Fisheries in the context of attaining Sustainable Development Goals (SDGs) in Bangladesh: COVID-19 impacts and future prospects

Atiqur Rahman Sunny[1, 2], Shamsul Haque Prodhan[1], Md. Ashrafuzzaman[1], Mahmudul Hasan Mithun[3], Monayem Hussain[4], Md Tariqul Alam[3], Aminur Rashid[5], Mohammad Mosarof Hossain[6]

[1]Dept. of Genetic Engineering and Biotechnology, Shahjalal University of Science and Technology, Sylhet, Bangladesh
[2]Suchana project, WorldFish, Bangladesh Office, Banani, Dhaka, Bangladesh
[3]Department of Fisheries Biology and Aquatic Environment, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Bangladesh
[4]Ecofish-ll project, WorldFish, Bangladesh Office, Banani, Dhaka, Bangladesh
[5]Department of Aquaculture, Sylhet Agricultural University,Sylhet, Bangladesh
[6]Department of Coastal and Marine Fisheries, Sylhet Agricultural University,Sylhet, Bangladesh

Abstract

Bangladesh has achieved tremendous progress in the fisheries sector that is making evidential contribution to food security, nutrition and livelihoods. Based on secondary data collected from the Department of Fisheries, Bangladesh and related un-published grey literature, this paper highlights the performance and challenges of the fisheries with emphasis on COVID-19 impact as well as the significance of this sector for achieving the Sustainable Development Goals (SDGs). The total fish production is increased more than six times over the last three decades (7.54 to 43.84 lakh MT) due to the dissemination of improved culture techniques and extension services. Inland closed water contributions have been increasing to 16.24%, while inland open water have declined 10.23% and marine fisheries have dropped 6.27% over the past 18 financial years (2000-2001 to 2018-2019). COVID-19, a major health crisis has also affects various issues associated with aquatic resources and communities. Transportation obstacles and complexity in the food supply, abstraction to start production, labour crisis, sudden illness, poor consumer demand, commodity price hike, creditor's pressure and reduced income were identified as affecting COVID-19 drivers. The combined effect of these drivers poses a significant threat to people's income (SDG1- eliminate poverty), nutrition (SDG2- erase hunger), food security (SDG3- good health and wellbeing, and SDG12- responsible consumption and production) that demands comprehensive actions. Several recommendations have been elicited, which are important to implement for the achievement of SDGs as well management and imprvement of the aquatic sector (SDG14- life below and SDG16- life above water) .

Keywords: Aquaculture, Fisheries, Food security, SDGs, COVID-19, Bangladesh

Correspondence to: Dept. of Genetic Engineering and Biotechnology, Shahjalal University of Science and Technolohy, Sylhet, Bangladesh
Corresponding author: Atiqur Rahman Sunny
Email:atiksunny@yahoo.com

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1. Introduction

Bangladesh is blessed with a diverse aquatic resource located in Southeast Asia between 20°34' to 26°38' N latitude and 88°01' to 92°42' E longitude with an area of 1,47,570 sq. km [1]. It is one play a vital role in food of the top fish producing countries in the world with full of vast inland, coastal and marine water resources [2]. The fisheries sector in Bangladesh is one of the most productive and dynamic sectors which is playing 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 a very significant role in food security as well socioeconomics of the dependent community [5, 6] which are crucially highlighted in the UN Sustainable Development Goals (SDGs). There are different types of interactions between SDGs and aquatic food production systems and the wellbeing of the dependent community. Fish from capture fisheries and aquaculture and nutrition security, good health and well-being, poverty alleviation, reduced inequalities etc. by helping marginal people to maintain their food supply and livelihoods. Around 12% of the total population of Bangladesh is involved in the fisheries sector directly and indirectly [7]. It contributes 3.50% to the national GDP and around 25.72% to the agricultural GDP and also provides a significant share of (around 24%) animal proteins to the country population [7, 8].

The diversified fisheries resources of Bangladesh are mainly divided into two groups as inland and marine fisheries [3, 9]. Inland fisheries have two sub-sectors as inland capture and inland culture fisheries which covers an area of 3.89 and 0.82 million ha respectively (Table 01). The inland open water habitats include rivers and estuary (853,863ha), the Sundarbans (177,700 ha), Beel (114,161 ha), Kaptai lake (68,800 ha) and floodplain (2,675,758 ha) (Figure 01). On the other hand, inland closed water habitats include pond (397,775 ha), seasonal cultured water body (144,217 ha), Baor (5,671 ha), shrimp/prawn farm (258,553 ha), crab (9,377 ha), pen culture (6,330 ha) and 1.76 lakh cubic meter for cage culture [7] . During 2018-2019, the inland capture, inland culture and marine fisheries contributed about 28.19%, 56.76% and 15.05% of the country's total fisheries production respectively [7] (Table 01, Figure 02). Although inland capture fisheries are an important source of total fish production, yet has been reduced remarkably during the recent past decades due to several anthropogenic human interventions and natural causes e.g. pollution, over-exploitation, destructive fishing, habitat degradation etc. [10]. In 1983-84, the total production of inland capture and culture fisheries was 62.59% and 15.53% respectively; whereas in 2018-19, inland capture fisheries sharply dropped to 28.19% and inland culture fisheries increased to 56.76% [7]. However, In the recent past years' several

socio-eco-friendly programs are being implemented to increase the productivity of inland open waters such as community-based fisheries management program, the establishment of fish sanctuaries, beel nursery management, stocking of fingerlings in the water bodies, restoration of the aquatic habitats, increase in water area under cage and pen farming [11].

Bangladesh has huge potential for marine fisheries that comprises artisanal (fishing below 40 m depth), industrial (Trawl fishing above 40m 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, recently settled maritime boundary with Myanmar and India, up to 200 nautical miles from the coastline comprise 118,813 sq. km of maritime water huge prospects of blue economy development. Earlier potential and challenges of fisheries and aquaculture sector of Bangladesh were reviewed by Ghose (2014) up to the year 2012 and Shamsuzzaman et al. (2017) up to the 2015 year. Despite aquaculture and fisheries sectors providing crucial provision of wider societies and having strong linkages for achieving the several SDGs in the context of Bangladesh. Nevertheless, literature addressing the linkage of fisheries and aquaculture sector with development-relevance (e.g. economic, social and environmental dimension of sustainability) and achieving the SDGs are scarce. This review focuses on highlighting the potential and challenges of the fisheries and aquaculture sector in Bangladesh by bridging the gap of the existing situation (e.g. update status of the sector, COVID-19 pandemic impact on the aquatic resource system, involved stakeholders and dependent community). This attempt also reflecting the potential linkage and significance of this sector for achieving several SDGs in the context of Bangladesh.

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Table 01: Sector-wise fish production and water areas of Bangladesh in 2018-19) [7].

Fisheries types	Fisheries sector	Water area (Ha.)	Production (MT)	Production (%)
Inland Fisheries	**Inland open water (capture)** Rivers, Estuary, Sundarbans, Beel, Kaptai Lake, Floodplain	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	
	Artisanal fishing		552,675	
Total (Marine)			659,911	15.05
Total production (Inland + Marine)			4,384,221	100

The total fish production is increased more than six times (7.54 MT in 1983-84 to 43.84 lakh MT in 2018-19) over the last three decades, due to the dissemination of improved culture techniques and extension services at the farmer's level at a minimum cost. Bangladesh earns a lot of foreign exchange by exporting fish, shrimps and other fishery products. In 2018-19, the country earns BDT 4,25031.00 lakh (as per EPB) by exporting almost 73.17 thousand MT of fish and fishery products [7]. Although total fisheries production has increased over the recent years, marine fisheries production has not yet attained its optimum level.

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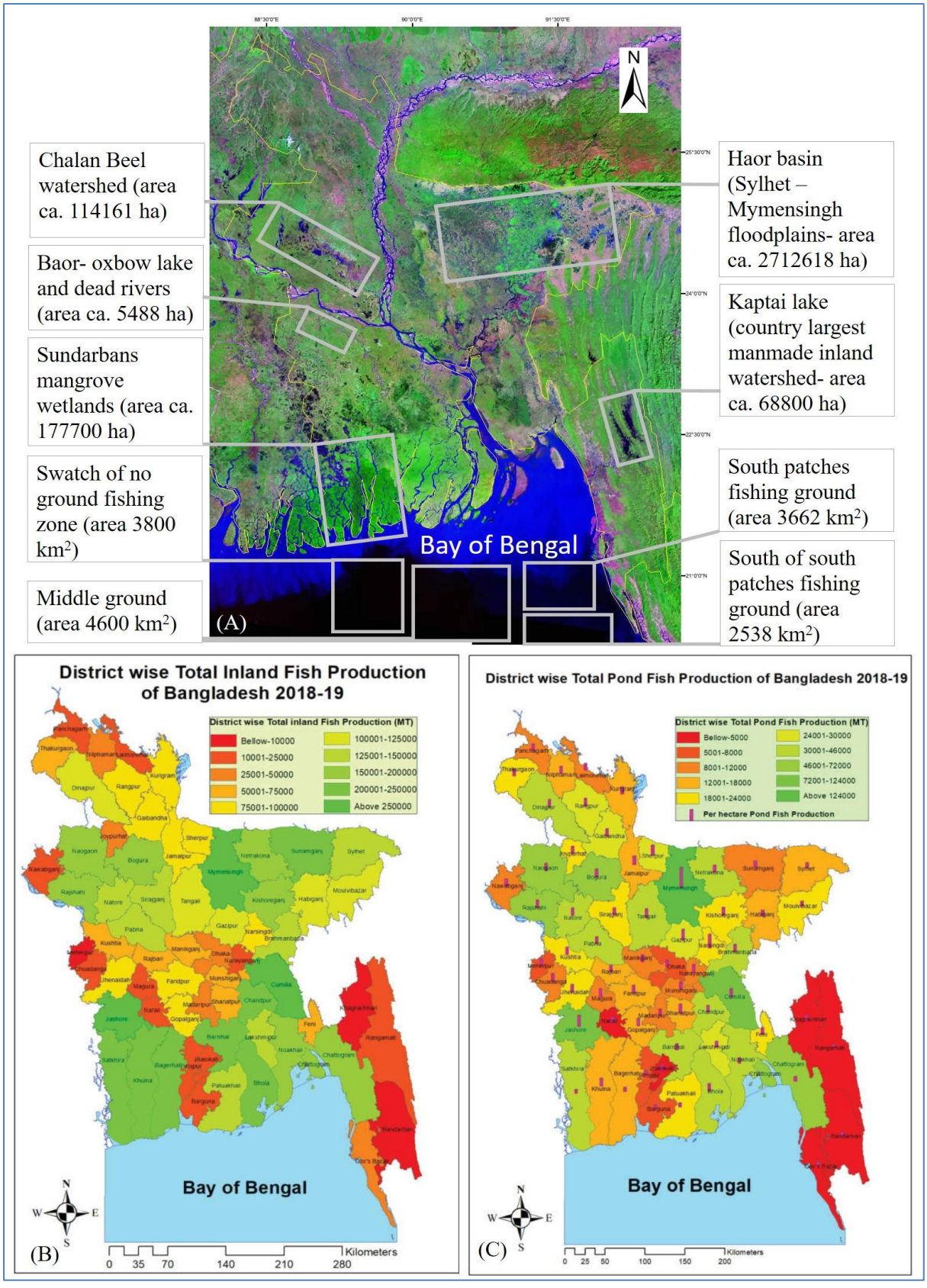

