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Assessing impacts of COVID-19 on aquatic food system and small-scale fisheries in Bangladesh

Atiqur Rahman Sunny^{a,b,*}, Sharif Ahmed Sazzad^{c,d}, Shamsul Haque Prodhan^a,
Md. Ashrafuzzaman^a, Gopal Chandra Datta^b, Ashoke Kumar Sarker^b, Mizanur Rahman^e,
Mahmudul Hasan Mithun^f

^a Department of Genetic Engineering and Biotechnology, Shahjalal University of Science and Technology, Sylhet, Bangladesh

^b Suchana Project, WorldFish, Bangladesh Office, House# 22B, Road# 07, Block-F, Banani, Dhaka, Bangladesh

^c Research Officer, Pathfinder Agro and Fisheries Consultation Center, Bangladesh

^d Department of Sociology, University of Dhaka, Bangladesh

^e Department of Food Engineering and Tea Technology, Shahjalal University of Science and Technology, Sylhet, Bangladesh

^f Department of Fisheries Biology and Aquatic Environment, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Bangladesh

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ABSTRACT

COVID-19 is now a major global health crisis, can lead to severe food crisis unless proper measures are taken. Though a number of scientific studies have addressed the possible impacts of COVID-19 in Bangladesh on variety of issues, problems and food crises associated with aquatic resources and communities are missing. Therefore, this study aimed at bridging the gap in the existing situation and challenges of COVID-19 by linking its impact on aquatic food sector and small-scale fisheries with dependent population. The study was conducted based on secondary data analysis and primary fieldwork. Secondary data focused on COVID-19 overview and number of confirmed, recovered and death cases in Bangladesh; at the same time its connection with small-scale fisheries, aquatic food production, demand and supply was analyzed. Community perceptions were elicited to present how the changes felt and how they affected aquatic food system and small-scale fisheries and found devastating impact. Sudden illness, reduced income, complication to start production and input collection, labor crisis, transportation abstraction, complexity in food supply, weak value chain, low consumer demand, rising commodity prices, creditor's pressure were identified as the primary affecting drivers. Dependent people felt the measures taken by the Government should be based on protecting both the health and food security. Scope of alternative income generating opportunities, rationing system, training and motivational program could improve the situation. The study provides insight into policies adopted by the policy makers to mitigate the effects of the pandemic on aquatic food sector and small-scale fisheries.

1. Introduction

The first cases of infection of a new corona virus (2019-nCoV) were reported in Wuhan, Hubei Province, China, on December 31, 2019 [1], which generates the disease known as COVID-19 [2]. It is different from SARS-CoV and MERS-CoV and has quickly outspread in more than 210 countries and territories as it is highly contagious in nature [3]. The World Health Organization (WHO) has officially declared the corona virus a global pandemic, as of 21 May 2020, there had been more than 6, 86 million corona virus cases and 398,483 deaths worldwide [4]. There has been a risk of developing new infectious diseases [5], from the

Spanish flu of 1918, to AIDS that still has no definitive cure. Well now, COVID-19 being the main global health problem is affecting the normal development of society and disturbing humanity with all its components. Researchers are working hard to understand better the biology and the epidemiology of the novel corona virus disease (COVID-19) but no vaccines or antiviral drugs has been approved yet for the control of this disease [6]. So, non-therapeutic interventions are being followed to control the spread of the virus. Billions of people are staying at home to minimize the transmission of the virus in the worldwide. Many countries are adopting preventive measures, e.g., mandatory lockdowns, work at home, online business, social distancing, and restriction in local and

* Correspondence to: Shahjalal University of Science and Technology, Bangladesh.

E-mail address: atiksunny@yahoo.com (A.R. Sunny).

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international travel.

COVID-19 is a health crisis, but it could also lead to a food security problem if proper measures are not taken. The pandemics that the world has experienced earlier, has been shown that quarantines and panic not only affect the human activities and economic [7–9]; but also affects the aquatic food systems and all sorts of agricultural activities that induces increase in hunger and malnutrition [10,11]. Global outbreaks like Ebola, SARS and MERS all had negative impacts on food and nutrition security, particularly in the developing countries and for vulnerable populations like children, women, old and the poor [12]. In 2014, when Ebola epidemic hit Guinea, Liberia and Sierra Leon, price of domestic rice increased by 30% while the price of cassava, a major staple in Liberia, increased by 150% [13]. If the COVID-19 pandemic continues in such a way the production of agricultural crops, aquatic foods and livestock such as wheat, rice, vegetables, fish, sea food, egg, meat and dairy will be affected. According to the Food and Agriculture Organization of the United Nations (UNFAO) more than 820 million people around the world are suffering from hunger. The world is already facing food and nutrition security challenges where the situation of the less developing, developing and lower middle countries is more vulnerable [14].

Bangladesh, a lower-middle-income riverine country of Southeast Asia and one of the world's most densely populated areas [15,16]. The economy of the country is dependent on agriculture which is divided into three sub sector named as crop, fisheries and livestock. Now Bangladesh is struggling to combat with the associated adverse impact of COVID-19 as the virus is hobbling economy by disrupting industries, poultry, dairy, agricultural and aquatic food system that also threatening the livelihoods of the dependent communities directly or indirectly. The COVID-19 pandemic may cause a food crisis in poor countries due to ongoing and arising issues related with both economic and physical accessibility. UNFAO reported that the people who are already malnourished, weak and vulnerable to disease are more prone and a 'crisis within a crisis' could emerge by compounding current health crisis to a hunger crisis [14].

Fish plays a vital role in the diet of the people of Bangladesh due to abundance of inland open water (capture fishery), inland closed water (culture fishery) and marine fisheries [15–17]. Bangladesh is one of the leading fish producing country of the world with total fish production of 4276,641 MT, of which 1216,539 MT (28%) were from inland open waters, 2405,415 MT (56%) from inland closed waters and 654,687 MT (16%) from marine fisheries [18]. Aquatic food system is contributing notably to ensure food and nutrition security through consistently supporting safer and good quality animal protein [19,20]. Bangladesh is providing 62.58 g fish to per person in daily dietary consumption that supplements 60% of daily animal protein intake [21–23]. Fisheries sector is not only playing an important role in maintaining nutritional demand but also socioeconomic status by contributing 3.57% percent to the national Gross Domestic Product (GDP) and more than one-fourth (25.30%) to the agricultural GDP [17,18]. In 2017–18, the country earned a significant amount of foreign currencies by exporting fish, shrimps and other fishery products and the amount is BDT 430,994 from the export of 68.94 thousand MT fishery products [18].

