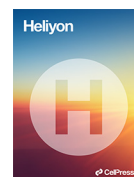




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## Research article

Implications of COVID-19 on oxbow lake (*Baors*) Fisher's community, Bangladesh: resilience to food security against probable natural calamities

Md. Abdus Samad<sup>a,b,\*</sup>, Md. Ataur Rahman<sup>a</sup>, Syeda Maksuda Yeasmin<sup>b</sup>, Sarower Mahfuj<sup>b</sup>,  
Md. Habibur Rahman<sup>b</sup>, Mst. Farzana Sultana<sup>c</sup>, Md. Ashekur Rahman<sup>a</sup>, Tarun Sen<sup>d</sup>,  
Md. Anisur Rahman<sup>b</sup>, Md. Sherazul Islam<sup>b</sup>, Md. Yeamin Hossain<sup>a</sup>

<sup>a</sup> Department of Fisheries, University of Rajshahi, Rajshahi, 6205, Bangladesh

<sup>b</sup> Department of Fisheries and Marine Bioscience, Jashore University of Science and Technology, Jashore, 7408, Bangladesh

<sup>c</sup> Department of Pharmacy, Jashore University of Science and Technology, Jashore, 7408, Bangladesh

<sup>d</sup> Department of Accounting and Information Systems, Jashore University of Science and Technology, Jashore, 7408, Bangladesh

## ARTICLE INFO

## Keywords:

Livelihood  
Food security  
*Baor*  
COVID-19  
Oxbow lake

## ABSTRACT

The purpose of studying the consequence of COVID-19 on oxbow lake (*Baor*) fisher's community is to counteract the negative impacts on livelihoods with food security and figure out diversified resilience options for sustaining basic needs of life. Individual questionnaire interviews, oral history, focus group discussion, and telephonic interviews were among the methodological techniques used to gather primary data. The *Baor* fisher's community was impaired with income, food and feeding habit, health and marketing. The *Baor* fishers had to stop harvesting or reducing the amount of fish harvest because of gradual decreasing of consumer demand and prices of fish during the course of COVID-19 pandemic period. The transportation costs were raised up to 50%–80%, while the prices of fish decreased by 15%–30% prior to the onset of COVID-19 pandemic. The frequency of fish consumption was significantly come down to 37.5%. Many households substituted fish to farm reared hens, eggs, domestic hens and ducks, lentils, and vegetables during the period of lockdown across the country. Supply chains of fish and fish culture inputs were disrupted due to inadequacy of transportation facilities. Many school- and college-going students were dropped out during the ongoing pandemic situation due to their financial problems (10%) and early marriage (7.5%). The secondary sources of income (labor of netting in other aquaculture farms) of *Baor* fisher's community were also impaired. The resilience options of this study will be helpful to minimize the sudden economic crises, ensure dynamic fish value chains and food security, protect individuals from ongoing health hazards, and promote sustainable food production systems followed by social cohesion and stability against the prevailing challenges owing to the pandemic and other natural calamities.

## 1. Introduction

At present novel-coronavirus become a worldwide health problem and public health exigency of intercontinental anxiety (Wang et al., 2020). The World Health Organization (WHO) has given the name of severe acute respiratory syndrome coronavirus (SARSCOV2), a positive sense single-stranded RNA virus as COVID-19 after it first appeared in Wuhan under Hubei Province of China in December 2019. Due to COVID-19's quick spread, more than 50 million cases had been reported in 213 nations, regions, or territories by November 11th, 2020. This led to more than 1.2 million deaths (WHO, 2020).

According to WHO (2020), maintaining social distance and self-isolation and following lockdown rules are the important preventive

measures of avoiding COVID-19. Because of quick dispersion Bangladesh's government had needed to announce a countrywide lockdown from March 26th through May 30th 2020 and April 5th through 30 first May 2021, followed by a partial lockdown, that means emergency transportation, selective access to work place, strong social distance, shutdown of educational institutions including school, college and universities like other nations. Countrywide shutdown due to pandemic situation of COVID-19 critically interrupted food supply chain along with exerting various difficulties on the aquaculture and fisheries sector. Though the COVID-19 does not directly affect the terrestrial species, it has had a significant influence on fisheries and aquaculture food systems (Mandal et al., 2021). The economy, culture, ecology and aesthetics of Bangladesh are closely related with fisheries and aquatic resources.

\* Corresponding author.

E-mail address: [ma.samad@just.edu.bd](mailto:ma.samad@just.edu.bd) (Md.A. Samad).

Fisheries contribute 3.5% of the country's GDP and 26% to agricultural GDP, 1.5% of total export wages. This sector provides 62.6 g of protein per person per day. In addition, this sector employs 12% of the population, including women, who are directly or indirectly reducing poverty, ensuring food security, and improving the socioeconomic conditions of fishermen (DoF, 2020). According to culture and capture fisheries, inland open and closed water bodies make up 84.69% of total fisheries production, while marine water resources account for 15.31% in Bangladesh (DoF, 2020).

Small-scale fishing (SSF) is the most common type of marine fishing, also referred as artisanal fishing, and it employs about 1.5 million people. More than 10 million coastal fishermen rely on these fisheries for their livelihood, either directly or indirectly (FRSS, 2020). However, the COVID-19 scenario is currently having an adverse impact on fisheries sector due to altering consumer needs, market access, and logistical problems caused by limited transportation and border restrictions. This sector directly related to stock food services deeply hampered by lockdown activities like shutdown of hotel, restaurant, tourist spots, as a result of low demand of fish supplies. Due to shortage of raw materials and restricted vehicle facility, the fish and fisheries related stakeholders are enabling to carry on their trade. These impediments have a direct impact on the socioeconomic situation of fishers, as well as national food safety, which is profoundly reliant on the fisheries division (FAO, 2020a).