Figure 01: Aquatic resources, fisheries and aquaculture production in Bangladesh (A) focal natural waters including major fishing grounds in the Bay of Bengal (B) district wise inland (capture) fish production, & (C) district wise pond (culture) fish production (adapted and contextually modified from DoF) [7].

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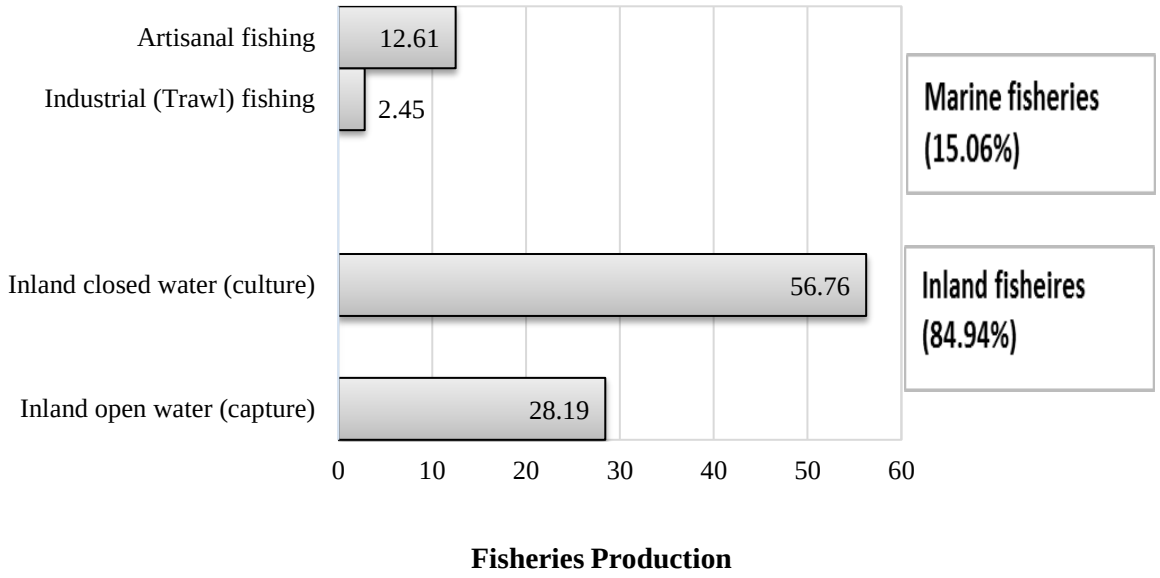

Figure 02: Sector-wise marine and freshwater fish production in 2018-19 of Bangladesh [7].

2. Present status of inland fisheries resources of Bangladesh

Inland fish production

Inland fisheries refer to the capturing and culturing of fishes in inland water. Bangladesh ranked 3rd in inland captured fisheries and ranked 5th in world aquaculture production [7]. However, in terms of production from single-species culture explicitly monoculture of Tilapia (*Oreaochromis niloticus*), Bangladesh ranked 4th in the world and became 3rd in Asia. The national fish hilsa (*Tenualosa ilisha*) solely contributed around 12.15% to the total fish production in the country and has been awarded the national Geographical Indication Registration Certificate [7, 8].

2.1. Inland open water fish production of Bangladesh

There are two fisheries sub-sectors in Bangladesh like inland and marine fisheries. Inland fisheries is sub-divided into inland capture (fishing from inland open water) and inland culture fisheries (aquaculture) while marine fisheries sub-divided into marine artisanal and marine industrial fisheries. The inland capture fishery contains five types of habitats and among them, the river and estuary cover approximately 853,863 ha. and the Sundarbans (world largest mangrove forest), Beel, Kaptai lake and floodplain covers approximately 177,700 ha. 114,161 ha, 68,800 ha and 2,675,758 ha respectively. The inland culture fishery contains seven types

of habitats like ponds, seasonal culture water body, Baor, shrimp and prawn farm, crab farm, pen culture and cage culture which covers approximately 397,775 ha, 144,217ha, 5,671 ha, 258,553 ha, 9,377 ha, 5,671 ha and 1.76 lakh cubic meter (m^3) areas respectively [7]. In 2018-19 the total fish production in Bangladesh was reported 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). As indicated in (Figure 01), inland open water fisheries are still a major source of total fish production, but their share has been declined from 38.68% in 2000-2001 [13] to only 28.19% in 2018-2019 [7]. Conversely, inland closed water fisheries contributions have been increasing from 40.01% in 2000-2001 [13] to 56.76% in 2018-2019 [7]. The contribution of marine fisheries over the same period has dropped from 21.30% in 2000-2001to 15.06% in 2018-2019 [7]. The average yield (annual fish harvest per hectare in metric tons) in open inland waters improved sharply in recent years (Table 05). The Beel fishery has high productivity of 875kg/ha than the other habitats of inland open water (Table 02). A total of 260 fish with 12 exotic fish and 24 prawn species have been recorded in Bangladesh and are known to inhabit the freshwaters of Bangladesh [14, 15]. Nowadays, major carps species such as Catla (*Catla catla)*, Rui *(Labeo rohita)*, Mrigal *(Cirrhinus mrigala)* 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 that are found in the market. There are about 40-50 small indigenous fish species that 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 lalius*), Koi (*Anabas testudineus*) and Baila (*Glossogobius giuris*). Several small indigenous species of fishes are now endangered or critically endangered in Bangladesh [14] although the inland water resources of Bangladesh offer major potential for the development of freshwater capture and culture fisheries [17, 18]. The catch from the inland capture fishery is noteworthy, especially for rural areas in terms of fish supply and employment. Species-wise annual fish production in inland fisheries for 2018-19 are presented in (Figure 03).

Table 02: Inland open water fish production of Bangladesh in 2018-2019 [7]

Inland open water (Capture fisheries)	Water Area (Hectare)	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

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2.2. Inland closed water (culture) fish production of Bangladesh

Inland closed water deals with the farming of fish and other aquatic organisms having economic importance and it may have multiple or sole ownership [19]. The total area of inland closed (culture) water bodies with coastal shrimp farms is about 0.79 million ha [11]. The overall pond area in Bangladesh is about 397,775 ha and ox-bow lakes (Baor) comprises 5,671 ha approximately [7]. The inland aquaculture has generally experienced the fastest growth with the adoption of advanced culture technologies, species intensification and improvement of farming systems, particularly in pond aquaculture, entirely over the country among various segments of the fisheries sub-sector [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 fisheries sectors over the last 10 years is about 5.01%, while aquaculture has grown 8.59%. Generally, two types of aquaculture are practised in Bangladesh such as freshwater and coastal aquaculture. Marine aquaculture is in its growing stage in the country and farming of marine fishes is highly significant. Freshwater aquaculture is mainly comprised of pond farming of carps (Indian major and Chinese carps), pangasius and other catfishes, tilapia, Mekong climbing perch 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 3,802 MT (0.09%) in the total fish production in 2018-2019, respectively (Table 04). These new methods have the highest potentiality to increase fish production in Bangladesh. Total fish production in pen culture decline than the previous years in 2018-2019, but the cage culture becoming more popular nowadays and the production rate has also increased during the last few 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 locally called *gher*) and in 2018-2019 the total production of shrimp and prawn was about 258,039MT. In Bangladesh, aquaculture production systems are mainly extensive and improved extensive, with some semi-intensive, and intensive systems, in very few cases [17]. The present 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 03). Inland pond culture represents the mainstay of aquaculture in Bangladesh, accounting for more than 80% of the total recorded aquaculture production. Inland close water body contributed 56.76% of the total fish production in 2018-2019 (Figure 02). Pond aquaculture is mostly practised closed water fisheries in Bangladesh and contributed 45.04% (1,974,632 MT) to the total fish production in 2018-19 [7]. The main

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cultured species in the coastal areas of Bangladesh are giant tiger prawn (*Penaeus monodon*) and giant river prawn (*Macrobrachium rosenbergii*) [21].

Table 03: Inland closed water fish production in 2018-2019 in Bangladesh [7]

Inland closed water	Water Area (Hectare)	Production (MT)	Productivity (Kg/ha)
Pond	397,775	1,974,632	,4964
Seasonal cultured water body	144,217	217,340	1,507
Baor	5,671	10,343	1,824
Shrimp/Prawn farm	258,553	258,039	998
Crab (capture and fattening cultı	9,377	12,084	1289
Pen culture	6,330	12,361	1953
Cage culture	176000 cubic meter (m^3)	3,802	22 kg/m^3

2.2.1. Species/group-wise annual fish production (MT) in inland water bodies (2017-18)

Major carps, Exotic carps, Pangus, Tilapia, Other inland fish and Hilsa are the dominant species from inland water area (Figure 03). Ilish alone contributes 12.15% of the country's total fish production and in 2018-19, the country's total hilsa production is 5.33 lakh MT [7].