Bangladesh has ranked 3rd in inland open water capture fisheries production and 5th in world aquaculture production. Currently Bangladesh ranks 4th in tilapia production in the world and 3rd in Asia [18]. 60% of the world's total Hilsa (*Tenualosa ilisha*) also comes from Bangladesh [17,21] but various natural calamities, droughts, floods, heavy rains, storms and hurricanes are major obstacles to fisheries production [17,20,24–26]. In addition, this year's global corona strike has become a thunder signal for the country's fisheries sector. The challenge ahead is to ensure uninterrupted aquatic food production and supply, fair prices for products as well as ensuring nutritious food for all. Although the Covid-19 did not disrupt aquatic food production directly but it hampers in transportation complexity and poor presence of buyer causes abnormal fall in prices of fisheries products. So, it is not only the

fishers, fish farmers, retailers, whole sellers and other members of the aquatic value chain who have been affected, but also the overall economy of the country. Therefore, ensuring food and nutrition security maintaining balance economy in the future is a priority agenda and challenge of Bangladesh. Though different scientific studies have addressed response of Bangladesh related to COVID-19 issue, there are very few studies that combine both the analysis of health crisis and food crisis. So, more in-depth studies are required to identify the trend of challenges and status of different agricultural sectors, sub sectors and dependent communities regarding which factors are most responsible to trigger the challenges and which factors further interact to deteriorate the situation. Considering the fact the study aims to makeup the gap by addressing the existing scenario of COVID-19 as well its associated impact on fisheries and aquatic food sector with dependent community. This paper also highlights the immediate responses and policy actions that have been taken so far.

2. Materials and methods

2.1. Study areas

The study was conducted among the thirteen communities of nine districts (7 locked and 2 partially locked) under eight administrative divisions. Among the divisions Dhaka, Chittagong, Khulna, Barisal and Rajshahi were partially locked while Rangpur, Sylhet and Mymensingh were fully locked (Fig. 1). The fully locked communities were Shibpur and Baghaba, Haimchar, Char Alexandar, Kawarchar and Laharhat, Palashbari, Osmaninagar and Balaganj, Phulpur respectively from Nar-singdi, Chandpur, Laxmipur, Barisal, Gaibandha, Sylhet and Mymensingh district. Partially locked communities included Chila and Joymonigul from Bagerhat and Bera from Pabna district.

2.2. Data collection

The study was conducted based on primary and secondary data sources. Primary data were collected by employing a number of qualitative tools such as individual interviews, key informant interviews with knowledgeable persons, oral history and telephonic interview. Telephonic interview assisted a lot to conduct the study during such lockdown period and helped to collect the data quickly with low cost.

Primary data were collected following a semi-structured questionnaire. The questionnaires were pilot-tested with a small sample of respondents. The final questionnaire was improved, rearranged and modified following the experience of pilot-test. The final questionnaire focused the questions on socioeconomic profile of the respondents, perceptions on COVID-19 pandemic, impact on fishing, fish transportation and preservation, status of aquaculture input, market and consumer demand, most affected section and government response. 45 individual interviews and 45 telephonic interviews with fisheries dependent communities (fish, shrimp, crab, snail and oyster harvesters) were conducted. In addition to the 90 individual interviews above (45 individual interviews and 45 telephonic interviews), 18 key informant interviews or cross-check interviews were conducted with government officials, NGO personnel and local entrepreneurs to collect and verify necessary information.

2.3. Secondary data

Secondary data of COVID-19 was collected from the Institute of Epidemiology, Disease Control and Research (IEDCR). The data included overview of Bangladesh, lockdown status, number of confirmed, recovered and death cases. Production, food demand, supply and relevant fisheries and aquaculture related data was collected from Department of Fisheries (DoF). Data was also collected from scientific articles, technical reports and newspaper reports for further materials.