*Baors* are oxbow lakes produced by dead river arms located in the Ganges delta in the country's west (Abdullah-Bin-Farid et al., 2013). *Baors* or oxbow lakes are important inland water assets in Bangladesh that form as a result of the changing course of the streams. Over 600 *Baors* are found in the districts of Jashore, Kushtia, and Faridpur in Bangladesh's south-western region, especially in the broader Jashore area. *Baors* now has a total area of 5671 hectares and a fish production of 10969 MT (DoF, 2021). Most of the wetland ecosystems (Rivers, Beels etc.) in greater Jashore, Jhenidah, Chuadanga, Narail and Kushtia districts except *Baors* have been dried up in dry season. As a result, indigenous fish species have been disappeared from those natural ecosystems. However, *Baors* are only the existing perennial water-bodies abounded with different types of indigenous species safe and free from different types of toxic contaminants. These indigenous fish species are main sources of micronutrients for *Baor* fisher's community along with the peoples inhabited greater Jashore, Jhenidah, Chuadanga, Narail and Kushtia regions (Samad et al., 2021).

COVID-19 infection outbreak had a huge impact on practically everyone, including fishermen and their families (Bennett et al., 2020; Demirci et al., 2020). Fish prices fell down during the pandemic due to constraints and restrictions, making it more difficult for fisher's families to keep continuing their regular daily lives and dietary protein intakes (Hidayati et al., 2021). The implications of COVID-19 may have some indirect and direct impacts on *Baor* fisher's communities due to fish trade interruptions followed by long-term imposed restrictions for minimization of the spread of infections and protection of public health. Although, a few research works have been performed on various impact of COVID-19 on small scale fisheries (Sharif et al., 2016; Islam et al., 2018; Hasan et al., 2021; Rahman et al., 2021; Sunny et al., 2021), no specific research works was found on the consequences caused by direct and indirect confounding factors, associated with COVID-19, on *Baor* fisheries and fisher's communities. The goal of this study was to ascertain the harmful consequences of the COVID-19 on *Baor* community livelihoods and food security, positive effects on technological innovations, alternative income generations etc. along with resilience to challenge the probable natural calamities.

## 2. Materials and methods

### 2.1. Study area

The research was conducted in Jashore District, Southwestern part of Bangladesh from August 2020 to January 2022. In the four major

districts named Jashore, Faridpur, Khulna, and Kushtia, there are approximately 600 oxbow lakes, with many of them located in the greater Jashore region. *Baor* fishers have been severely suffering due to socioeconomic difficulties induced by COVID-19 pandemic.

### 2.2. Data collection

The research was based on both primary and secondary data sources. Individual questionnaire interviews, key informant conversations with *Baor* fishers, oral history, focus group discussion (FGD), and telephonic interviews were among the methodological techniques used to gather primary data. The use of a telephonic interview made it much easier to perform the study during the period of restrictions and constraints. The Institute of Epidemiology, Disease Control and Research provided secondary data for COVID-19 (IEDCR, 2022). The information presented a general summary of COVID-19 affected rate, the status of the lockdown, and the number of people infected by COVID-19, and number of samples testing for COVID-19 of Jashore districts of Bangladesh (Figure 1). For additional items, data were incorporated from scientific journals, technical reports, and press reports.

The Department of Fisheries (DoF), which is part of the Bangladesh's Ministry of Fisheries and Livestock (DoF, 2020), provided data on fish harvest, demand, and supply, as well as related aquaculture.

### 2.3. Data analysis

The proportion of responses was calculated using descriptive statistics. The changes in fish prices were calculated using the average price during study period. To accomplish this, the increase or decrease in price of each fish species was recorded. The mean increase or decrease for each fish was calculated by calculating its average mean. Excel, PAST4.0 software was used to analyze the data.

### 2.4. Ethical statement

This research work was conducted with the consent from the respondents according to approval guidelines of ethical review committee, Faculty of Biological Science and Technology, Jashore university of Science and Technology, Jashore-7408, Bangladesh.