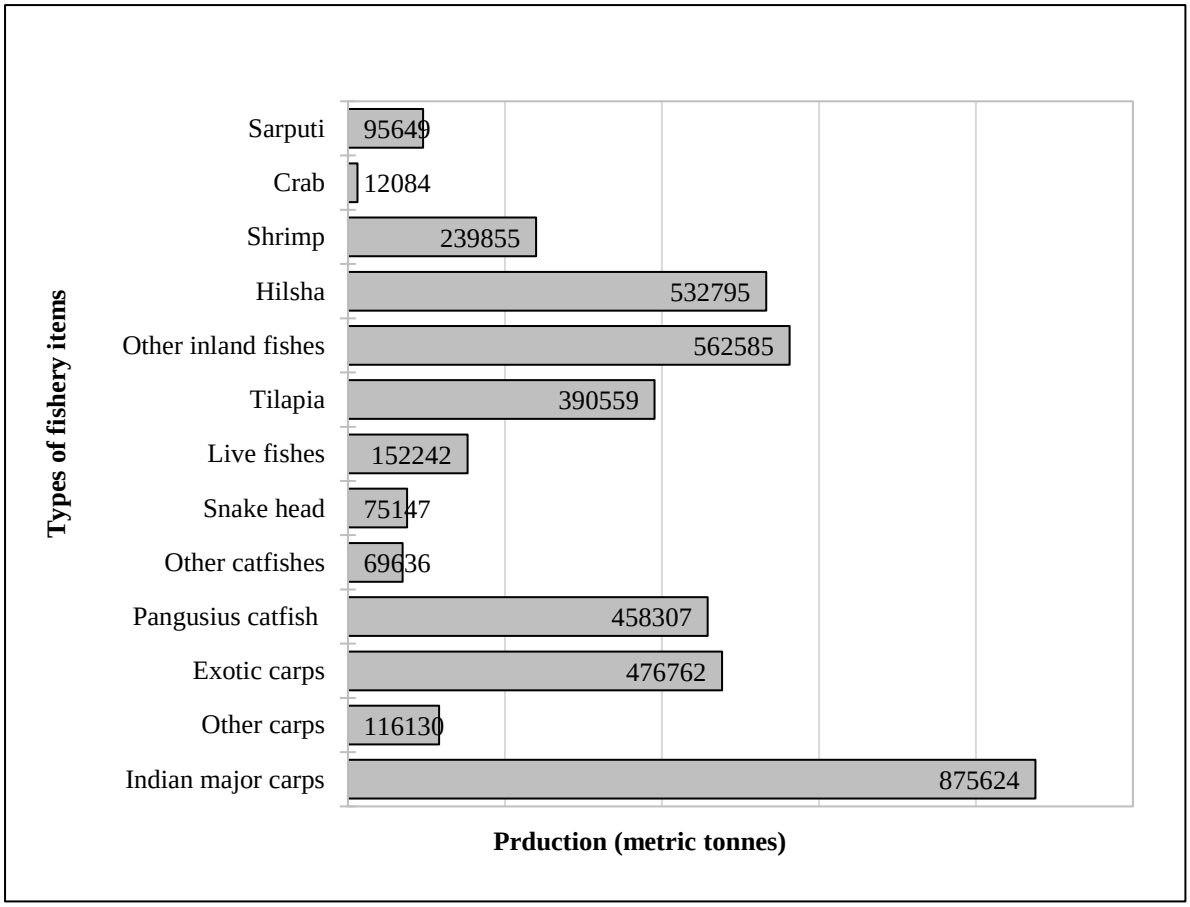

Figure 03: Species-wise annual inland fisheries production in 2018-19 [7].

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2.2.2. Shrimp and prawn production trend in Bangladesh

Shrimp and prawn are the major export items and mainly produced in coastal Districts such as Khulna, Satkhira, Barisal, Patuakhali, Bagerhat, Bhola, Chittagong, and Cox's Bazar. As a result of increasing demand and price, shrimp culture started to expand in the 1970s aiming mainly at the export markets [22]. It is reported that the Shrimp and prawn culture area has expanded from 217,177 ha in 2005-06 to over 258,553ha in 2018-19. Production of shrimp has increased from 211, 010 MT to 239,855 MT respectively (Figure 4) 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]. However, different programs and development projects are also being implemented for the increased production and promotion of shrimp aquaculture. The shrimp cluster farming approach is popularizing for enhancing shrimp production and promote 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 been intensified over the last few years, but the production level has not increased satisfactorily. One of the main reasons for that is the unavailability of good quality PL and feed. In that case, the specific pathogen-free post-larvae (PL) should be supplied broadly to the shrimp farms for reducing the mortality due to different viral and bacterial diseases of shrimp.

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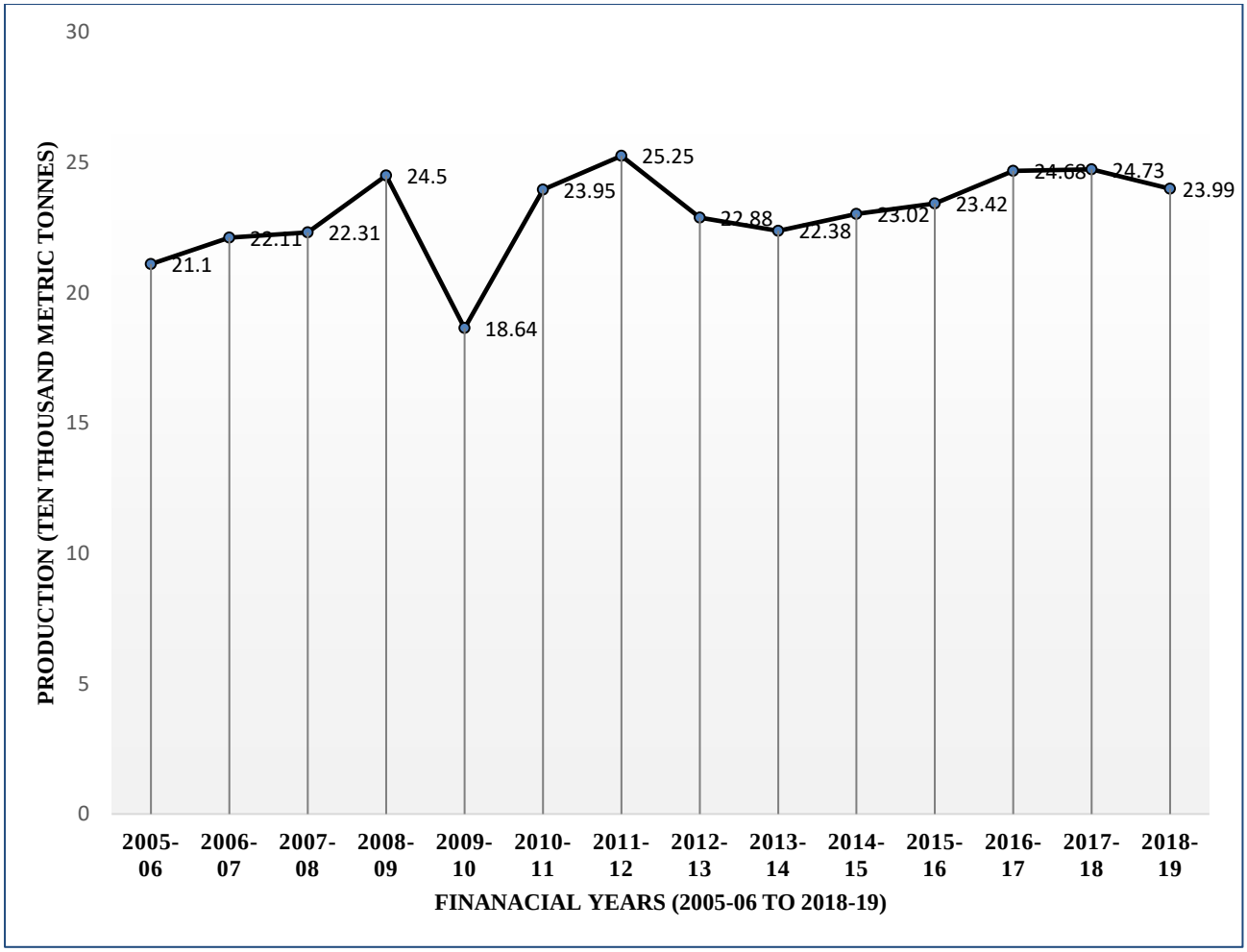

Figure 04: Trend of shrimp/prawn production from 2005-06 to 2018-19 [7].

2.2.2.1. Constraints for shrimp culture

There is no doubt that shrimp culture is the major export earning source of Bangladesh, it has created some serious environmental concerns. Firstly, there was no zone-based restriction on the location of shrimp farms. As a result, many farms in the greater Khulna and Chittagong area were set up by clearing the mangrove forest. In the process, the Chokoria Sundarban has been completely wiped out - a loss that can perhaps never be reversed [23]. Secondly, the collection of shrimp PLs from the coastal areas adversely affects other fish and aquatic species. Fine nets, which are used to catch shrimp PLs, indiscriminately catch many other species that die in the process, gets thrown away leading to biodiversity loss and water pollution [23, 24]. This problem can be solved by the introduction of modern hatcheries and intensive shrimp culture. Thirdly, brackish water shrimp farms need an inflow of saltwater that often hampers growing crops and vegetables that cannot tolerate brackish water. Discharge of wastewater from shrimp farms also cause serious local water pollution. Moreover, shrimp culture being less labour-intensive; it has indirectly contributed to

rural unemployment, marginalization of landless labourer's and social conflicts between locals and immigrant workers in the shrimp farms.