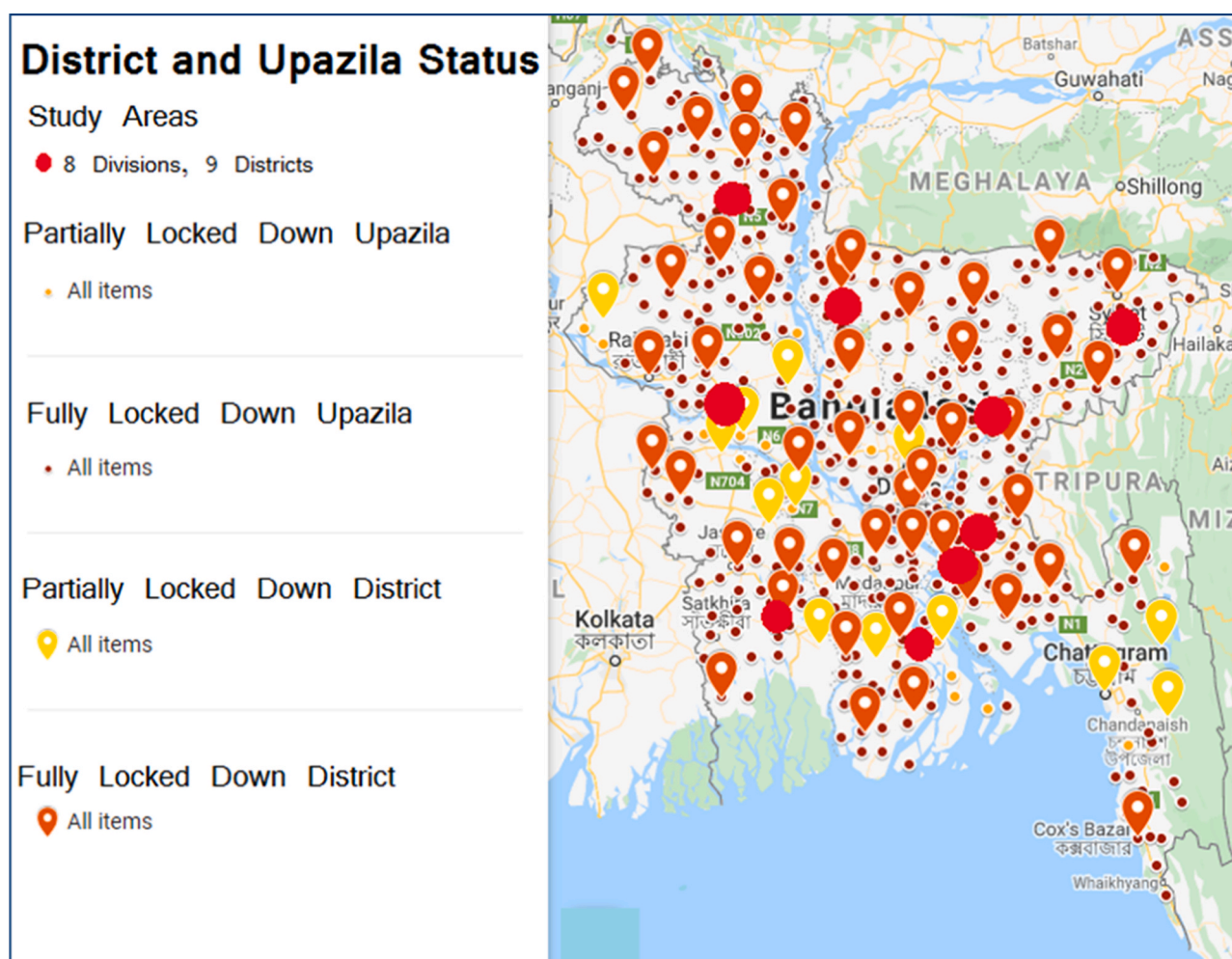


Fig. 1. Study areas and lockdown status of Bangladesh (up to 31th May 2020).

2.4. Data analysis

Quantitative data were analyzed in MS Excel (Version 2016) using descriptive statistics in the form of frequencies and percentages. Qualitative data were analyzed through text analysis. After transcription of qualitative data, contents were analyzed and themes were developed. Data were presented in the form of graphs and tables to provide graphical representations of the data. After analyzing all the data, results were verified by nine household and nine telephonic interviews.

3. Results and discussion

3.1. COVID-19 scenarios in Bangladesh

Bangladesh is facing significant challenges in combating COVID-19 as it is a densely populated country of about 160 million where 46 thousand people living per square kilometer of its Capital city Dhaka [16,27]. Bangladesh confirmed the first COVID-19 case in its territory on March 8 and first death took on 18 March, though the media and many experts speculated that nCoV-2 may have found earlier but had not been detected due to inadequate monitoring and insufficient test. Number of positive cases remained low until the end of March but saw a sharp rise in April (Fig. 2). In the week of mid-April, new cases in Bangladesh grew up 1155%, the highest in Asia, ahead of Indonesia with 186% [28,29]. As of May 31, a total number of 312061 individuals have been tested. Among all those tested the country had reported 47,153 confirmed cases of COVID-19, 9781 recovered cases and the death toll stood at 650

(Fig. 2).

In response to the emergence of the virus, Bangladesh did not impose any strict protocol initially. Bangladesh suspended on-arrival visas for all countries and flights from all European countries on 14 March. Since then, over 631 thousand people who came from COVID-19-affected countries entered Bangladesh in just 55 days from January 21. Most of the people did not follow suggested quarantine and found to meet friends and family and travel here and there. To control the situation the government shut down all educational institutions, for unknown time on 17 March and deployed the army to supervise quarantine on 19 March. Government also banned all political, social, cultural, and religious gatherings in the country. On 23 March, when Bangladesh had got then highest confirmed cases (33), the government declared a ten-day nationwide lockdown effective from 26 March to April 4, ordering banned in all sorts of movement (route, rail, water and air) while all public and private offices to be closed, except for pharmacies, groceries, and other unavoidable necessities and other emergency services. People have been asked to practice social distancing and stay at home through it has been proved that maintenance of social distancing protocol is challenging in Bangladesh context. Till then gradually 63 districts of Bangladesh out of 64 is following lockdown where 50 districts are fully locked down and 13 districts are partially locked down.

3.2. Response of aquatic resource dependent communities on COVID-19

People who were solely dependent on aquatic resources i.e. fishing, fish processing, fish selling and fish farming were facing difficulties to