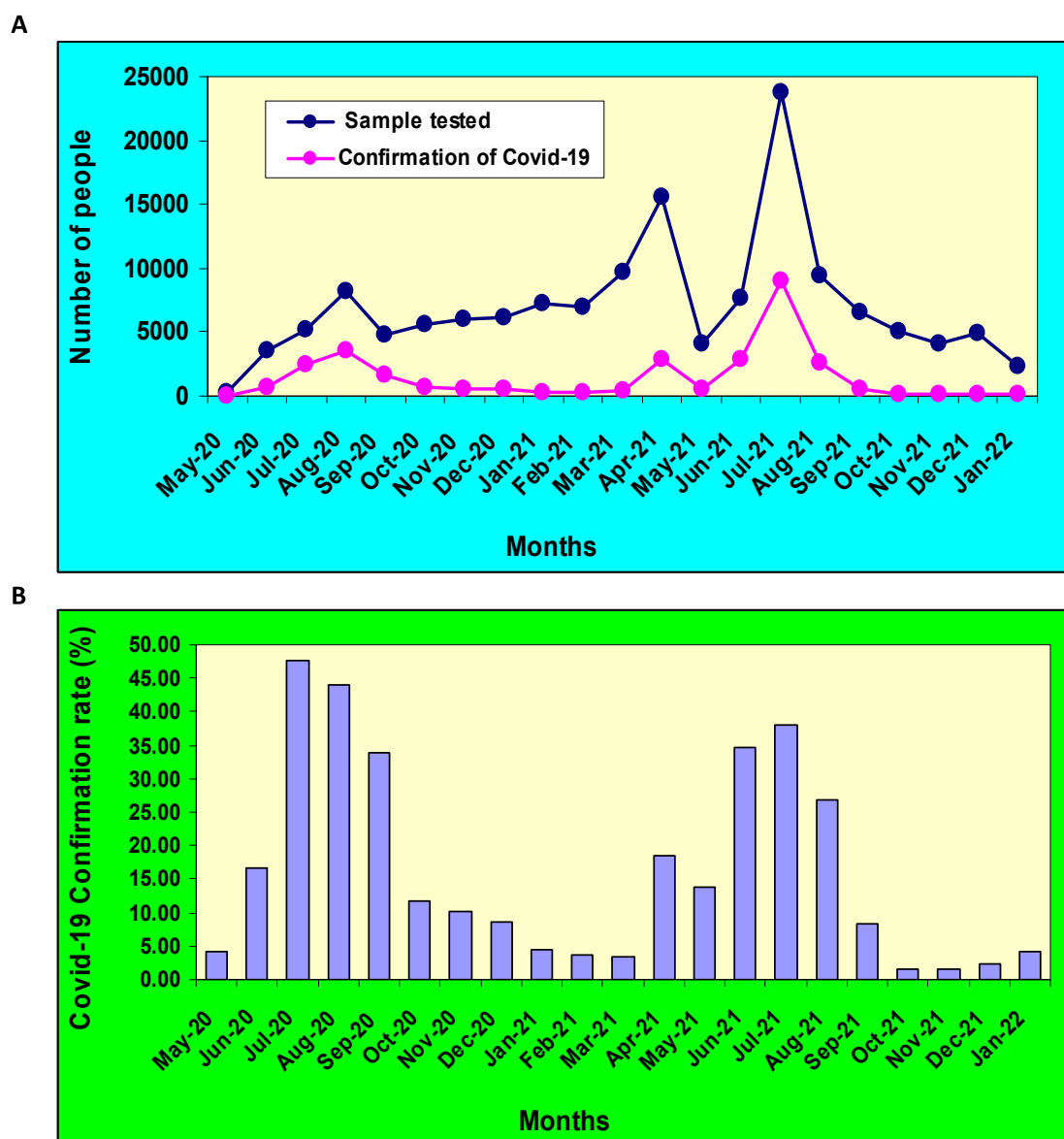
## 3. Results

### 3.1. Socio-demographic information

A total 400 respondents were interviewed during COVID-19 and post COVID-19 pandemic situations. The age and gender of the participants are among the social-demographic data obtained through the questionnaire, oral history, and telephonic interviews (Table 1). Around 75% of the participants were men and 25% were women. Respondents who were completely reliant on fishing in *Baor* were selected for interview. The highest confirmation rate of COVID-19 infection at Jashore district of Bangladesh was observed during the month of July and August in both 2020 and 2021 (Figure 1A and 1B).

### 3.2. Fish availability

According to the *Baor* fishers (40%), Small indigenous fish species (SIFS), and Indian major carps (IMCs) were abundant fish in the *Baor* areas throughout the pandemic (Table 2). On the other hand, majority of *Baor* fishermen (60%) agreed that, Pabda catfish, Tilapia, SIFS, IMCs, Koi, Chital and Ayer fishes were most abundant species in the *Baor* water bodies.



**Figure 1.** (A) The number of confirmed case and number of sample tested of Jashore district of Bangladesh (B) COVID-19 confirmation rate of Jashore district of Bangladesh (IEDCR, 2022).

### 3.3. Fishing practice

The majority of the *Baors* (85%) are administered using a community-based fisheries management (CBFM) approach, with individual fish harvesting SIFS and group fish harvesting (IMCs and cat fishes).

### 3.4. Negative effects of COVID-19 on Baor Fisher's community

Different negative consequences of COVID-19 on *Baor* fisher's community are demonstrated in Figure 2.

#### 3.4.1. Impacts on livelihood

The Novel Corona Virus (COVID-19) has had quite a substantial detrimental impact on Bangladesh's disadvantaged community. This global health crisis affected livelihood and food security for the *Baor* fisher's community. Members of this community who are mainly depends on fishing (90%), they can't harvest fish from *Baors*. Sometimes they harvested fish but they could not sell all of those fish with appropriate price due to COVID-19 pandemic (60%). From the middle of March 2020, the government of Bangladesh implemented statewide general holidays

and lockdown, which had a significant influence on the general people livelihood, particularly for lower-income people who live on the *Baor* fisher's community. The general summary of COVID-19 affected rate, the number of confirmed case, and number of sample tested of Jashore districts of Bangladesh were demonstrated in Figure 1. A total of 28% respondents were working in the informal sector have lost their employment and income as a result of the ongoing pandemic. They could not fulfill their basic needs due to financial problem. A sum of 34% respondents was affected with COVID-19. As their income was very low during this period, so they reduced the sacrifice of animal lives during this pandemic situation in their religious festival. They also minimized their use of recreational item cost (Mobile, Television) on entertainment purposes.

#### 3.4.2. Impacts on marketing

The primary problem fisher's encounter was fish marketing (86%). Fishermen were unable to market their captured fish due to the lockdown, despite the fact that the fish were suitable for harvesting in March. The cost of transportation climbed from 40% to 80% during the same time period, whereas the cost of fish reduced 15%–30% from typical

**Table 1.** Demographic profile of the respondents in *Baor* fisher's communities of Jashore district.

Upazila	Name of the Baor	Management (Individual/Cooperative/Open access)	Baor Area (acre)	Number of respondents	Male	Female
Sadar Upazila	Bukvora <i>Baor</i>	Cooperative	385	70	60	10
	Joghathi <i>Baor</i>	Individual	122	30	23	07
Sharsa	Rajgonj <i>Baor</i>	Cooperative	200	50	35	15
	Bahadurpur <i>Baor</i>	Cooperative	300	50	40	10
Monirampur	Khatura <i>Baor</i>	Cooperative	290	60	30	30
	Jhapa <i>Baor</i>	Cooperative	605	40	32	08
Chaugacha	Bergobindopur <i>Baor</i>	Cooperative	300	100	80	20

levels. Fishers (40%) typically picked limited quantity of fish, with the remainder being preserved in the *Baors*, which have been known to harbor diseases in some situations.

### 3.4.3. Impacts on fry stocking

Two types of fish culture including exotic carp culture (78%) and indigenous species capture (22%) were found during this study. Fish

harvest was postponed in some *Baors* (75%) due to transportation issues, the problems in marketing system, and lower fish prices, as well as the inability to stock new fish fry for the remaining fishes. Hatchery owners also did not produce fish fry because of the decreasing the seed demands. The demands of fry or fingerlings were dropped by about 20%, resulting in significant financial losses for hatchery/nursery owners.