2.3. Marine fisheries production in Bangladesh

The warm tropical climate and high rainfall, enriched with nutrients from the land, is a blessing for the coastal and marine environment of Bangladesh, creating one of the world's richest ecosystems with high productivity [25, 26]. The Bay of Bengal is blessed with rich coastal and marine ecosystems, hosting a wide range of biodiversity, such as fishes, shrimps, molluscs, crabs, mammals, reptiles, seaweeds, etc. (Figure 05) [29]. It has the potential to substantially contribute to the economy of Bangladesh by exploration, exploitation and management of living and non-living resources. Most specifically, after the recent decision of the International Tribunal for Law of the Sea (ITLOS) regarding the Bangladesh-Myanmar maritime boundary, 2012 and the decision of the Arbitral Tribunal of the UNCLOS on India-Bangladesh maritime boundary, 2014 established sovereign rights on more than 118,813 km2 area of territorial sea and 200 nautical miles (NM) of Exclusive Economic Zone (EEZ) and all kinds of living and non-living resources under the continental shelf up to 354 nautical miles from the Chittagong coast [27]. Currently, 32,440 km2, starting from the coastline to 40 m depth, in the Bay, are open to around 67,669 unlicensed fishing boats, of which about 51% are non-motorized boats [3]. Fisheries resources are extracted in three tiers from Bangladeshi marine waters: (i) from the coastline to 40 m in depth where normal fishing boats are operated; (ii) from 40 m to 200 m in depth where mid-water trawlers are operated; and (iii) from 200 m in depth to the end of the Exclusive Economic Zone (EEZ) where long-liner trawlers are operated [28]. There are only 253 trawlers that are allowed for fishing in those regions by the government [11].

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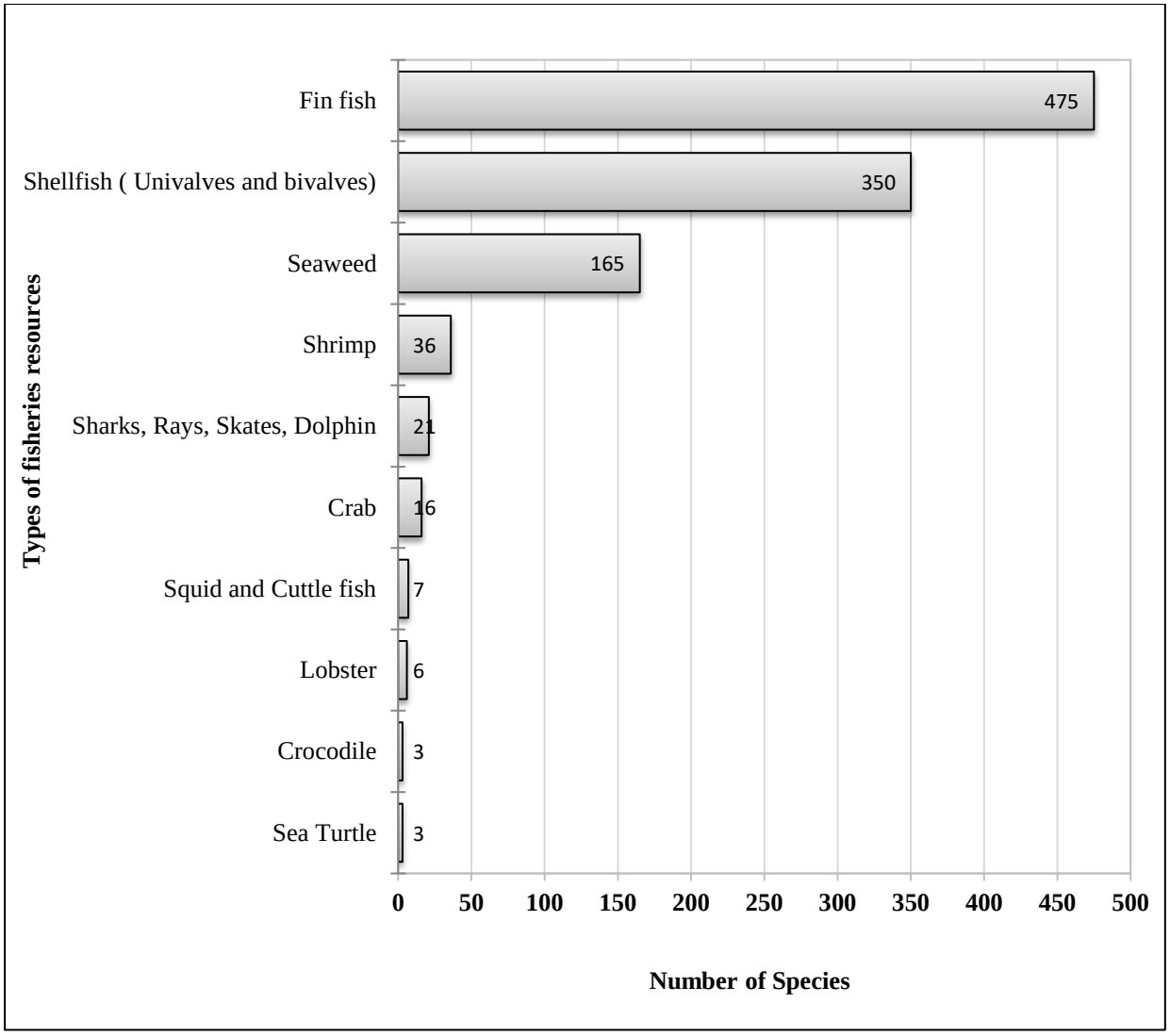

Figure 05: Coastal and Marine fisheries resources in Bangladesh [29].

Marine fisheries production contributes only 15.3% of the national fish production (Table 01) [30]. The coastal fisheries resources have not been rationally harvested rather the resources have been over-exploited and as a result, the fish stocks and other resources have been declined. Many surveys examined the status of marine fisheries resources between the 1970s and 1980s, but no recent or comprehensive knowledge is available on the fisheries stocks, systematics, biological and ecological aspects of the coastal and marine fisheries of Bangladesh [3]. The main commercial fishing zones in the Bay of Bengal are Swatch of no Ground, Middle Ground, South Patches and South of South Patches [31].

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Artisanal or subsistence fishing is done near the coastal area of Bangladesh. Hilsa (*Tenualosa ilisha*), Sardine, Bombay Duck, Salmon, Pomfret, Jew Fish, Sharks and Rays are the dominant species among others captured from marine and coastal water area (Figure 05) [7]. The species wise productions of marine fisheries are given in (Figure 06).

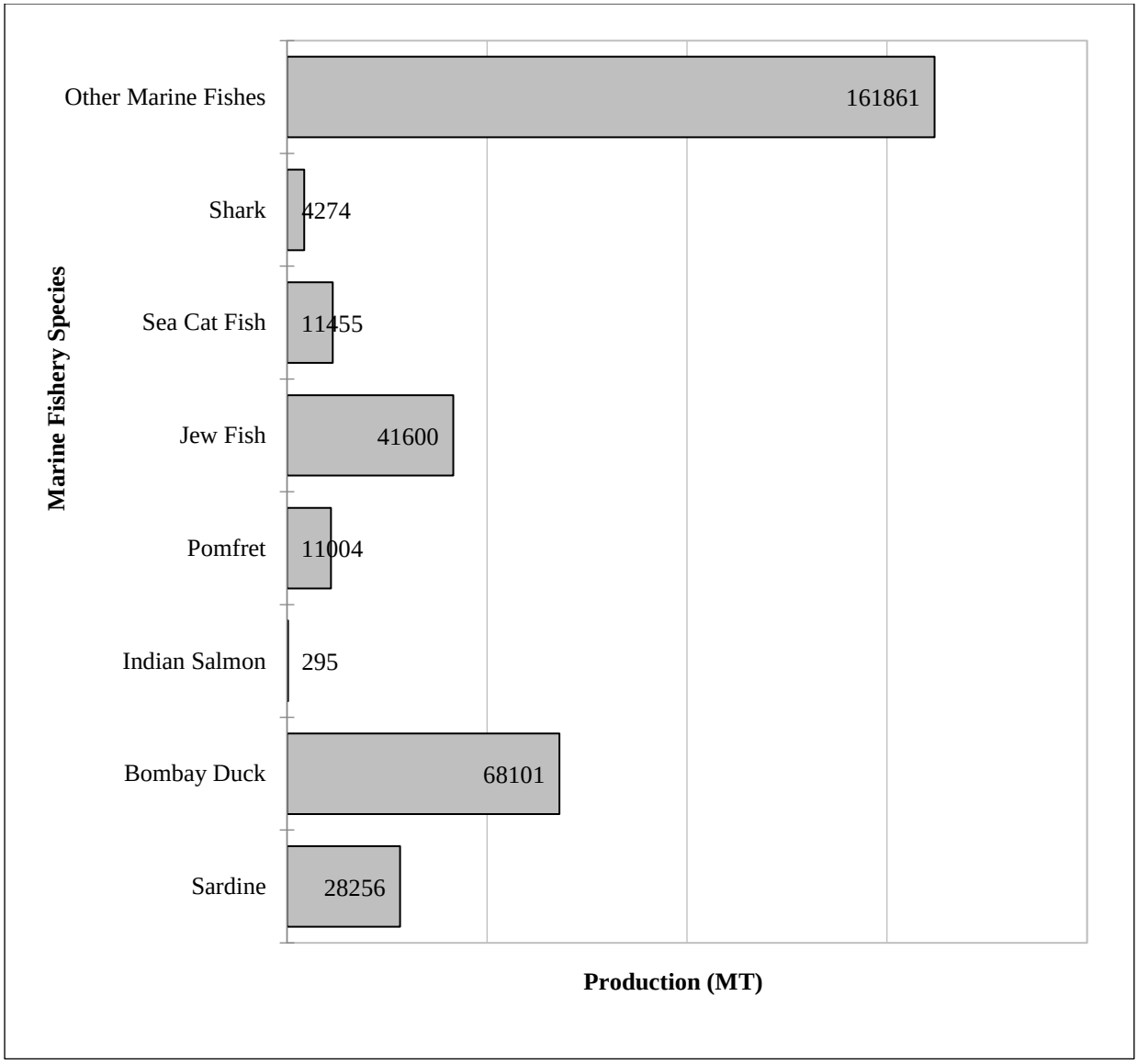

Figure 06: Species-wise annual marine fisheries production in 2018-19 [7].