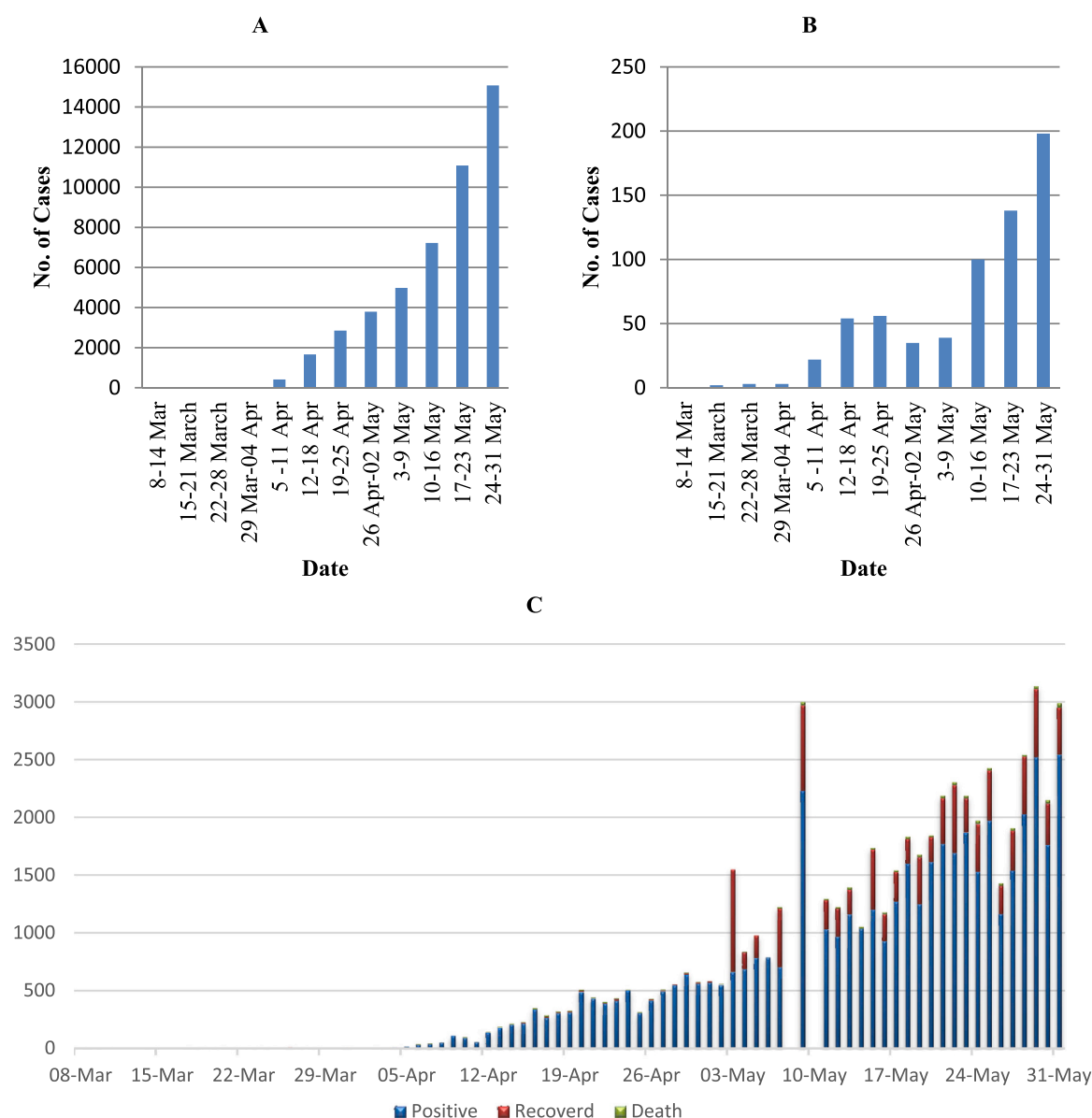


Fig. 2. Current situation of COVID-19 in Bangladesh (May 31, 2020). (A) Number of cases identified weekly in Bangladesh, (B) number of weekly death incidences in Bangladesh, (C) number of daily positive cases, recoveries and death incidences.

combat emerging COVID-19 situation. Most of them were illiterate and live in the margin, were hardly aware of the threat from COVID-19. More than 75% respondents believed that lockdown was perfect initiative to control fast spreading of COVID-19 while 20% argued that social distancing is not effective for them. About 88% fishers reported they could not go out for fishing jointly due to COVID-19 restriction while 79% fish farmers mentioned COVID-19 put adverse impact on their fish production due to scarcity of input and service provider. In response to a question regarding whether COVID-19 restriction adversely impacted their ability to meet their household food consumption needs, 71.1% respondents agreed, 9.5% dissented and 19.4% could not eat three times a day (Table 1).

It was quite evident according to consent of 83% respondents that COVID-19 would negatively affect aquatic resource dependents income due to restrictions placed on them. Aquatic resource dependents lived hand to mouth and earnings was around 10,000 BDT/month (119USD/month) that created difficulty to buy soap, hand sanitizer, mask and other personal protective equipments. The situation was more vexatious in the fishing communities where 10–15 families had to share one

bathroom/toilet with scarcity of regular water supply that made them more prone. About 45% of respondents felt that they were very prone to COVID-19 and treatment facility that had in district hospital was very inadequate to support marginal aquatic resource dependents.

3.3. COVID-19 and aquatic food system in Bangladesh

The world is facing a crisis and WHO officially has declared the corona virus a global pandemic. Bangladesh is also combating the crisis and experiencing its terrible effect [30]. In addition to affecting the public health sector, COVID-19 has covered the country's economy, business activities, transportation, food supply, food security and more. The lockdown situation has made the food supply worse respectively. Supply of fish and fisheries resources (aquatic food) that play an important role in the diet and nutrition of the people of Bangladesh is also become disrupted.

3.3.1. Food supply

It was found that 92% respondents mainly took fish, shrimp,

Table 1
Perceptions of the respondents on influence of COVID-19.

Questions	Responses (%)				
	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
Covid-19 has negatively influenced my fish production	57.00	22.00	21.00	0.00	0.00
Covid-19 has negatively influenced my fishing	53.70	34.30	8.70	0.00	0.00
Covid-19 has negatively impacted my household food consumption	20.90	52.20	17.40	5.20	4.30
Covid-19 has negatively influenced my income	54.80	28.90	16.30	0.00	0.0
Covid-19 has increased conflicts among stakeholders	3.50	16.50	45.90	24.10	10.00
Social distancing is beneficial for me	4.90	15.10	49.80	20.20	10.00
Covid-19 has increased my hygiene	0.00	5	57	23	15.00
Covid-19 has increased mental stress	2.90	7.10	47.20	32.80	10.00
Lockdown is an effective tool for covid-19 management	23.60	51.20	14.90	5.10	5.20
Covid-19 treatment facility is adequate in my district	0.00	4.70	50.30	34.30	10.70

molluscs and crab as aquatic food. So, the term aquatic food of this research will indicate fish, shrimp, molluscs and crab. The study found that COVID-19 was affecting aquatic food system in two significant aspects: the supply and demand for aquatic food. These two aspects were directly related to food security, so food as well nutrition security is also at risk (Fig. 3). As the supply of fish and other aquatic food was disrupted it created less diversity and availability in the market that raised market price. So, the consumer couldn't get desired fish species and other aquatic food items that put adverse impact on consumer demand and consumption. 56% respondents reported it also reduced dietary diversity as if they buy fish with high price they couldn't afford more

diversified food items for diet that ultimately put adverse impact in nutritional security.

