 March 2020	First COVID cases identified
14 March 2020	Shut down of all educational institution
15 March 2020	Banned flights from Europe
18 March 2020	First death and banning of all types of gatherings
26 March 2020	Nationwide lockdown declared
1 June 2020	Eased restrictions despite ongoing pandemic
25 October 2020	Implemented “no mask, no service” policy
19 December 2020	Closure of educational institutions extended
5 April 2021	Imposed seven days-controlled movement
14 April 2021	Strict lockdown imposed
1 June 2021	Eased restrictions despite ongoing pandemic
1 July 2021	Strict shutdown imposed

8. Impact of COVID-19 on Bangladesh Fisheries

This section presents the quantitative and qualitative findings to identify the impact of the COVID-19 pandemic on the fisheries sector.

8.1. Perceived Impacts of COVID-19 on the Fisheries Sectors

The COVID-19 pandemic has seriously hampered fishing, fish farming, and fish marketing activities and impacted the livelihood of fishery-dependent communities. Respondent perceptions of the COVID-19 impact on the fisheries sector were explored through seven statements with five-point Likert scales (Table 7). Participants strongly believed that the pandemic negatively impacted fish production, fishing activities, household food consumption, and income. Some perceived the pandemic to be associated with increased conflicts and stress.

Table 7. Perceptions of the respondents on the influence of COVID-19 on the fisheries sector of Bangladesh.

Questions Related to Impact COVID-19: COVID-19 Has	Responses (%)				
	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree
Negatively influenced fish production	59.00	22.00	19.00	0.00	0.00
Negatively influenced fishing	55.70	33.30	7.70	0.00	0.00
Negatively impacted household food consumption	27.90	47.20	15.40	5.20	4.30
Negatively influenced income	59.80	25.90	14.30	0.00	0.0
Increased conflicts	3.50	21.50	40.90	24.10	10.00
Increased hygiene practice	0.00	11.00	51.00	23.00	15.00
Increased stress	2.90	9.10	45.20	32.80	10.00

Data source: Field survey, 2021.

8.1.1. Markets

COVID-19 has drastically transformed Bangladesh’s fish markets, homestead, and commercial aquatic food production system (SDG 12: responsible production and consumption). Usually, marginalised fish farmers cultured fish to meet their nutritional demands and sold any remaining fish to supplement their family income. COVID-19 impacted the supply of farming inputs and restricted farmers to the home, which decreased business profitability. During the first weeks of lockdown, the fish prices fell in alignment with the reduced demand, despite fish being the most consumed animal-source food in Bangladesh (SDG 14: life below water). Fish farmers and vendors reported transportation of fish, fingerlings, feed, and other inputs as a main problem, and more than 58% of fish farmers indicated that they could not sell their marketable fish due to transportation complexity

and low market demand. As a result, a good portion of mature fish remained unsold, with farmers spending extra money to feed them, which ultimately increased expenditures and reduced the family income (SDG 12: responsible production and consumption). Generally, low-income workers are the primary consumers of pangus (*Pangasianodon hypophthalmus*) and tilapia (*O. niloticus*), which are produced inexpensively all over the country. Nevertheless, at the start of COVID-19, millions of workers migrated back to their hometowns, thereby reducing demand, and the price of pangus in the retail markets decreased from BDT 120/kg to BDT 60/kg.

COVID-19 also affected the livelihood of crab farmers and traders as exports were indefinitely postponed. With China as the primary export market for crabs, and due to an import ban on 25 January, the export market of crabs remains closed. According to the Rampal-Bagerhat Crab Dealers Association, the main import target is the Chinese New Year festival, which was hindered due to the export ban with many crabs dying as a result of COVID-19 restrictions [45–48]. Though COVID-19 restrictions reduced the export opportunities, however, they opened the door to local markets and increased the access to fishery items. During the COVID-19 pandemic, local people were able to access fishery items that were previously relegated to the seafood processing industry and considered export items. The increased supply of fish in the local market reduced its price and the income of fishers.

8.1.2. Fishers

In Bangladesh, April and May are the best time to release fry into farming ponds, and between March and April, fish farmers prepare the pond for the new season by selling the mature fish from the previous year. About 39% of the fish farmers and vendors claimed that they could not start a new farming cycle due to unsold mature fish (SDG 12: responsible production and consumption). It also affected the supply chain, as the local vehicles, such as trucks, pickups, and vans, were hesitant to transport fish fingerlings, feed, and other materials; because of the lockdown, transporters often face various obstacles and fines that adversely impact the fish landing centre, wholesale, and retail market. During the early phases of the pandemic, very little fishing is thought to have taken place even though no regulations were preventing it. Fishers were compelled to stay at home and were hesitant to fish when the demand for fish was decreasing [45]. Many fishers and entrepreneurs lost their income at the beginning of the crisis when they could not arrange transport for their most recent catch.