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Table 04: Sector-wise annual fish production from financial years of 2008-2009 to 2018-2019 in Bangladesh [7]

A. Inland Fisheries	2008-09	Year-wise fisheries production (Metric Tonnes) 2009-10	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19
(a) Inland (capture)											
1. River	138160	141148	144566	145613	147264	167373	174878	178458	271639	320598	325478
2. The Sundarbans	18462	20437	22451	21610	15945	18366	17580	16870	18086	18225	18282
3. Beel	79200	79209	81564	85208	87902	88911	92678	95453	98117	99197	99890
4. Kaptai lake	8590	7336	8980	8537	9017	8179	8645	9589	9982	10152	10578
5. Floodplains	843671	781807	797024	696127	701330	712976	730210	747872	765782	768367	781481
(b) Inland (culture)											
1. Pond	912178	1140484	1219736	1392412	1446594	1526160	1613240	1719783	1833118	1900298	1974632
2. Seasonal culture	35842	46902	51230	132163	200833	193303	201280	207658	215547	216353	217340
3. Baor	5038	8727	4864	5186	6146	6514	7267	7729	8002	8072	10343
4. Shrimp	145585	155866	184939	196306	206235	216447	223582	239798	246406	254367	258039
5. Crab	-	-	-	-	-	-	-	13160	14421	11787	12084
6. Pen culture	-	-	-	-	-	13054	13070	13364	13368	10285	12361
7. Cage culture	-	-	-	-	-	1447	1969	2062	2490	4253	3802
B. Marine Fisheries											
1.Marine Industrial	35429	34182	41665	73386	73030	76885	84846	105348	108479	120087	107236
2. Marine Artisanal	479215	483100	504668	505234	515958	518500	515000	521180	528997	534600	552675
Total (MT)	**2701370**	**2899198**	**3061687**	**3261782**	**3410254**	**3548115**	**3684245**	**3878324**	**4134434**	**4276641**	**4384221**
Growth rate (%)	**5.39**	**7.32**	**5.6**	**6.54**	**4.55**	**4.04**	**3.84**	**5.27**	**6.6**	**3.44**	**2.52**

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3. Fish production trend in Bangladesh (1983-84 to 2017-18)

According to DoF (2019), the total inland open water fish production of Bangladesh in 2003-04 was 732,067 MT, which is very slowly increased and reached 1,235,709 MT in 2018-19 (Figure 07) [7]. Whearase Inland closed water fish production of Bangladesh has increased more than double by the last decades while inland open water production has not increased that much. It was reported that the total inland closed water fish production of the country was 914,752 MT in 2003-04 and has become 2,405,415 MT by 2017-18. The total marine water fish production of the country was 455,207 MT in 2003-04 and has become 654,687 MT by 2017-18. However, during the last three years it was observed a slight increase in the marine water fish production while it remained more or less constant in the year of 2015-18.

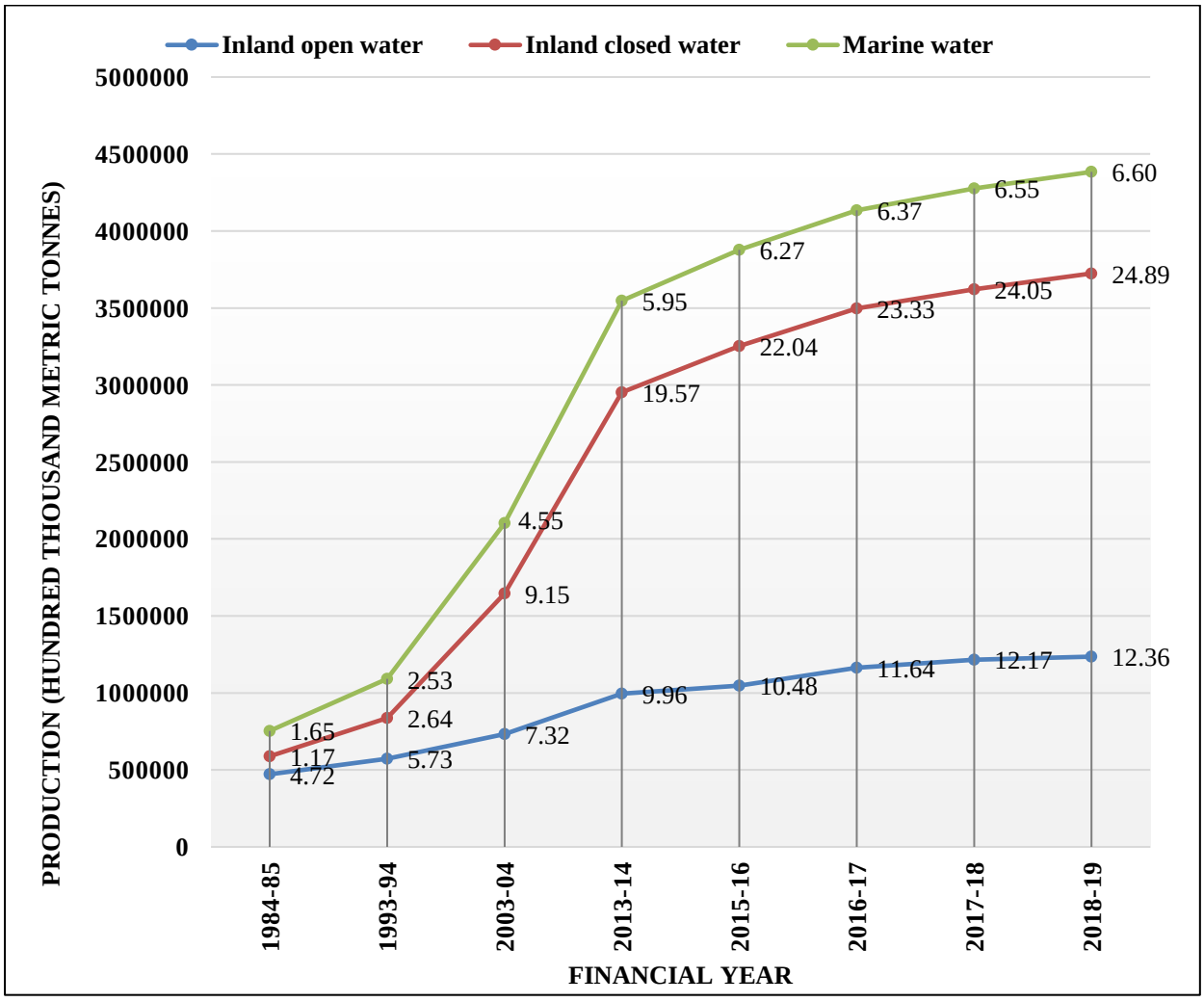

Figure 07: Trend of fish production in Bangladesh (1983-84 to 2018-19) [7].

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4. Export of fish and fishery products

The Fisheries sector of Bangladesh has emerged as the second most important contributors to export earnings. Ten categories of fishery products (frozen freshwater fish, frozen marine water fish, frozen shrimp, chilled fish, live fish, dry fish, salted dehydrate, Kuchia (*Monopterus cuchia*), and crab (*Scylla* sp.) in live condition, and fish scale/shrimp skull) are exported from Bangladesh to more than 55 countries. The shrimp export in Bangladesh is primarily based 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, Saudi Arabia [11]. Year-wise annual export value was highest in 2013-14 but during the last three years (2015-2019) the export value and quantity had been sharply decreased compared to the previous years (Figure 08, 09) [7].