3.3.2. Food demand

Demand refers the compliance and ability to pay money for a specific good or service during any particular time [31]. The government of Bangladesh set restriction on mobility to prevent corona spreading that created panic to marginal people along with some other constraint the supply of aquatic food item with other daily commodities have ensured in the crisis. About 54% respondents said labor was an essential component in agriculture value chains from farm to fork. 54.5% respondents reported restrictions on people movement impacted fry releasing and harvesting of fish. Transportation delay and scheduled cancellations hampered the timely supply of aquatic food items (fish, shrimp, crab and molluscs). More than 80% respondents mentioned that during the lock down gradually people started to lose job that reduced the aquatic food demand due to lack of income. The respondents predicted that the situation could worsen if the pandemic lasted longer. As in any situation, the consumers had to pay cash for their demandable goods and service [32,33].

3.3.3. Food security

Food security ensures that people have uninterrupted access to food that makes them satisfy [34]. Food security is the composition of two key elements: economic access, or whether the people are able to spend enough money to buy food; and physical access, or whether people have enough scope to find available food. Globally 113 million people were battling severe acute food insecurity due to pre-existing shocks or crises even before COVID-19 [35]. More than 60% respondents predicted The COVID-19 pandemic could cause food crises due to ongoing and raised issues associated with economic and physical accessibility. 63% aquatic resource dependents assumed they would be on the extreme end of the hunger spectrum, weak and less well-equipped to fend off COVID-19 infection. The findings also agreed with global situation where 820 million people were more vulnerable with incurable starvation and less access to consume nutritious diet [35]. Small scale fishers and fish farmers were prohibited for working on their fields (wetland, pond), collecting inputs (fishing gear, fuel, fish fry, lime, fertilizer etc.) and unable to collect necessary essentials by selling their products in the market. Finally, such low income families' children, lactating women, adolescent faced dietary diversity crisis which would gradually decrease the ability of fighting with diseases and viruses like COVID-19 [36].

3.4. Impact of COVID-19 on small-scale fisheries

3.4.1. Impact on homestead and commercial farmers, hatcheries and nurseries

COVID-19 directly and indirectly hampered homestead and commercial aquatic food production system drastically. Marginal fish

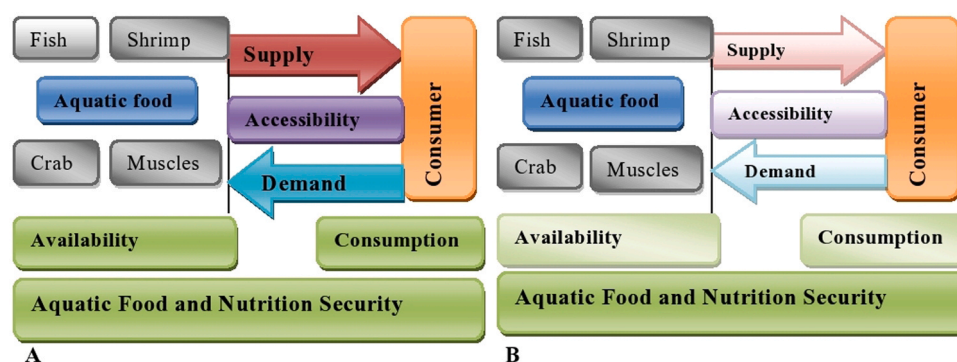


Fig. 3. Aquatic Food security system (A) without COVID-19 and (B) with COVID-19. Both supply and demand have been affected. Effect on demand due to pass-ability restrictions affects accessibility.

farmers cultured fish mainly to meet home consumption demand and sold the remaining production that added money to their family income. During lockdown period they couldn't collect input timely as well didn't get usual service from the specialist. Fish farmer and the entrepreneurs indicated that transportation of fish, fingerling, feed and other inputs was the main problem. More than 50% fish farmers also reported that they couldn't sell mature fish due to transportation complexity and low market demand (Fig. 4). So, a good portion of mature fish remained unsold and the farmers spent extra money to feed the fishes that ultimately reduced family income and increase expenditure as well. Among the farmers and entrepreneurs 35% reported they could not start new farming cycle due to unsold mature fish that also declining the selling price of fish (Fig. 4). The crisis of fish sales was affecting the supply chain as the local vehicles like truck, pickup were afraid to transport fish, fingerling, feed and other materials. Because of the lockdown on the way back to the empty vehicles after delivery was facing various questions and obstacles, many times fine have to be calculated that put adverse impact in the fish landing center, whole sale and retail market.

April and May is the best time to release fry in the farming pond. Between March and April the fish farmer prepare the pond for new season by selling the marketable fish of the previous year. But at this time of new season, transporting fry is a big challenge for fish hatcheries, nurseries and fish farmers [37]. Hatchery specialist from Bagerhat reported that the hatchery remained close but we had to pay the hatchery stuffs. Another hatchery manager from Barisal informed hatcheries were selling their product at very low price and most of the hatcheries and farmers were in doubt whether they would be able to cover the production cost or not. A key informant mentioned fish cultivation would be disrupted due to shortage of aquaculture inputs such as good quality fry, lime, aqua chemicals and feed. 47% of respondents reported gradual weight loss due to inadequate food supply day after day. Respondents of Sylhet, Dhaka, Barisal and Khulna mentioned due to lack of medicine, necessary ingredients and proper management water quality became deteriorated and fish were getting diseases infected (Fig. 4). After the COVID-19 outbreak, crab farmers and traders of coastal areas were leading miserable life as exports were indefinitely postponed. The damage started well before the pandemic reached Bangladesh, as China, the main market for crabs, imposed an import ban on January 25. A key informant from Rampal–Bagerhat Crab Dealers Association said that crabs were usually sold in large quantities during Chinese New Year festival. However many crabs had already died due to COVID-19 ban

[38]. Workers were not also interested to work due to spreading of corona pandemic. Again some of them who were interested to work would not be paid properly due to lack of capital. Because of these problems, farmers, workers, hatchery owners and related members were facing losses which ultimately could have a long term impact on fisheries economy.