**Table 2.** Available fish species from *Baors* during the study period.

SL No.	Species name	Availability in the <i>Baor</i>	IUCN Bangladesh Status (IUCN Bangladesh, 2015)	IUCN World-wide Status (IUCN, 2021)
1	<i>Amblypharyngodon mola</i>	TYL	LC	LC
2	<i>Anabas testudineus</i>	LM	LC	LC
3	<i>Badis badis</i>	SM	NT	LC
4	<i>Chanda nama</i>	TYL	LC	LC
5	<i>Chanda ranga</i>	TYS	LC	LC
6	<i>Channa orientalis</i>	TYS	LC	LC
7	<i>Channa marulius</i>	SM	EN	LC
8	<i>Channa punctatus</i>	TYL	LC	LC
9	<i>Channa striatus</i>	SM	LC	LC
10	<i>Esomus danrica</i>	TYS	LC	LC
11	<i>Glossogobius giuris</i>	TYL	LC	LC
12	<i>Gudusia chapra</i>	TYL	VU	LC
13	<i>Heteropneustes fossilis</i>	SM	LC	LC
14	<i>Lepidocephalichthys guntea</i>	LM	LC	LC
15	<i>Macrogathus aculeatus</i>	SM	NT	NE
16	<i>Macrogathus pancalus</i>	TYS	LC	LC
17	<i>Mastacembelus armatus</i>	SM	EN	NE
18	<i>Mystus cavasius</i>	LM	LC	VU
19	<i>Mystus tengara</i>	TYS	LC	LC
20	<i>Nandus nandus</i>	SM	LC	LC
21	<i>Ompok pabda</i>	SM	EN	NT
22	Parambassis ranga	TYL	LC	NE
23	<i>Puntius sophore</i>	TYL	LC	LC
24	<i>Salmostoma bacaila</i>	TYL	LC	LC
25	<i>Trichogaster fasciata</i>	TYL	LC	LC
26	<i>Trichogaster lalius</i>	TYS	LC	LC
27	<i>Xenentodon cancila</i>	TYS	LC	NE
28	<i>Cirrhinus cirrhosus</i>	TYL	NT	VU
29	<i>Cirrhinus reba</i>	TYL	NT	LC
30	<i>Labeo bata</i>	TYL	LC	LC
31	<i>Labeo calbasu</i>	TYL	LC	LC
32	<i>Labeo rohita</i>	TYL	LC	LC
33	<i>Aristichthys nobilis</i>	TYL	LC	DD
34	<i>Gibelion catla</i>	TYL	LC	LC
35	<i>Hypophthalmichthys molitrix</i>	TYL	LC	NT

Note: LC-Least concern, VU-Vulnerable, EN-Endangered, CR- Critically endangered, NT-Near threatened, DD- Data deficient, NE- Not evaluated, TYS (throughout the year in small amount), TYL (throughout the year in large amount), SM (found in small amount during monsoon), LM (found in large amount during monsoon), and NE (not evaluated).

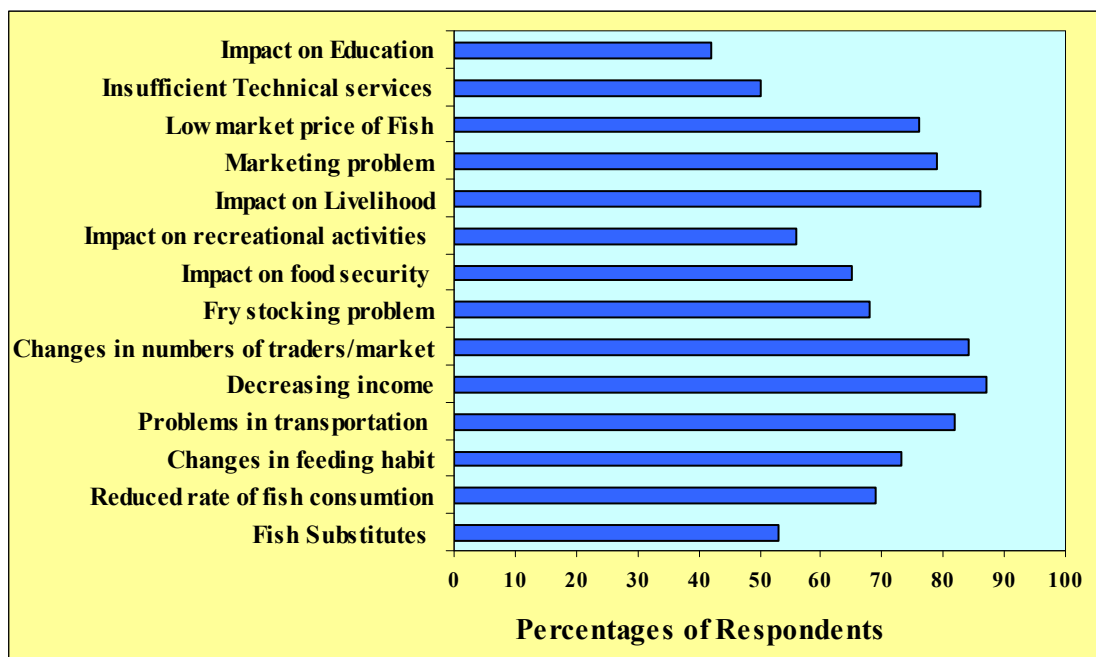


Figure 2. Major negative impacts of Baor fisher's communities during COVID-19 situation.

3.4.4. Impacts on feeding habits

Bangladesh's COVID-19 pandemic has prompted modifications in traditional food purchasing patterns and eating habits. Due to a lack of income (87%), people have become more reliant on cheaper foods (e.g., more rice with less meat, eggs, vegetables, and fruit) and people are spending more time indoors and limiting their physical activity. On the other hand, they have resulted in some positive behaviors such as an increase in cooking (30%), household consumption (25%), increase social interaction (36%) etc. People in Baor villages are coping with new techniques as a result of the pandemic. Fishermen's protein requirements were mostly met by eating lentils, eggs, and low-cost fish.

3.4.5. Impacts on income

To deal with the loss of income, many urban households lowered their food consumption; a similar number of people sought assistance from friends. Many people in the Baor fishing villages have lost their jobs, their working hours have been cut, and their profession has changed. In the

rural homes of the fishery community, 38% reduced their food consumption, 10% received support from friends, and 10% received reliefs from the government. 8% had to use their savings, 20% looked for additional work, and 15% took micro-credit loan from different micro-credit financing organizations (Figure 3). The secondary source of income of Baor fisher's community was from labor of netting in other aquaculture farms, but they were not hired to fishing from other water bodies such as fish farming ponds, reservoirs and ghers during the COVID-19 pandemic situation. As a result, their secondary income was significantly reduced during those times.