March to April was also the seasonal hilsa conservation ban period, which affects the fishing communities in the major rivers of Bangladesh. During the ban period, a restriction is imposed in all hilsa sanctuaries, and, with the seasonal ban period, the lack of alternative sources of income increased the vulnerability of these communities in addition to the COVID-19 crisis. The government-provided-subsidisation was far less than what was required for the fishers to maintain their wellbeing (SDG 1: no poverty). It was also reported that many fishers were unable to receive this support due to nepotism [8,49,50].

8.1.3. Fish Farmers

In Bangladesh, March and April are the peak season for fish stocking, which coincided with the beginning of the COVID-19 crisis that began in March 2020, just before peak harvest season. As the prices and demand for fish were decreasing gradually and transportation systems broke down, most farmers decided to retain their fish in their ponds instead of harvesting them (SDG 12: responsible production and consumption). One interviewee predicted that the price of fish might remain low even after the pandemic when other farmers also begin harvesting fish, and that the surplus supply will depress prices further.

Traders usually pay fish farmers after the fish are sold. With COVID-19, farmers fear losing their income if the traders are unable to sell the fish, while unsold fish cannot be returned due to transport disruptions and a lack of storage options. Due to the delayed harvesting of mature fish, the fry cannot be stocked at the onset of the monsoon (the start

of the primary growing season), which may reduce the supply of fish in the first half of 2021 [8].

8.1.4. Seed

In Bangladesh, the COVID-19 crisis started in March 2020; March is the peak season for hatchery owners to sell their fish seeds and ready themselves for a new production cycle. The demand for fish seed fell dramatically due to farmers' uncertainty and the inability to harvest (SDG 12: responsible production and consumption). In some hatcheries, due to the lack of separate nursing ponds, they were unable to store seed five to seven days more. One of the hatchery specialists from the Jessore district reported that, while the hatchery had remained closed, they had to pay the hatchery staff. Another hatchery manager from Mymensing informed us that, due to COVID-19, they had to sell their seed at a low price, and that most hatcheries and farmers doubted whether they would get their production cost or not. Hatchery owners from Northwest Bangladesh were reported to have reduced production by at least 30–40%, and four out of twenty-one have shut down completely. Credit facilities for supplying fry to farmers are no longer possible as nurseries face a liquidity crisis due to a lack of sales. Hatchery inputs, such as pituitary glands, hormones, and probiotics, are imported from outside Bangladesh. Due to lockdown, the inputs import has become more challenging. The price of the pituitary gland has tripled since the crisis started. Due to the COVID-19 lockdown, transporting hatchery inputs and fry is a crucial challenge faced by fish hatcheries, nurseries, and fish farmers [51].

8.1.5. Feed

Most of the feed mills import their ingredients to produce feed. Due to the COVID-19 situation, importing goods has become more challenging as a result of the price hike and transportation complexity. Experts predicted a 42% reduction in feed supply due to input shortages and low demand. As the feed production costs increased, this led to speculation on whether millers will compromise the feed quality. Commercial small-scale producers are concerned about feed access.

9. Prospects, Development-Relevance and Linkage of Fisheries and Aquaculture Sectors in Achieving SDGs in Bangladesh

Bangladesh achieved a prestigious global position due to its outstanding production of inland open water capture fisheries (third) and culture fisheries (fifth) [7]. Globally, 60% of total hilsa (*Tenualosa ilisha*) production is from Bangladesh [8]. The fisheries and aquaculture sectors are inextricably linked to achieving several SDGs and have development relevance (e.g., economic, social, and environmental) in Bangladesh. Among the 17 SDGs, these sectors directly or indirectly contribute to achieving several SDGs, such as eliminating poverty (SDG 1), reducing hunger (SDG 2), promoting good health and well-being (SDG 3), establishing decent work and economic growth (SDG 8), influencing responsible consumption and production (SDG 12), organising climate action (SDG 13), developing life below water (SDG 14), and advancing life on land or life above water (SDG 15) (Table 8).

9.1. Prospects of Inland Closed Water

Inland closed water fish production is almost saturated, but a five-fold increase in production will be needed within the next five decades to maintain current levels of aquatic food intake (SDG 12: responsible production and consumption). Bangladesh has advanced technology, such as RAS (re-circulatory aquaculture system), biofloc, and aquaponics [2]. These technologies are considered eco-friendly alternatives of fish culture, a less disease-prone system, which enhances productivity and, consequently, sustainable production.