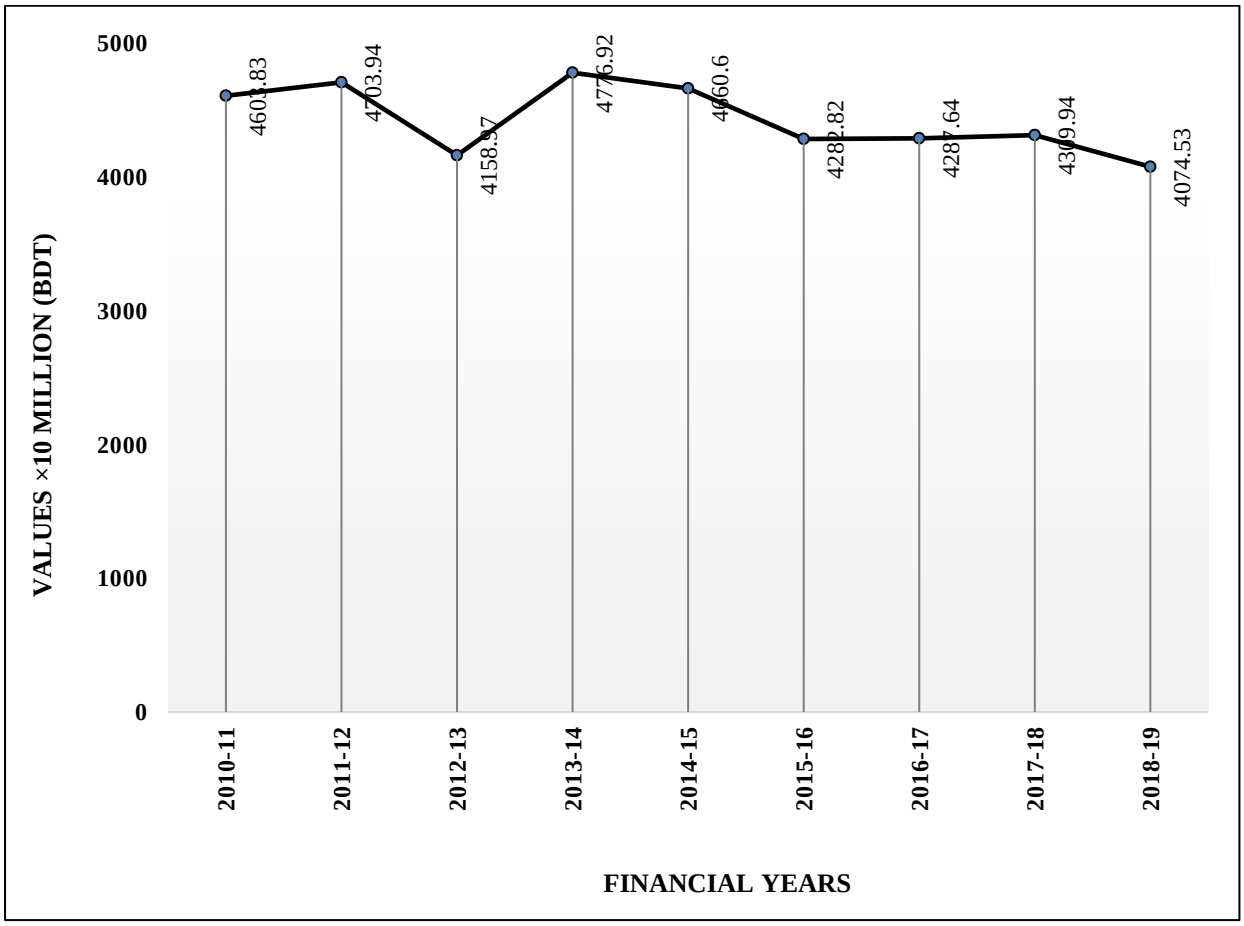

Figure 08: Year-wise annual export value of fish and fisheries product in BDT [7]

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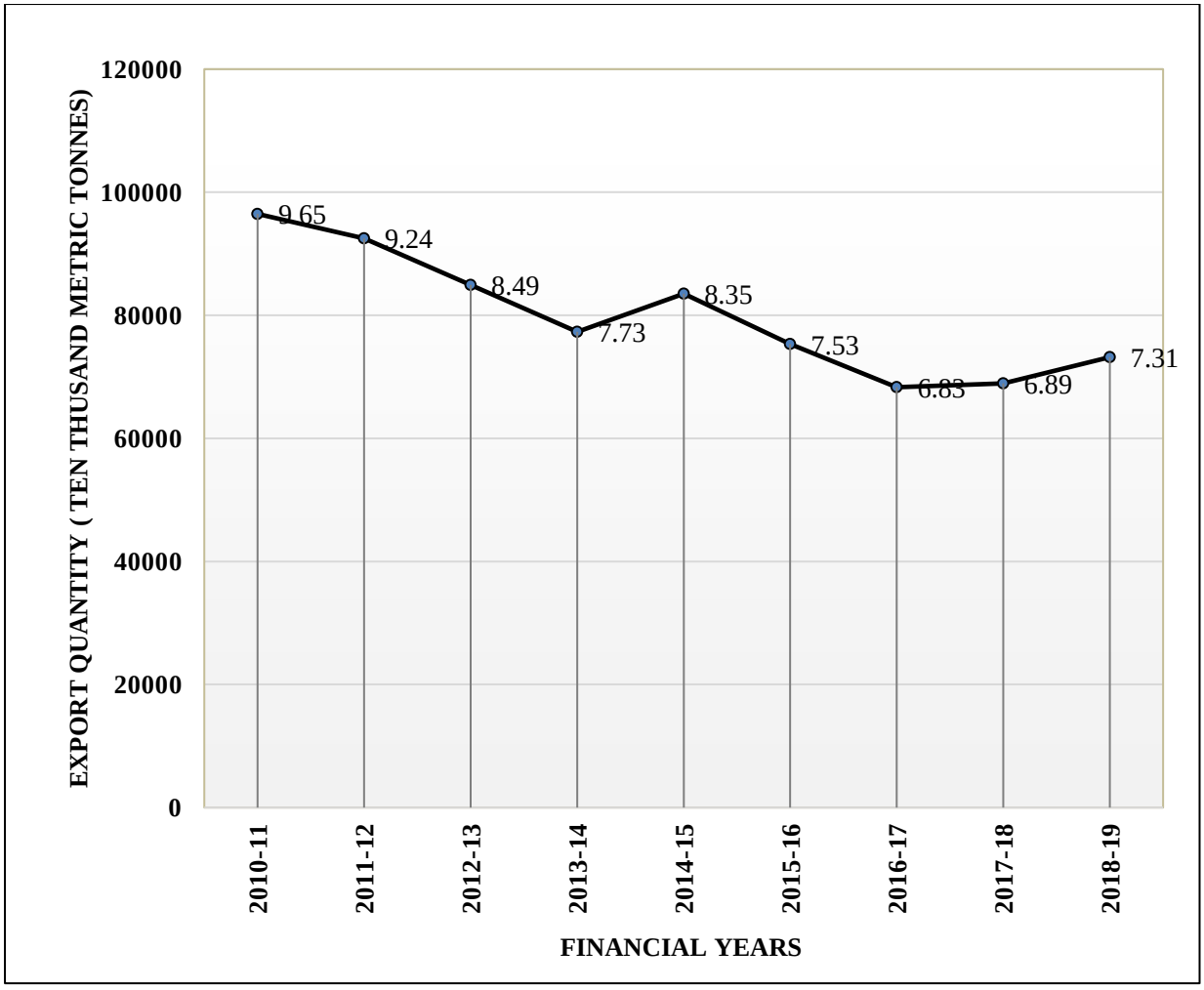

Figure 09: Year-wise annual export quantity of fish and fisheries product **[**7]

5. Status of fisher's livelihood

Fishers in Bangladesh are one of the most vulnerable communities who live from hand to mouth and are considered as poorest of the poor [9]. Per capita annual income of the fisherman is BDT 2,442 i.e. about 70% lower than the per capita income of the country as a whole [32]. The housing and infrastructure facilities of the fishermen are very poor, about 60% of fishers live on other lands by making tin shed house with the wooden floor by paying 2000 taka per year while 40% of fishers lived in their own house [33]. Road and transportation system of the area where fishermen are living usually not well developed. Fishermen usually get married in the early ages and the family type is becoming a nuclear type from joint. Their family usually consists of 5-7 members in a nuclear family and 10-15 members in a joint family [34]. Educational status is very poor in the fisher's community. Most of the fishers cannot sign. A small percentage of fisher's children can go to high school and college. Most of them drop out from primary school level. Illiteracy is very common among them (SDG4- quality education).

Treatment facilities in the fishermen villages are very poor [35]. They have to take any treatment from the nearby community clinic of their village with minimum or not adequate facilities for necessary diagnostics and pathological test. However, the scarcity of expert doctors and nurses are also notable. It is a matter of hope that most of the fishers are aware of sanitary problems and very keen to ensure safe sanitary facility as a reason almost 100% of people used sanitary latrine (SDG3- good health and well-being). A study conducted in the fisher's community of Char Atra union of Naria Upazila under Shariatpur district and found that only 30% of people had electricity facility that put an adverse impact on the literacy rate of the community. Around 70% of the people of this community used solar power as a source to enlighten their house [33]. The status of nutrition is very poor among the fishing community. They have little knowledge about the nutritional quality of food and the importance of a balanced diet (SDG3- good health and well-being). Price hike of the daily commodities, illiteracy of the fishers, more income tendency are the main reason for the malnutrition of this community. Fishing is their main occupation but it was observed in a study that, 55% of fishermen were involved solely in fishing, 15% in fishing with agriculture, and the remaining 30% in day labour with other professions. Fishers usually live below the poverty line in Bangladesh. Generally, fishers got wages from 200 BDT to 300 BDT depending on their capability. Fishers usually took a loan to maintain their family during their hard time as well as for purchasing fishing equipment (e.g., net, fishing pot, boat etc.). It has been studied that, fishers took loan mainly from NGOs (40%), 35% took a loan from boat owners or *Mahajan* where they bound to work round the year. About 22% of fishers took a loan from *Arotdar* or *Dadondar* (moneylender), only 2% could take a loan from a bank due to the complexity of the official system [4]. There are different types of constraints that are faced by the fishers (Figure 10). Among them, the main constraints are natural calamities, reduction in fish catches, unsatisfactory law and order situation, lack of credit access, ban periods, environmental degradation in coastal areas, lack of alternative Income Generating Activities (IGAs), lack of community organization, lack of infrastructure, the burden of *Dadon* (rent money), poor market facilities, loss of fishing equipment especially nets and boats during fishing etc.. Dependency on a single profession (fishing) made their life more vulnerable. Conflicts between the stakeholders like boat owner, moneylender, also hampered the stability of the livelihood and allures fishers to illegal fishing [36]. The livelihood status of the fishing communities also affected by various types of seasonal stress. Ban period and seasonal shifts in the fish availability make the fishers more vulnerable depending on the availability of fishes [8, 37].

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Sometimes fishing communities had nothing to do with seasonal stress periods due to a lack of alternative sources of income.