3.4.6. Impacts on frequency of fish consumption

In Bangladesh, fish is a significant and vital animal source of food, and it plays an important part in providing food security. The nutritious benefit of fish consumption, increased profits from fish sales, and improved economic stability of women through aquaculture participation are indicators of fish's support to family food security in poor

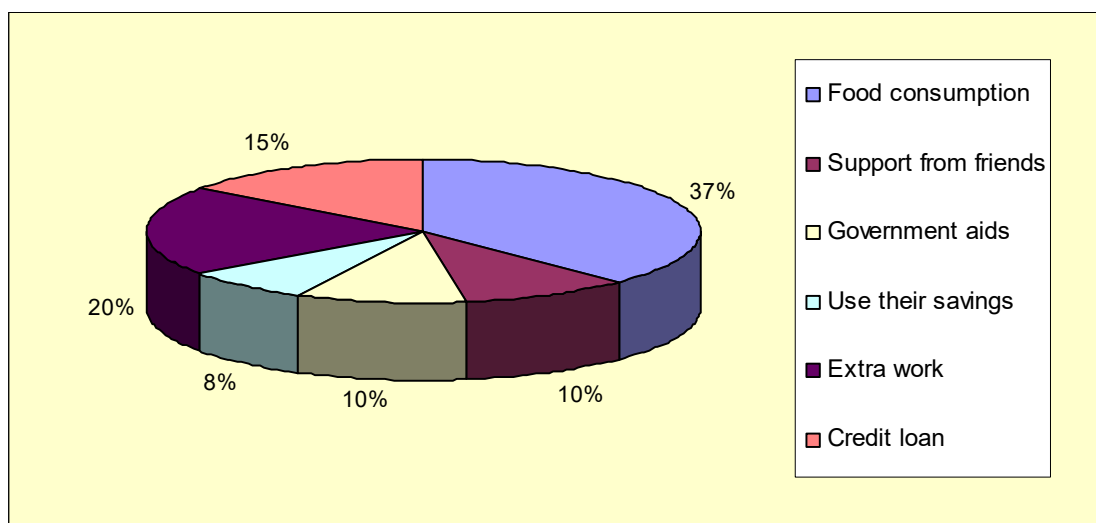


Figure 3. Multiple adaptations and changes of fisher's livelihood during COVID-19 pandemic.



nations. In the current study, the frequency of fish eating by *Baor* fishermen in Jashore areas throughout a seven-day period was found to be associated with average incomes before and during the pandemic. The frequency of fish consumption was significantly decreased by 37.5%. More relatively wealthy families consumed fish at a higher frequency than economically disadvantaged backgrounds families. However, after the onset of COVID-19, the overall consumption of fish decreased significantly. Fish intake, which is a significant element of Bangladeshi diets, declined drastically during the pandemic. The lockdown hampered fish worker transit and availability, causing agricultural commodities supply chains around the world, especially in Bangladesh, to be interrupted. The fishing sector in Bangladesh, like all agricultural supply chains, has been severely disrupted by bottlenecks in transportation, commerce, and labor, as well as fears about COVID-19 virus transmission through fish, despite the lack of proof of transmission via foods. Reduced household incomes and the loss of a housemaid as a result of the COVID-19 lockdowns may have influenced demand for fish. Large families ate less fish, and tiny families couldn't eat fish all seven days of the week, because it was quite difficult to eat fish twice a day for *Baor* fisher's family, so they had to settle with low-cost fish like Silver, tilapia and Pangas.

### 3.4.7. Changes in fish and fish farming inputs price

The sharp drop in consumer demand for fish has resulted in lower prices, prompting some farmers to postpone harvesting their product (Table 3 & Figure 4). According to Mann Whitney test, there was significant difference between average fish prices before pandemic and during pandemic situation ( $P = 0.073$ ). Due to a lack of liquidity, some farmers have been compelled to sell at considerably lower prices, resulting in significant losses. As a result of COVID-19, the mid-stream of supply chains has been dramatically reorganized. Prior to COVID-19, the chain was dominated by a limited number of large traders who bought fish directly from *Baor* farmers and sold it to major marketplaces in the big cities. However, a new form of trading pattern emerged as a result of the COVID-19 local overstock of fish and the absence of major established

**Table 3.** Fish prices during COVID-19 and post COVID-19 in Jashore district.

Species	Average price (BDT) before Covid-19	Average price (BDT) during Covid-19	Changes in price (%)
<i>Amblypharyngodon mola</i>	250	200	-20
<i>Anabas testudineus</i>	500	450	-10
<i>Chanda nama</i>	200	150	-25
<i>Channa punctatus</i>	400	360	-10
<i>Channa striatus</i>	400	350	-13
<i>Glossogobius giuris</i>	250	200	-20
<i>Gudusia chapra</i>	250	210	-16
<i>Heteropneustes fossilis</i>	600	540	-10
<i>Lepidocephalichthys guntea</i>	450	400	-11
<i>Macragnathus pancalus</i>	500	450	-10
<i>Mystus tengara</i>	550	450	-18
<i>Ompok pabda</i>	450	400	-11
<i>Pethia ticto</i>	250	200	-20
<i>Puntius sophore</i>	220	200	-20
<i>Cirrhinus cirrhosus</i>	200	160	-20
<i>Cirrhinus reba</i>	170	130	-24
<i>Labeo bata</i>	180	130	-28
<i>Labeo calbasu</i>	200	180	-16
<i>Labeo rohita</i>	250	210	-16
<i>Aristichthys nobilis</i>	250	210	-16
<i>Hypophthalmichthys molitrix</i>	200	150	-25
<i>Gibelion catla</i>	250	200	-20

traders from the market. Prior to the COVID-19 pandemic, established dealers provided farmers competitive pricing to generate high turnover, but local oversupply during the pandemic created a buyers' market, causing farmers to sell fish at far lower prices than before the pandemic. Prices of fish farming inputs-fish seeds, fish feeds, fertilizers etc. were going up to the apex because of inadequate artificial seed productions from hatchery, increasing transportation costs along with activities of the unscrupulous and dishonest traders associated with fish farming inputs.