Table 8. Prospective linkage of fisheries and aquaculture sectors with achieving the SDGs in the context of Bangladesh.

The United Nations Sustainable Development Goals SDGs (1–17)	Direct or Indirect Linkage with Fisheries and Aquaculture Sub-Sectors			Linked with the Dimensions of Sustainable Development
	Inland Closed Water (Culture)	Inland Open Water (Capture)	Marine Water (Capture)	
Eliminate poverty	High	High	Medium	1, 2
Erase hunger	High	High	High	1, 2
Establish good health and promote well-being	High	Medium	Medium	1, 2
Provide inclusive and equitable quality education	Low	Low	Low	1, 2
Gender equality and women empowerment	Low	Low	Low	2
Ensure clean water and sanitation	Low	Low	Low	3
Affordable, reliable, and modern clean energy	Low	Low	Low	3
Create decent work and promote economic growth	Medium	Medium	Low	1, 2
Increase industry, innovation, and infrastructure	Medium	Medium	Medium	1, 3
Influence reduction of inequalities	Low	Low	Low	2
Mobilise sustainable cities and communities	Low	Low	Low	2
Ensure responsible consumption and production	High	High	High	1, 2
Climate action to combat climate change impacts	Low	Low	Low	3
Develop life below water or conserve and sustainable resource utilisation	Very high	Very high	Very high	1, 2, 3
Advance life above water or life on land	Low	Low	Low	3
Assurance peace, justice, and strong institutions	Low	Low	Low	2
Build and strengthen global partnerships for the sustainable development	Low	Low	Low	1, 2

Criteria and scores are based on the authors' critical qualitative evaluations of field observations and experiences. Low (too little, scant or negligible linkage, score: 0–25); Medium (moderate or mild linkage exists but not well-defined, score: 26–50); High (good linkage, nevertheless, still needs to be defined clearly, score: 51–75); Very high (direct linkage with clear definition, score: 76–100) The idea of contextualising and generating this table benefited from Wang et al. (2020) and de Bisthoven et al. (2020) [52,53]. Potentially linked with dimensions of sustainable development indicates: (1) economic growth, (2) social inclusion, and (3) environmental protection.

9.2. Prospects of Inland Open Water

Although Bangladesh is blessed with substantial open water resources (SDG 14: life below water), only 28% of fish production derives from closed inland waters. Increasing production requires the promotion of the pen and cage culture system. It is estimated that only 1.29 lakh m³ and 5294 ha are under the cage and pen culture system. For example, the community-based fisheries management, i.e., the Daudkandi model of community floodplain aquaculture [54,55], is expected to improve fisher access, livelihoods, and the sustainability of the fisheries sector. Co-management of natural wetlands could be another option to protect and increase the biodiversity and livelihood of the dependent community [9].

9.3. Prospects of Marine Fisheries Resources

The utilisation of marine resources by implementing proper management strategies is essential to meet SDG 14 (life below water). Following prospects will open the door for establishing a special economic zone to develop the southern part of Bangladesh.

9.3.1. Blue Economy

The blue economy is an emerging concept in Bangladesh, which refers to the ocean, seas, and coast [56,57]. Ocean resources are a potential resource for increasing food security, improving nutrition and health, alleviating poverty, creating jobs, generating alternative energy, seaborne trade, and industrial profiles (SDG 1: no poverty; SDG 2: zero hunger; SDG 3: good health and well-being; SDG 10: reduced inequalities) [58,59]. According to

expert opinion, Bangladesh would extract about USD 1.2 billion from its substantial marine resources [60,61]. It will be a stepping stone to meet the Vision-2041 of Bangladesh if the resources are sustainably extracted and adequately used. It is possible to achieve 5% of the GDP by 2030 through the utilisation of sea resources.

9.3.2. Biotechnology and Marine Genetic Resource

Marine biotechnology can address several global challenges, including, but not limited to, human health, sustainable food supplies, environmental remediation, and energy security [62]. Many marine resources are a significant source of potential drugs, particularly antibiotics. For example, in 2017, there were over 36 marine-derived drugs in clinical development, including 15 to treat cancer [63,64].

9.3.3. Research

Research works related to marine fisheries resources and their production performance are very limited in Bangladesh. Therefore, appropriate research works on marine fisheries are required. Several marine fishery academies and institutes are available in Bangladesh, which can significantly increase marine fisheries production.