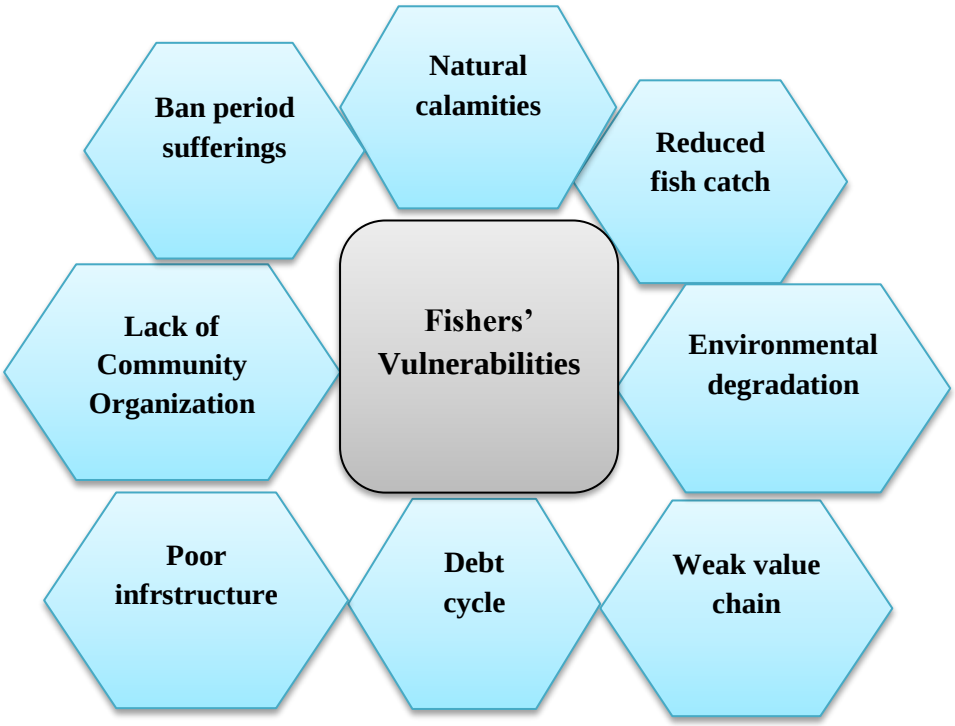

Figure 10: Fishers' vulnerabilities

Shocks are unpredictable events affecting livelihoods such as natural disasters like floods, droughts, cyclones, earthquakes, landslides, disease epidemics and sudden economic changes e.g., currency devaluation. In the fishery context, cyclones and floods have a devastating effect on people's lives and properties (SDG13- climate action). Many lives are lost (loss in human capital), and physical infrastructure and assets are wiped out, such as loss of fishing gear, roads, bridges and transport linkages being washed away, thereby again limiting access to health and education services and employment opportunities in other sectors. In comparison with other farming communities, coastal fishing communities are more susceptible to weather conditions [33, 38]. Fishermen's livelihood status is not up to the mark in Bangladesh. The government should take more initiatives to improve the livelihood of the fishers and should provide adequate support during ban periods. For this, a different training program should be arranged to increase awareness among resource users and improve their skill for the sustainable use of natural resources.

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6. Impact of COVID-19 on Bangladesh Fisheries

6.1 Response of dependent stakeholders

People who relied solely on aquaculture and fisheries i.e. fishing, fish farming and fish selling were facing difficulties to maintain livelihood during COVID-19. Most of them were illiterate and unaware of this global pandemic. About 75% of respondents thought that lockdown was the right initiative to control the fast-spreading of COVID-19. More than 88% of fishers noticed they could not fishing jointly due to COVID-19 restriction and 79% of fish farmers faced difficulty to get input and technical support. About 71.1 % of respondents reported an adverse impact on daily household food consumption (Table 05). According to the consent of 83% of respondents that they couldn't maintain the necessary precaution and measures (maintenance of social distance, use of hand sanitiser, soap, mask and other protective equipment) required during COVID-19 due to poor income. About 45% thought them helpless in terms of treatment due to inadequate facilities [8].

Table 05: Perceptions of the respondents on the influence of COVID-19 on the fisheries sector of Bangladesh [8]

Questions related to impact COVID-19: COVID-19 has	Responses (%)				
	Strongly agree	Agree	Neither agrees nor disagree	Disagree	Strongly disagree
Negatively influenced fish production	57.00	22.00	21.00	0.00	0.00
Negatively influenced fishing	53.70	34.30	8.70	0.00	0.00
Negatively impacted household food consumption	20.90	52.20	17.40	5.20	4.30
Negatively influenced income	54.80	28.90	16.30	0.00	0.0
Increased conflicts	3.50	16.50	45.90	24.10	10.00
Increased hygiene practice	0.00	5	57	23	15.00
Increased stress	2.90	7.10	47.20	32.80	10.00

6.1.1 Markets

COVID-19 has transformed the fish markets, homestead and commercial aquatic food production system drastically in Bangladesh (SDG12- responsible production and consumption) . Usually, marginal fish farmers cultured fish mainly to meet their nutritional demand and sold the remaining production to add some extra money to their family income [8]. Due to lockdown, they couldn't collect input timely as well didn't get the usual service from any organization. Many fish vendors have to stay at home due to health concerns or lack of fish to sell. The fish vendors who still operating a business may be less profitable than usual. During the first weeks of April, the fish prices fall in line with reduced demand, despite fish being the most consumed animal-source food in Bangladesh (SDG14- life below water). Fish

farmer and vendors claimed that transportation of fish, fingerling, feed and other inputs was the main problem and more than 50% of fish farmers indicated that they couldn't sell their mature fish due to transportation complexity and low market demand [8]. As a result, a good portion of mature fish remained unsold and the farmers spent the extra money to feed them that ultimately increases the expenditure and also reduced the family income(SDG12- responsible production and consumption). In Bangladesh, the factory workers are the primary consumers of Pangus (*Pangasianodon hypophthalmus*) and Tilapia (*O. niloticus*), which are produced inexpensively all over the country by a network of fish farmers. But, at the start of the COVID-19, millions of workers migrated back to their hometowns that reduced the demand. As a result, the price of a kilogram of Pangus in the retail markets was said to be decreased from BDT 120/kg to BDT 50/kg [8, 39].

Due to COVID-19 outbreak, the life of crab farmers and traders became distressed as exports were indefinitely postponed. China is the main export market for crabs. As China imposed an import ban on January 25, the export market of crabs also closed. Rampal-Bagerhat Crab Dealers Association said that crabs were usually sold in large quantities during the Chinese New Year festival. However many crabs had already died due to COVID-19 restriction [39]**.** Though the COVID-19 restriction reduced the export opportunities however open the door of the local market and access to fishery items has increased tremendously. During the COVID-19 pandemic, local people get access to those fishery items that were previously going to the seafood processing industry and considered as export items. Due to the high supply of a large quantity of fish to the local market, people get more fish at a reduced price compare to the past.

6.1.2 Fishers

In Bangladesh, April and May are the best time to release fry in the farming pond and between March and April, the fish farmer prepares the pond for the new season by selling the mature fish of the previous year. About 35% of the fish farmers and vendors claimed that they could not start a new farming cycle due to unsold mature fish (SDG12- responsible production and consumption) . It also affects the supply chain as the local vehicles like truck, pickup, and van were afraid to transport fish fingerling, feed and other materials because of the lockdown they often facing various questions and obstacles and many times they have to calculate fine that put adverse impact in the fish landing centre, wholesale and retail market [8]. 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 for their health and were hesitant to fish when the demand for fish is decreasing. Many fishers and entrepreneurs

had lost their income at the beginning of the crisis when they were unable to arrange transport for their most recent catch.

March-April was the seasonal hilsa conservation ban period that affected the fishing communities in the major rivers of Bangladesh. During the ban period, a restriction was imposed in all hilsa sanctuary and the People had nothing to do against the seasonal ban period due to the lack of alternative sources of income that made them more vulnerable in COVID-19 crisis [8]. The government-subsidized was far less than what was needed for the fishers to keep their lives normal (SDG1- no poverty). It was a pity that many real fishers didn't get this support due to nepotism [37].

6.1.3 Fish farmers

In Bangladesh, March and April is the peak season for fish stocking and the COVID-19 crisis struck in April, just before peak harvest season. When farmers saw that the prices and demand for fish decreasing gradually and transportation systems break down, then many of them decided to retain their fish in their ponds instead of harvest (SDG12- responsible production and consumption). One interviewee predicted that the price of fishes may remain low even after the pandemic when other farmers also begin harvesting fish and that surplus supply will depress prices further [8].

Traders usually pay farmers for their fish after they have been sold [3]. For COVID-19 situation, farmers are in fear that they will be a loser from their crop if the traders would not sell the fishes, and unsold fish couldn't be returned due to transport disruptions. They also thought these disruptions could prevent traders from picking up the fish. Considering the situation, retaining fish in ponds seems to be a safe immediate option, but it also creates the prospect of investing more money for fish feed. Due to the delayed harvesting of mature fish, the fry cannot be stocked at the onset of the monsoon (the start of the main growing season), which may reduce the supply of fish in the first half of 2021 [8].

6.1.4 Seed

In Bangladesh, COVID-19 crisis started in March which was the peak season for the hatchery owners for selling their fish seeds and gearing up a new production cycle. The demand for fish seed falls dramatically due to farmers' uncertainty and inability to harvest (SDG12- responsible production and consumption). In some hatcheries due to the lack of separate nursing ponds, they are unable to store seed five to seven days more. One of the hatchery specialists from

Bagerhat claimed that the hatchery remained close but they had to pay the hatchery staff. Another hatchery manager from Barisal informed that due to COVID-19, they had to sell their seed at a very low price and most of the hatcheries and farmers were in doubt whether they would get their production cost or not [8]. 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 lack of sales. Hatchery inputs such as pituitary glands, hormones, probiotics, and probiotics are imported from outside Bangladesh. Due to lockdown, the inputs import has become more challenging. The price of the Pituitary gland has become tripled since the crisis started. Due to COVID- 19 lockdown, transporting of hatchery inputs and fry is a crucial challenge for fish hatcheries, nurseries and fish farmers [40].

6.1.5 Feed

Most of the feed mills import their ingredients to produce feed. Due to the COVID-19 situation, importing of goods have become more challenging due to the price hike and transportation complexity. Experts predicting that a 40% reduction in feed supply could occur due to input shortages and low farmer's demand. As the feed production cost increase, this has led to speculation on whether millers will compromise the feed quality. Commercial small-scale producers are concerned about feed access [8].

7. Prospects, development- relevance and linkage of fisheries and aquaculture sectors with achieving SDGs in the context of Bangladesh

Bangladesh achieves prestigious global postion due to its outstanding production in inland open water capture fisheries (3^{rd}) and culture fisheries (5^{th}) [7]. 60% of the total Hilsa (*Tenualosa ilisha)* in the world also comes from Bangladesh [8]. So, The Fisheries and aquaculture sectors promisingly linked with achieving several SDGs and have development relevance (e.g. economic, social and environmental dimension of sustainability) in the context of Bangladesh. Among the 17 SDGs, these sectors directly or indirectly connected towards achieving several SDGs such as eliminate poverty (1^{st}), erase hunger (2^{nd}), establish good health and well-being (3^{rd}), create decent work and economic growth (8^{th}), influence responsible consumption and production (12^{th}), organize climate action (13^{th}), develop life below water (14^{th}) and advance life on land or life above water (15^{th}) (Table 6).