### 3.4.8. Changes in numbers of traders/market

The government has made adjustments to market place locations in order to comply with social distancing regulations, such as relocating to non-market public spaces (such as a school playground, field, or open space), which has resulted in fewer customers visiting them. Traders that do not have an established shop in the market area may have been impacted by these regulations. As a result of the open environment and exposure to direct sunshine, fresh fish became dirty and dried quickly. Vendors gave varying assessments of whether and how the market composition had altered in recent weeks. Because of changes in vocations, the respondent believed the number of sellers had increased.

### 3.4.9. Impacts on food security

Since March 2020, the entirety of the world's population has been confined as a result of the continuing pandemic disaster, which has impacted global food security. The prevalent lockdown has exacerbated the whole food supply chain from harvest to consumption, such as food manufacturing, supply and discharge, and consumption, in which people work in different supply chain segments such as fisheries input suppliers, fishers, food manufacturers, wholesalers and vendors, shipping, and various organizations. Furthermore, food supply had been disrupted on a massive scale, and people will go hungry twice as fast if local governments and associated institutions do not take corrective action. The government's efforts to stop the virus from spreading resulted in a transportation halt, making it difficult for farmers to obtain production inputs, keeping products from reaching markets, and preventing customers from making routine purchases. As a result of the limited supply, prices increased and demand decreased. The problem of fish value chain due to COVID-19 interrupted food security and resulted in massive losses.

### 3.4.10. Impacts on education

To reduce COVID-19 infection, Bangladesh government closed primary, secondary schools, and colleges for 18 months at the peak of the pandemic. Many students who were in school or college are dropped out after the pandemic for their financial problems (10%) and early marriage (7.5%).

### 3.4.11. Impacts on early marriage

Travel limitations and physical distance caused by the pandemic find it difficult for girls to get the health care services, social assistance, and community support that they need to avoid child marriage. Due to employment losses, the rate of child marriage has risen over the past 7.5%, and rising economic uncertainty may lead parents to marry their daughters in order to minimize financial problems.

### 3.4.12. Impacts on recreational activities and economic losses

The *Baors* are an important recreational area for the residents of the Jashore districts. About 50% members of the *Baor* communities earn extra money from boating for recreational purposes throughout the year, but they are unable to earn money due to movement restrictions. During the winter season, the wider populace visits *Baors* in search of migrant birds, but during the COVID-19 pandemic, they are unable to do so. As a result, the *Baor* fishing community will suffer significant economic losses.

### 3.4.13. Fish substitutes

In Jashore districts, about 90% of fisher's households studied used available alternative food items in varying proportions. As a substitute to

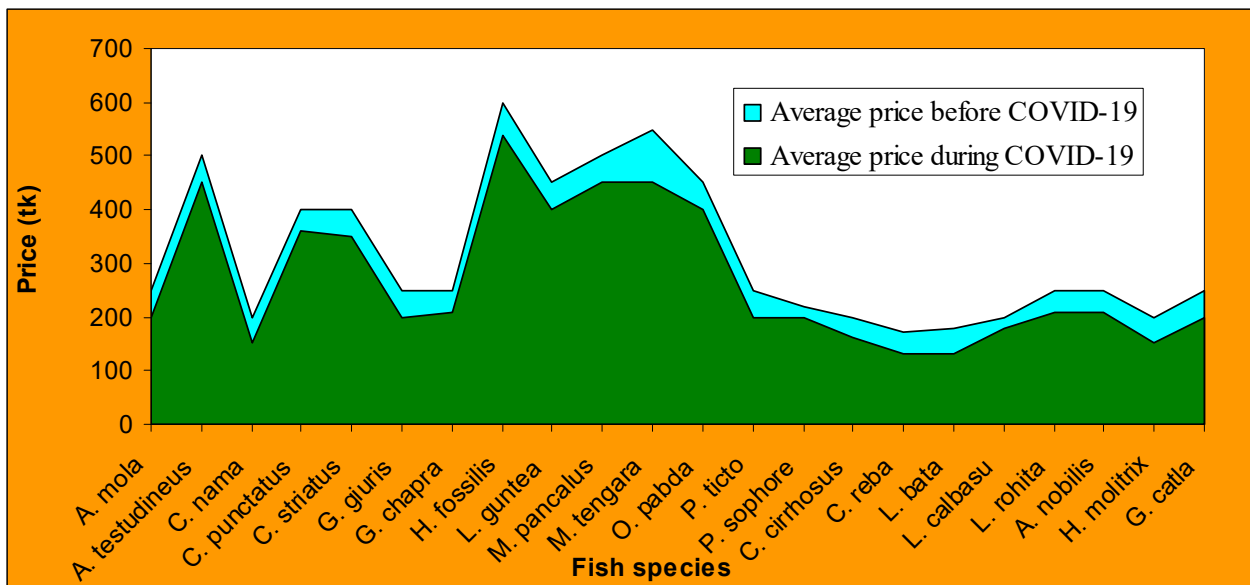


Figure 4. Comparison of fish price changes during and before COVID-19 in Jashore district.

fresh fish, five types of foods were consumed: poultry, eggs, domestic hens and ducks, lentils, and vegetables. Eggs were the most commonly used substitute for fish among the five types. During the pandemic, 50% of survey participants said they ate eggs instead of fish, and 15%, 22.5%, 7.5%, and 5% ate poultry, domestic hens and ducks, lentils, and vegetables, respectively (Figure 5).

3.4.14. Extra cost for health measures

Baor fishers' community has to spend additional currency for protecting themselves from the infection by COVID-19. Majority of the respondents compelled to pay out money for purchasing health protective mask, disinfectants (hand sanitizers), soaps, oral medicine (paracetamol, anti allergic drugs, anti asthmatic drugs, zinc tablet etc) for defending for both pandemic phobia and infection.