3.4.2. Impact on fishing communities

Fishers, fish labors and other actors of fisheries value chain of Bangladesh encountered many problems due to COVID-19 pandemic. During the crisis, their life and life of the people associated with them became more difficult than before. Fishers' major problems to lockdown periods were ban period (72%), low fishing rate (68%), low income (86%), lack of alternative income generating activities (88%), low consumer demand (56%), weak value chain (47%), gradual increase in lockdown days (88%), and 65% mentioned constraint of *dadon* (rent money) while 47% respondents reported supply of fishing gears was also insufficient (Fig. 5). One key informant mentioned this marginalized group faced rising commodity prices as the transport crisis disrupted commodity transport. The middle man intervention also greatly complicated the situation [39].

The study found 88.5% fishers relied entirely on fishing which made them more vulnerable to COVID-19 pandemic. Meanwhile a large portion of the fishing labor (59%) engaged in fish processing, harvesting and marketing were unemployed. Unemployment situation exacerbated conflicts between different stakeholders which created social uncertainty [26,40]. Any kind of ups and downs from the regular life flow adversely affect the well-being of this marginalized class [26,41]. Most of the fishers couldn't sell their fishes that forced them to borrow with high interest from the local money lender. They were also unable to take loan from the concerned bank as they didn't have enough resources to mortgage [17]. More than 68% respondents reported government subsidies were inadequate to support their families, promoting them to fish illegally and breach corona precautions. In a word, fishers and other marginal actors of small-scale fisheries were facing a four-pronged crisis in-term of human, physical, social and financial capital. The major vulnerabilities could be noticed in the three specific parts. These are- i) COVID-19 Shocks, ii) Adverse COVID-19 trends and iii) Unfavorable seasonal ban period (Table 2).

3.4.2.1. Shocks. Fishers' illness and unemployment were the main

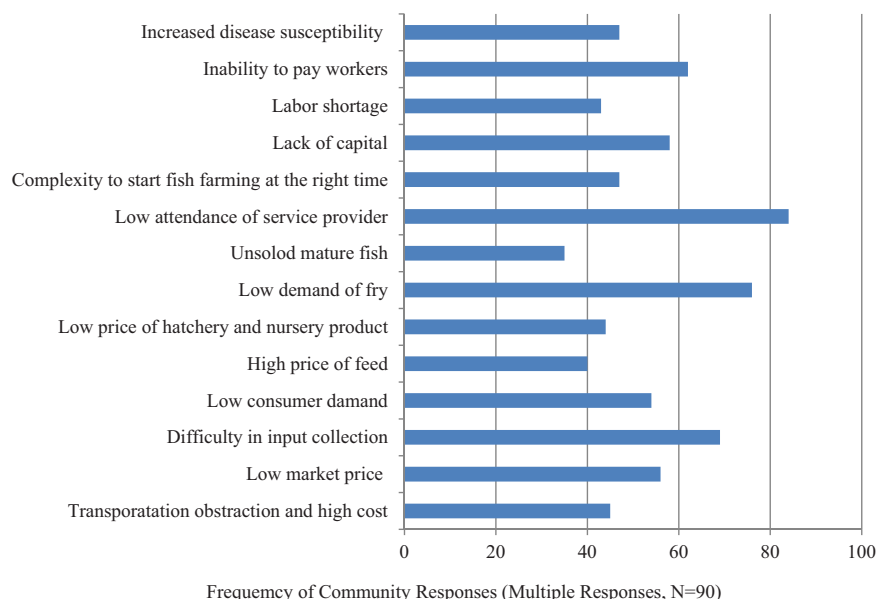


Fig. 4. Problem arising in homestead and commercial farming.

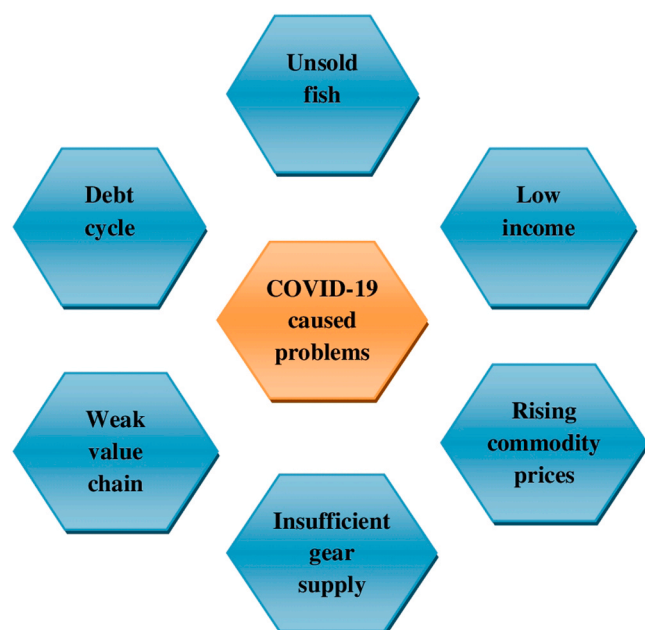


Fig. 5. COVID-19 caused problems faced by the small-scale fishers and associated people.

Table 2
COVID-19 vulnerabilities of small-scale fishers and associated people.

COVID-19 shocks	Adverse COVID-19 trends	Unfavorable seasonal ban period
<ul style="list-style-type: none"> • Illness • Death of family members • Dismissal from current work • Reduced income 	<ul style="list-style-type: none"> • Complexity in fish supply • Shortage of fishing gear • Low consumer demand • Pressure from creditors • Political crisis • Environmental changes 	<ul style="list-style-type: none"> • Dependency on single profession • Seasonal unemployment • Inadequate subsidy • Nepotism

shocks. They all had to stay at home and their income stopped. The impoverished fishers were at great risk which forced them to deplete their resources.

3.4.2.2. Trends. Various trends damaged the livelihoods of the small-scale fishers in COVID-19. Larger family size, political crisis and environmental changes made them more vulnerable while COVID-19 induced complexity of fish supply and shortage of fishing gear in the market, low demand from consumer, pressure from creditors and rising commodity prices made the situation worse.

3.4.2.3. Seasonality. Seasonal hilsa conservation ban period during March–April affect the fishing communities in the major rivers of Bangladesh. During this time restriction was imposed in all sanctuary areas. 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. The government subsidized the fishers to keep their lives normal which was far less than what was needed (Table 2). It was pity that many real fishers didn't get this support due to nepotism [19,40].