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Table 6. Prospective linkage of fisheries and aquaculture sectors with achieving the SDGs in the context of Bangladesh

Sl	The United Nations Sustainable Development Goals- SDGs (1-17)	Direct or indirect linkage with fisheries and aquaculture sub-sectors[1]			Linked with the dimensions of sustainable development
		Inland closed water (culture)	Inland open water (capture)	Marine water (capture)	
1	Eliminate poverty	High	High	Medium	1, 2
2	Erase hunger	High	High	High	1, 2
3	Establish good health and promote well-being	High	Medium	Medium	1, 2
4	Provide inclusive & equitable quality education	Low	Low	Low	1, 2
5	Gender equality and women empowerment	Low	Low	Low	2
6	Ensure clean water and sanitation	Low	Low	Low	3
7	Affordable, reliable & modern clean energy	Low	Low	Low	3
8	Create decent work and promote economic growth	Medium	Medium	Low	1, 2
9	Increase industry, innovation, and infrastructure	Medium	Medium	Medium	1, 3
10	Influence reduction of inequalities	Low	Low	Low	2
11	Mobilize sustainable cities and communities	Low	Low	Low	2
12	Ensure responsible consumption and production	High	High	High	1, 2
13	Climate action- to combat climate change impacts	Low	Low	Low	3
14	Develop life below water or conserve and sustainable resource utilization	Very high	Very high	Very high	1, 2, 3
15	Advance life above water or life on land	Low	Low	Low	3
16	Assurance peace, justice, and strong institutions	Low	Low	Low	2
17	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 on 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 define much clearly, score: 51-75); Very high (direct linkage with clear definition, score: 76-100) The idea of contextualizing and generating this table were benefited from Wang et al. (2020) and de Bisthoven et al. (2020) [41, 42]). Potential linked with dimensions of sustainable development indicates 1. economic growth, 2. social inclusion, 3. environmental protection.

7.1. Prospects of inland closed water

In Bangladesh (2017-18), around 56% of fish production comes from inland closed water (SDG2- zero hunger). Inland closed water fish production is almost saturated in condition but

a 5-fold increase in production will be needed within the next 5 decades to maintain current aquatic food consumption levels (SDG12- responsible production and consumption). Bangladesh needs new technology to cope with this demand. So, the country is moving towards advanced technology like RAS (Re-circulatory Aquaculture System), biofloc and aquaponics [2]. Bio-floc technology has a self-nitrification process within culture ponds with zero or minimum water exchange which is a cost-effective method with better control of water pollution. These technologies are considered as eco-friendly alternatives of fish culture, fewer diseases prone system which gives higher productivity and consequently a sustainable production.

7.2. Prospects of inland open water

Although Bangladesh is blessed with huge open water resources (SDG14, live below water) but only 28% of fish production comes from inland closed water. The productivity in the Beel-river and estuary is 859 and 318 kg/ha, respectively. To increase this value either 1000 kg/ha or 1200 kg/ha the water area under the pen and cage culture system could be adopted. It is estimated that only 1.29 lakh cubic meter and 5,294 ha area are under cage and pen culture system, respectivelywhich could be increased to maximize the production. For instance the community-based fisheries management i.e. Daudkandi model of community floodplain aquaculture [43] which has expected to improve fisher access, livelihoods, and the sustainability of fisheries sector. Co-management of natural wetland could be another option to protect and increase the biodiversity of aquatic organisms which eventually help to maintain the livelihood of the dependent community [9].

7.3. Prospects of marine fisheries resources

Bangladesh is rich in coastal and marine resources (SDG14- live below water). The utilization of marine resources by implementing proper management strategies will develop an economic zone in the southern part of Bangladesh. It will create employment opportunities and other income-generating activities.

7.3.1. Blue economy

The blue economy is a quite new and emerging concept in Bangladesh, which refers to the economic activities related to the ocean, seas and coast [44]. Blue economy means the extraction of the resources from the sea for the growth of an economy (SDG14- live below water). Ocean resources can be utilized for increasing food security, improving nutrition and

health, alleviating poverty, creating job, generating alternative energy, lifting seaborne trade and industrial profiles (SDG1- no poverty; SDG2- zero hunger; SDG3- good health and well-being; SDG10- reduced inequalities) [45, 46]**.** By the recent settlement of maritime boundary with Myanmar and India, Bangladesh has acquired 118,813 square kilometres of the Bay of Bengal. According to expert opinion, Bangladesh would be able to extract about 1.2 billion dollars from its huge marine resources. 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 acquire 5 percent of the country's GDP by 2030 from the resources of the sea. Thus, the development of blue economy will open a new window for the development of Bangladesh [46].

7.3.2. Biotechnology and marine genetic resource

Marine biotech has the potential to address a suite of global challenges such as sustainable food supplies, human health, energy security and environmental remediation. Different marine resources are a rich source of potential drugs. In 2017, there were over 36 marine-derived drugs in clinical development, including 15 for the treatment of cancer [46]. One area in which marine biotech can make a critical contribution is in the development of new antibiotic for medical science [47].

7.3.3. Research

Freshwater fish production is higher compared that in marine fish production in Bangladesh [11]. Research works related to marine fisheries resources and their production performance are very limited in the country. A recent settlement of maritime area with India and Myanmar provides the country with a huge marine water area, which has diversified fisheries resources. Therefore, appropriate research works on marine fisheries are required. Several marine fisheries academy and institutes are available in Bangladesh, which can play a significant role in increasing marine fisheries production.

8. Challenges of fisheries resource management in Bangladesh

Despite the silent revolution in aquatic food production the situation of inland open water (capture) and marine fishery production is under threat due to natural (climate change) and anthropogenic drivers. (overexploitation, pollution, non-compliance of regulations etc.).

8.1. Climate change

Bangladesh is at high risk due to climate change [5]. In the next 3 decades, the country will face the greatest danger due to global warming (SDG13- climate action). Large low-lying coastal regions are at risk of annual floods and cyclones which have identified Bangladesh as the number one exposed country to climate change [12]. Climate changes have devastating impacts on fishery-based livelihoods and domestic food supply. World's biggest mangrove can be smeared out by a one-meter rise in sea level [24, 48]. The mangrove similarly supports offshore and deep-sea fisheries by playing a noteworthy part as a nursery ground for many deep-sea fishes and shrimps including the *P. monodon.* Thus, sea-level rise due to climate change may abolish the marine fish nursery ground in the Sundarbans [49]. The climate change effect may reduce pH and increase the CO_2 level in the sea, which can affect the survival of marine fishes, eggs and larvae.

8.2. Reduced fish diversity

The total number of freshwater fish species in Bangladesh ranges from 289 to 293 (SDG14- live below water) [50], but IUCN assessed 253 fish species of which 64 species are under the threatened category. About 9 species are critically endangered, 30 species are endangered and 25 species are vulnerable [51]. The production of eggs and carp fry has also been declined in the Halda River [52, 53].

8.3. Water quality and productivity

Plankton productivity in the water bodies greatly affected by temperature changes as a consequence of changing climate. Deteriorated water quality is tended to escalate disease outbreaks and reduce fish growth and production [54].

8.4. Installation of Rampal power station and Matarbari coal power plant

Bangladesh government has decided to establish a 1320 MW coal-fired power plant at the mouth of the Sundarban under Rampal Upazila of Bagerhat district beside the Poshur River. This, the coal-based power plant would affect the ecosystem of Sundarbans and surrounding areas permanently [55] and thereby affect the marine fish nursery ground in the Sundarban. Furthermore, the Matarbari Coal Power Plant in Moheshkhali Upazila of Cox's Bazar would be another threat for the marine ecosystem, which in turn may affect the marine organisms including fishes and turtles [56]. However, further study could initiate time to time to assess the actual impact of these big projects and set strategies for mitigation measures.

8.5. Other challenges

The challenges need to be addressed to increase marine production in a sustainable manner, which will have a tremendous and long-term impact on the livelihoods of the coastal people (SDG1- no poverty; SDG2- zero hunger; SDG3- good health and well-being; SDG14- live below water) [3, 57]. Lack of awareness about modern aquaculture techniques like cage culture, marine and coastal aquaculture, inadequate facilities concerning information, communication, transportation, market and lack of skilled manpower in this field are needed to be be addressed properly. The areas for Mari-culture not yet also been demarcated by the government that should be brought in the priority agenda.

9. Conclusions and recommendations

Fisheries is a crucial sector in the national macroeconomic, food and nutrition security perspectives (SDG1- no poverty; SDG2- zero hunger; SDG14- live below water). Therefore, efficient and sustainable management of the aquatic resources will contribute significantly to the health and economic sector of the country. Despite the huge prospects and potentials, several reasons (climate change, installation of a coal-based power plant nearby the sea, lack of scientific information, skilled manpower, and poor implementation of acts and rules related to marine fisheries) limit the fisheries resources with their production and performance. The government should not consider installing any harmful power plant nearby or in the sea, which may disturb the ocean ecosystem. Appropriate technologies should be developed for coastal and marine aquaculture development. The supply of good quality seed, feed, and extension services will increase fisheries production in inland water bodies. The development of communication and transportation system for rapid access to information, transdisciplinary coordination with the regional and international networks for updated technology, value chain and proper utilization of the marine resources can boost up 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, the introduction of modern storage and marketing facilities could improve the scenario rapidly. Perceptions of small-scale fishers should consider during policymaking. Special strategies and emphasis is required to assess their vulnerability and sustainability. Attention should also be paid to the environmental abnormalities and constraints such as frequent natural disasters

(SDG13- climate action), declining aquatic biodiversity trend (SDG14- live below water) and increased water and air pollution trend in connection with the success of the fisheries sector.

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