10. Challenges of Fisheries and COVID-19 Nexus to Achieve SGDs and Recovery Plans

Short-term and long-term recovery plans can potentially tackle the COVID-19 crisis in terms of addressing the immediate need and durable requirements for the sustainable recovery of the fisheries sector. Some recovery plans elicited from community perception and the authors' suggestions are discussed below.

10.1. Need for Emergency Financial and Non-Financial Support

The overall income of fish farmers, fishers, and relevant stakeholders was severely affected, influencing the violation of fisheries rules. Immediate financial support, such as a rationing system as well as psychological counselling, could be effective. An urgent management strategy needs to be developed and implemented to save the livelihoods of fishers, hatcheries, feed industries, and other stakeholders [53].

10.2. Building Resilient Fisheries and Aquaculture Sector

During the COVID-19 lockdown and imposed restrictions, many fishers and fish labourers lost their income. In order to make the fisheries and aquaculture sector resilient, emphasis should be given to increase the capacity of the stakeholders by providing subsidies, incentives, interest-free loans, and alternating income-generating options.

10.3. Addressing Potential Threats in Aquatic Biodiversity

The degradation of aquatic biodiversity is one of the primary concerns in Bangladesh. IUCN assessments show that 64 out of 253 fish species are threatened, 9 are critically endangered, 30 are endangered, and 25 are vulnerable [56,65]. Excessive use of surgical face masks, disinfectants, hand sanitiser, and other pharmaceutical chemicals may also induce threats and water pollution. The return of the unemployed in the fishing sectors may increase overfishing and impose threats to biodiversity. A comprehensive management strategy including, but are not limited to, an awareness program is required for biodiversity conservation and COVID-19 risk mitigation.

10.4. Integrating Climate Change Risks with the Responses of COVID-19

Bangladesh is highly sensitive to climate change due to its geography, and experiences frequent floods and cyclones (SDG 13: climate action) [66,67]. The current pandemic affects the coping strategy of fishers and the domestic food supply [24,48,49]. Developing appropriate technology and management strategies for resilient inland and marine fisheries is a mandate for Bangladesh, integrating climate change and COVID-19.

10.5. Initiatives to Address the Risk of Orders Cancellation by Foreign Buyers

During the lockdown, foreign shellfish buyers cancelled their orders due to border travel restrictions, which was an alarming issue for the shrimp industry. Minimising the risk of such cancellations requires more initiatives by fisheries and transport sectors for the smooth and safe transport of fish products.

10.6. Developing Long-Term Strategies

A long-term management strategy is essential for the sustainable development of the fisheries sector and for tackling the COVID-19 pandemic threats. The human resources and budget allocation (0.56% of the national budget) for the fisheries sector should be increased. A package of development and extension projects need to be implemented at the marginal level to provide financial, technical, and moral support to the fish farmers and fishers.

11. Conclusions and Recommendations

Fisheries are crucial in the national macroeconomic, food and nutrition security perspectives (SDG 1: no poverty; SDG 2: zero hunger; SDG 14: life below water). The COVID-19 pandemic adversely affected the fisheries and aquaculture sectors in many ways. Therefore, efficient and sustainable management of aquatic resources is essential for the continued and significant contribution to the country's health and economic sector. Despite the enormous prospects and potential, several reasons, such as climate change, onshore coal-based power plant installation, a lack of scientific information, skilled human resources, and poor implementation of acts and rules related to marine fisheries, limit the fisheries resources, production, and performance. However, the supply of good quality seed, feed, and extension services could increase fisheries production in inland water bodies. To have a resilient coastal and marine aquaculture development, adopting appropriate technology is a prerequisite for Bangladesh. The development of communication and transportation systems for rapid access to information, coordination with the regional and international networks for updated technology, value chain, and proper utilisation of the marine resources is required to boost the total fisheries production of Bangladesh.

Policymakers should be more aware of their well-planned efforts to meet the SDGs that can also ensure precise and prompt functioning of the fisheries sector. Interdisciplinary coordination for enhancing investment, research infrastructure, environmental policies, and the introduction of modern storage and marketing facilities could rapidly improve the situation. Perceptions of small-scale fishers should be considered during the policymaking process. Particular strategies and emphasis are required to assess their vulnerability and sustainability. Attention should also be paid to the environmental abnormalities and constraints, such as frequent climatic disasters (SDG 13: climate action), a declining aquatic biodiversity trend (SDG 14: life below water), and increased water and air pollution trends, in connection with the success of the fisheries sector.

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