4. Conclusion and recommendation

The pandemic known as COVID-19 has had a catastrophic impacts on human action and activities, with aquatic food sector and small-scale fisheries being no exception. Food demand and thus food security are severely compromised due to movement restrictions, reduced purchasing power, and further impact on the most vulnerable small-scale fishers and associated people. So, any action taken by the Government should be based on protecting the health and food security of the people particularly to the marginalized class, although it could be detrimental to economic growth in the short run. Furthermore, policies should ensure that both economic and physical elements of total food security, including agriculture, fisheries, dairy and poultry are taken into account. Sufficient baseline information to initiate proper developmental steps and to improve the livelihood of fishermen should be collected. Resource based data bank should be preserved for further research and development. Scope of alternative income generating opportunities, rationing system, training and motivational program, implementation of appropriate policies, legal instruments and establishment of co-management strategies for wetland management could improve the situation of the aquatic food production and fishing communities of the relevant wetland. Without concerted and sustained effort, there is no doubt potential risk associated with food security will arise during and after COVID-19 pandemic. This paper will contribute to current COVID-19 research by interlinking the global health pandemic and aquatic food security and will provide insight into policies taken by the policy makers to mitigate the impacts of the pandemic on aquatic food sector and small-scale fisheries in Bangladesh.

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References

- [1] World Health Organization (WHO). Novel Coronavirus (2019-nCoV). Situation Report – 1. 21 January 2020. 2020a. 5 pp. Available in: (<https://www.who.int/emergencies/diseases/novelcoronavirus-2019/situation-reports>).
- [2] R. Wang-Shick, *Molecular Virology of Human Pathogenic Viruses*, Elsevier Inc. Academic Press, 2017, p. 440.
- [3] R. Siche, What is the impact of COVID-19 disease on agriculture? *Sci. Agropecu.* 11 (1) (2020) 3–6.
- [4] Worldmeters. 2020. (www.worldometers.info/coronavirus/) (accessed on 06.06.2020).
- [5] M. Burnet, D.O. White, *Natural History of Infectious Disease*, 4th ed., Cambridge University Press, Cambridge, United Kingdom, 1972, p. 279.
- [6] S. Anwar, M. Nasrullah, M.J. Hosen, COVID-19 and Bangladesh: challenges and how to address them, *Front. Public Health* 8 (8) (2020) 154, <https://doi.org/10.3389/fpubh.2020.00154>.
- [7] M. Hanashima, K. Tomobe, Urbanization, industrialization, and mortality in modern Japan: a spatiotemporal perspective, *Ann. GIS* 18 (1) (2012) 57–70.
- [8] A. Bermejo, HIV/AIDS in Africa: international responses to the pandemic, *N. Econ.* 11 (3) (2004) 164–169.
- [9] C. Arndt, J.D. Lewis, The HIV/AIDS pandemic in South Africa: sectoral impacts and unemployment, *J. Int. Dev.* 13 (4) (2001) 427–449.
- [10] Burgui, D. Coronavirus: how action against hunger is responding to the pandemic, 2020 Available in: (<https://www.actionagainsthunger.org/story/coronavirus-how-action-against-hunger-responding-pandemic>), 2020.
- [11] T.T. Sar, P.T. Aernan, R.S. Houmsou, H1N1 influenza epidemic: public health implications for Nigeria, *Int. J. Virol.* 6 (2020) 1–6, 2010.
- [12] S.T. Hossain, Impact of Covid-19 on the Afri-food sector: food security policies of Asian productivity organization members, *J. Agric. Sci. -Sri Lanka* 15 (2) (2020) 116–132, <https://doi.org/10.4038/jas.v15i2.8794>.
- [13] Fan, S. Preventing global food security crisis under COVID-19 emergency, 2020, (<https://www.ifpri.org/blog/preventing-global-food-security-crisis-under-covid-19-emergency>). 20.4.2020. DOI: (<https://doi.org/10.2499/p15738coll2.133678>).