3.4.15. Insufficient technical services

Complete and temporally spatial lockdown across the country imposed by the government of Bangladesh disrupted the technical services required for sound management of Baor fisheries. Measures for protecting fish disease outbreaks, harvesting of target species, impaired

to hold meeting among the Baor beneficiaries with authorities of Department of Fisheries to make a decision on time of harvesting, marketing, releasing of threatened fish species caught inside the net for conservation purposes along with community health centre services were not available during the pandemic situation due to movement restriction and unavailability of public transport facilities.

3.5. Positive effects of COVID-19 on Baor fisheries

Although, the majority of the effects are negative indicated with red line, there are some positive aspects indicated with green line generated and innovated to normalize our daily lives (Figure 6) aftermath the long-term prevalence of COVID-19 pandemic situation. To cope with the ongoing challenging situation, the member of Baor fisher's community have adapted and adopted to new technology for their occupations, increase homestead income generation through developing innovative business idea, and increase social interaction among their neighbors as well as their friends and relatives through the usage of social media (apps) and ways of physical communications. As Baor fisher's communities have the potential natural resources and capacity to be locally

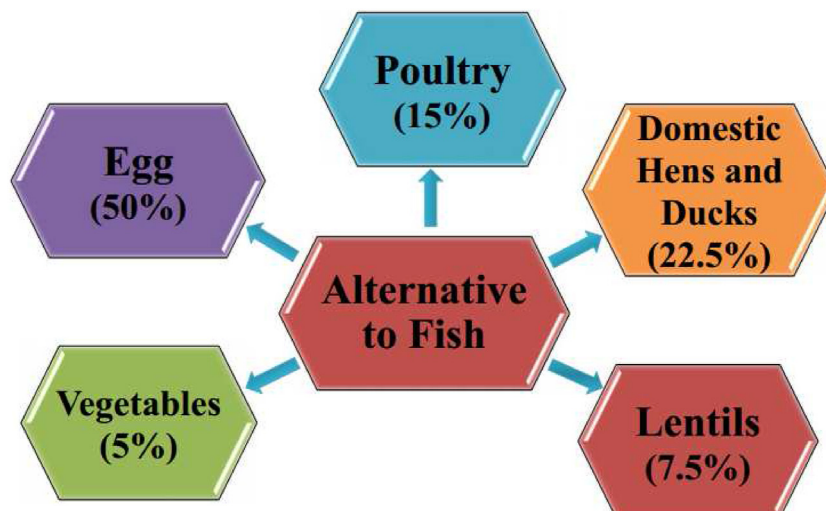


Figure 5. Alternative food items used to replace the protein supply from fish.



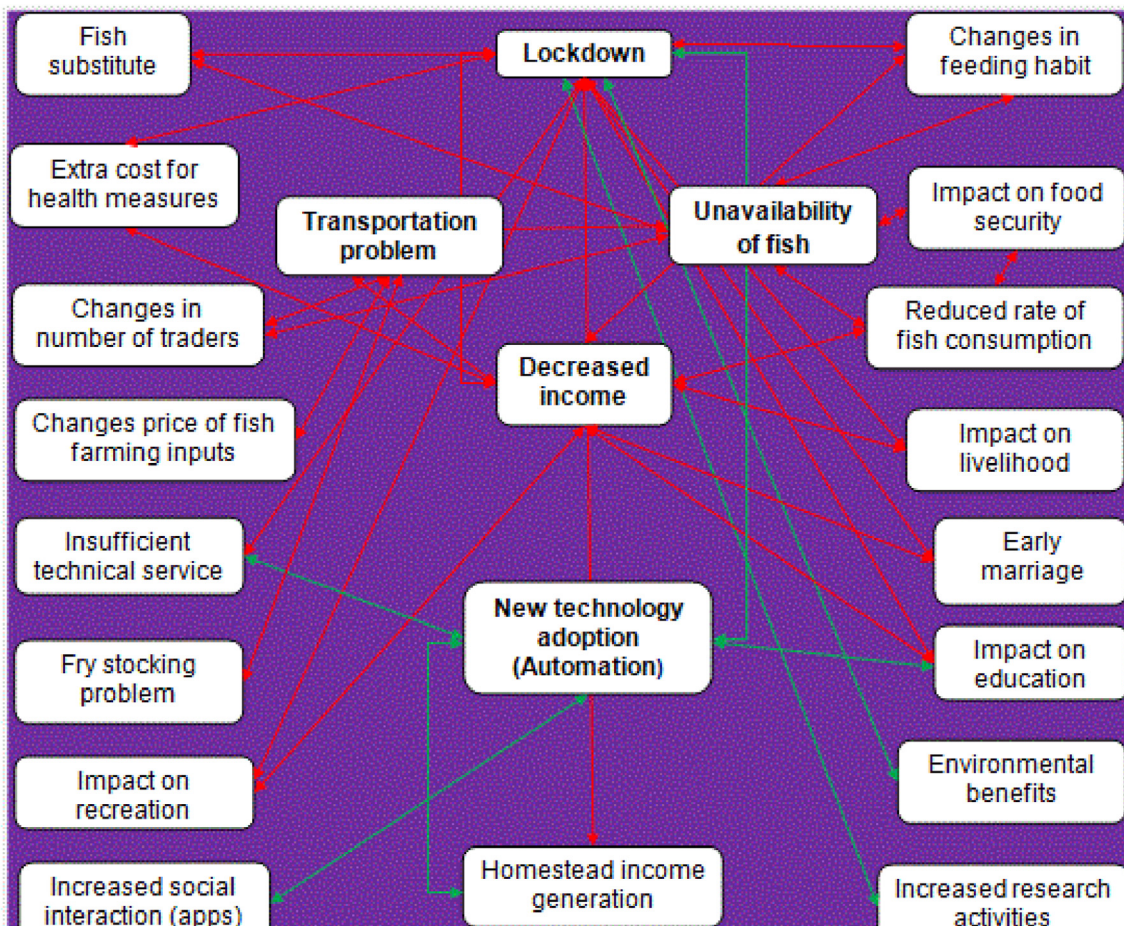


Figure 6. Major positive (green line) and negative effects (red line) of Baor fisher's communities during COVID-19 situation.