- [14] Food and Agriculture Organization (FAO). COVID-19: our hungriest, most vulnerable communities face “a crisis within a crisis.”, 2020, ([http://www.fao.org/news/story/en/item/1269721/icode/](http://www.fao.org/news/story/en/item/1269721/icode/.). 20.4.2020).
- [15] A.R. Sunny, R. Alam, A.K. Sadia, Y. Miah, S. Hossain, S.B. Mofiz, et al., Factors affecting the biodiversity and human well-being of an ecologically sensitive wetland of North Eastern Bangladesh, *J. Coast. Zone Manag.* 23 (1) (2020) 471.
- [16] A.R. Sunny, J. Reza, M. Anas, M.N. Hassan, M.A. Baten, R. Hasan, M.M. Monwar, H. Solaiman, M.M. Hossain, Biodiversity assemblages and conservation necessities of ecologically sensitive natural wetlands of north eastern Bangladesh, *Indian J. Geo-Mar. Sci.* 49 (01) (2020) 135–148.
- [17] A.R. Sunny, G.S. Ahamed, M.H. Mithun, M.A. Islam, B. Das, A. Rahman, et al., Livelihood status of the Hilsa (*Tenualosailisha*) fishers: the case of coastal fishing community of The Padma River, Bangladesh, *J. Coast. Zone Manag.* 22 (2) (2019) 469.
- [18] DoF, Yearbook of Fisheries Statistics of Bangladesh, 2017-18. Fisheries Resources Survey System (FRSS), Volume 35, Department of Fisheries., Bangladesh: Ministry of Fisheries, 2018, p. 129.
- [19] A.R. Sunny, M.M. Islam, M. Rahman, M.Y. Miah, M. Mostafiz, N. Islam, M. Z. Hossain, M.A. Chowdhury, M.A. Islam, J.H. Keus, Cost effective aquaponics for food security and income of farming households in coastal Bangladesh, Egypt. *J. Aquat. Res.* 45 (2019) 89–97, <https://doi.org/10.1016/j.ejar.2019.01.003>.
- [20] M.M. Islam, A.R. Sunny, M.M. Hossain, D. Friess, Drivers of mangrove ecosystem service change in the sundarbans of Bangladesh, Singap. *J. Trop. Geogr.* 39 (2018) 244–265, <https://doi.org/10.1111/sjtg.12241>.
- [21] A.R. Sunny, M.N. Hassan, M. Mahashin, M. Nahiduzzaman, Present status of hilsa shad (*Tenualosailisha*) in Bangladesh: a review, *J. Entomol. Zool. Stud.* 5 (6) (2017) 2099–2105.
- [22] M.M. Shamsuzzaman, M.M. Islam, N.J. Tania, M.A. Al-Mamun, P.P. Barman, X. Xu, Fisheries resources of Bangladesh: present status and future direction, *Aquac. Fish.* 2 (2017) 145–156, <https://doi.org/10.1016/j.aaf.2017.03.006>.
- [23] M.M. Islam, N. Islam, A.R. Sunny, S. Jentoft, M.H. Ullah, S.M. Sharifuzzaman, Fishers' perceptions of the performance of hilsa shad (*Tenualosailisha*) sanctuaries in Bangladesh, *Ocean Coast. Manag.* 130 (2016) 309–316, <https://doi.org/10.1016/j.ocecoaman.2016.07.003>.
- [24] M.R. Islam, T. Cansse, M.S. Islam, A.R. Sunny, Climate change and its impacts: the case of coastal fishing communities of the Meghna river in south central Bangladesh, *Int. J. Mar. Environ. Sci.* (2018), <https://doi.org/10.5281/zenodo.1474924>.
- [25] A.R. Sunny, M.M. Islam, M. Nahiduzzaman, M.A. Wahab, Coping with climate change impacts: the case of coastal fishing communities in upper Meghna hilsa sanctuary of Bangladesh, in: M.S. Babel, A. Haarstrick, L. Ribbe, V. Shinde, N. Dichti (Eds.), *Water Security in Asia: Opportunities and Challenges in the Context of Climate Change*, Springer, 2018. ISBN 978-3-319-54612-4, at, (<http://www.springer.com/us/book/9783319546117>).
- [26] A.R. Sunny, Impact of oil spill in the Bangladesh sundarbans, *Int. J. Fish. Aquat. Stud.* 5 (5) (2017) 365–368.
- [27] Bangladesh Bureau of Statistics (BBS). Population and Housing Census 2011 National volume 2: Union Statistics. Dhaka.2015. Available online at: ([http://www.bbs.gov.bd/WebTestApplication/userfiles/Image/National Reports/Union Statistics.pdf](http://www.bbs.gov.bd/WebTestApplication/userfiles/Image/National%20Reports/Union%20Statistics.pdf)).
- [28] Perera, W. Bangladesh Government Downplays COVID-19 Threat as Job Losses Mount, 2020. Available online at: (<https://www.wsns.org/en/articles/2020/03/16/bang-m16.html>) (accessed March 26, 2020).
- [29] Sriharsha, D., Dentewadia, P. Mint Covid Tracker: India's corona trajectory has tapered this week but still remains steeper than Asian peers, 2020. Available online at: (<https://www.livemint.com/news/india/india-s-corona-trajectory-tapered-but-still-remains-steeper-than-asian-peers-11586576536468.html>).
- [30] Bhuiyan, M.S. A. COVID-19 and its impact on Bangladesh economy. THE BUSINESS STANDARD., 2020. Accessed 5 May 2020 at: (<https://tbsnews.net/thoughts/covid-19-and-its-impact-bangladesh-economy-69541>).
- [31] F.M. Gottheil. Principles of Microeconomics, 7th ed., Cengage Learning, EEUU, 2013, p. 592.
- [32] Food and Agriculture Organization (FAO). FAO Director-General urges G20 to ensure that food value chains are not disrupted during COVID-19 pandemic, 2020, Available in: (<http://www.fao.org/news/story/en/item/1268254/icode/>).
- [33] Food and Agriculture Organization (FAO). FAO Food Price Index., 2020, Available in: (<http://www.fao.org/worldfoodsituation/foodpricesindex/en/>).
- [34] Rosales, G., Mercado, W. Efecto de los cambios en el precio de los alimentos sobre el consumo de la quinua y la seguridad alimentaria rural en el Perú. *Scientia Agropecuaria*, 2020, 11(1): 83–93.
- [35] R. Siche, What is the impact of COVID-19 disease on agriculture? *Sci. Agropecu.* 11 (1) (2020) 3–6.
- [36] Food and Agriculture Organization (FAO). FAO alerta sobre el impacto del COVID-19 en la alimentación escolar de América Latina y el Caribe, 2020, Available in: (<http://www.fao.org/americas/noticias/ver/es/c/1267028/>).
- [37] Rashid, H. Problems arising in fish farming due to corona disaster. BonikBarta, 2020, Available in (https://bonikbarta.net/home/news_description/229391/).
- [38] Kawsar, M.A. Impact of corona virus on fisheries: Bangladesh perspective. *Agrinews24.com*. 2020, Available in (<http://www.agrinews24.com/impact-of-corona-virus-on-fisheries-bangladesh-perspective/>).
- [39] E.Y. Mohammed, L. Ali, S. Ali, B. Hussein, M.A. Wahab, N. Sage. Hilsa's Non-Consumptive Value in Bangladesh: Estimating the Nonconsumptive Value of the Hilsa Fishery in Bangladesh using the Contingent Valuation Method, IIED., London, 2020. IIED Working Paper.
- [40] M.M. Islam, M.M. Shamsuzzaman, A.R. Sunny, N. Islam, Understanding fishery conflicts in the hilsa sanctuaries of Bangladesh, in: A.M. Song, S.D. Bower, P. Onyango, S.J. Cooke, R. Chuenpagdee (Eds.), *Inter-Sectoral Governance of Inland Fisheries*, 2017, pp. 18–31.
- [41] I. Porras, E.Y. Mohammed, L. Ali, M. Ali, M.B. Hossain, Power, profits and payments for ecosystem services in Hilsa fisheries in Bangladesh: a value chain analysis, *Mar. Policy* 84 (2017) 60–68.