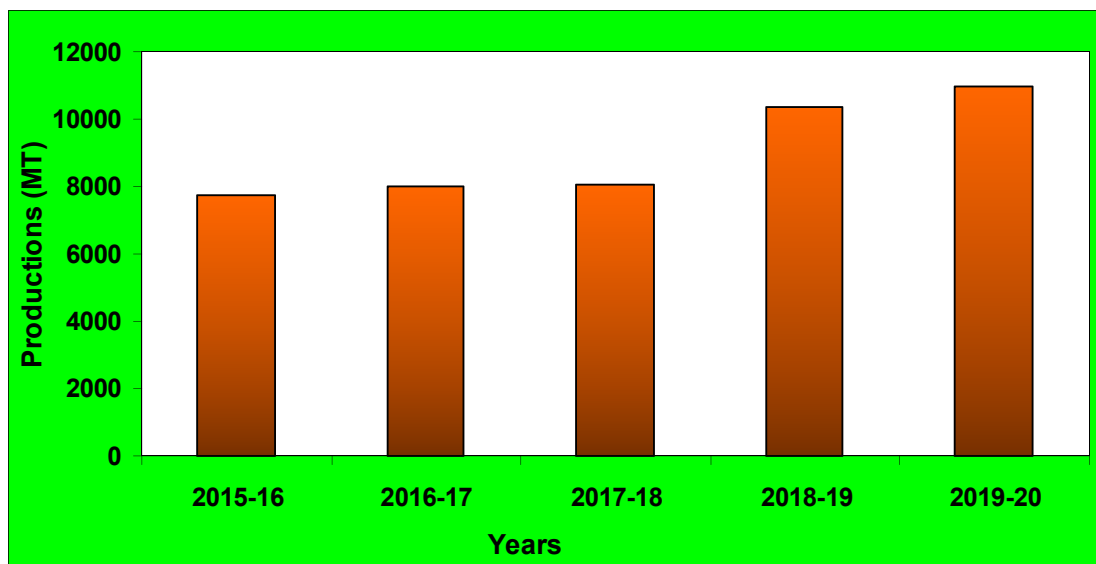


Figure 7. Current status of fish production of Baors, Bangladesh (DoF, 2017, 2018, 2019, 2020, 2021).

independent in terms of food productions and food security, they introduced a voluntary work of food sharing with the neighbors who were susceptible to starvation.

In addition, household fish consumptions for subsistence fishers were increased by Baor fishers due to sudden losing their employment from their work place. During this period, they spent their leisure period by fishing self-recruiting species using traditional fishing gears.

As, there was a long term strong restriction on fish market accessibility to the mass people, they had to intake the remaining fish (unsold) even if after meeting their daily household consumption. Moreover, fish productions of Baors were increased due to restoring favorable conditions of environmental factors and reduction of anthropogenic interferences (Figure 7). Besides, fish harvesting was disrupted during this time, brood fish under self sustaining fish species (SRS) have more

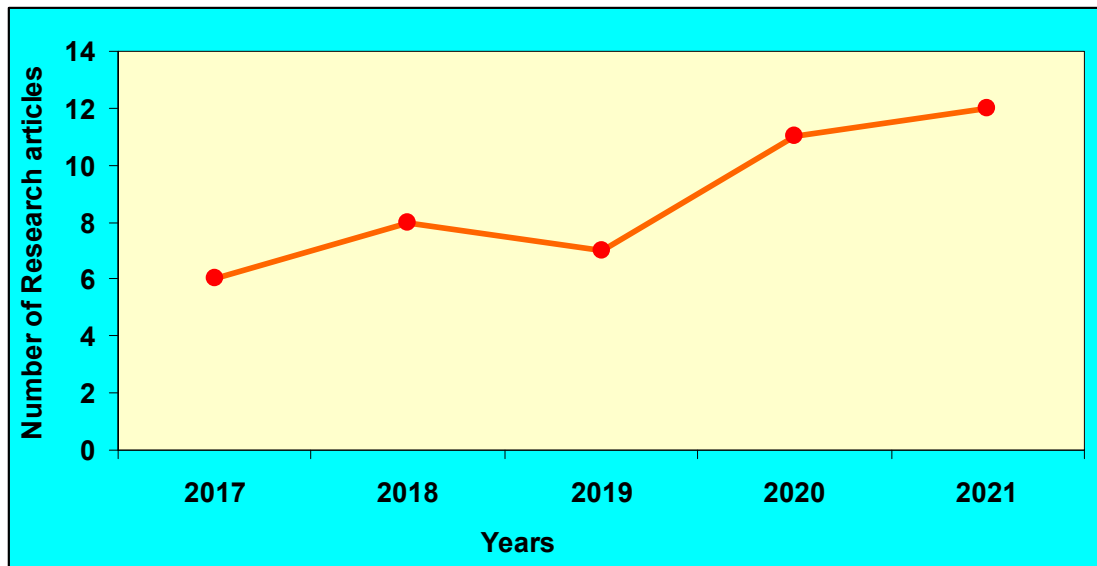


Figure 8. Number of different types of research works focused on various aspects of oxbow lake.

opportunities to spawn freely and thus by recruitment occurs to new year class.

Furthermore, during the course of this time, the number of different types of research works focused on various aspects of oxbow lake rose dramatically (Figure 8). The researchers cum academicians have more time to do research on oxbow lake because of the institutions having closed for the long termed pandemic period.

3.6. Proposed resiliencies against covid-19/probable environmental extremes

The following resiliency options are recommended to further develop the Baor fisheries, as well as the entire fisheries sector in general, as a

means of addressing the current challenges of the COVID-19 pandemic (Figure 9).

Due to COVID-19 lockdown prohibition of mass gathering and limited transport facilities as well as closed and displaced local market were resembled throughout the country. So, Baor fishers could reach the market properly as a consequence huge amount of fishes were remaining unsold. If government can introduce cold storage facilities in near Baor region then Baor fishers will get escape from these losses in future as COVID-19 is heating the world again and again through mutation.

Government should fix subsidy with diversified food items for the entire stakeholders involving fish production and marketing systems based on their requirements (e.g. edible starch and carbohydrates enriched food items for the fisher's community, fuel for fish product

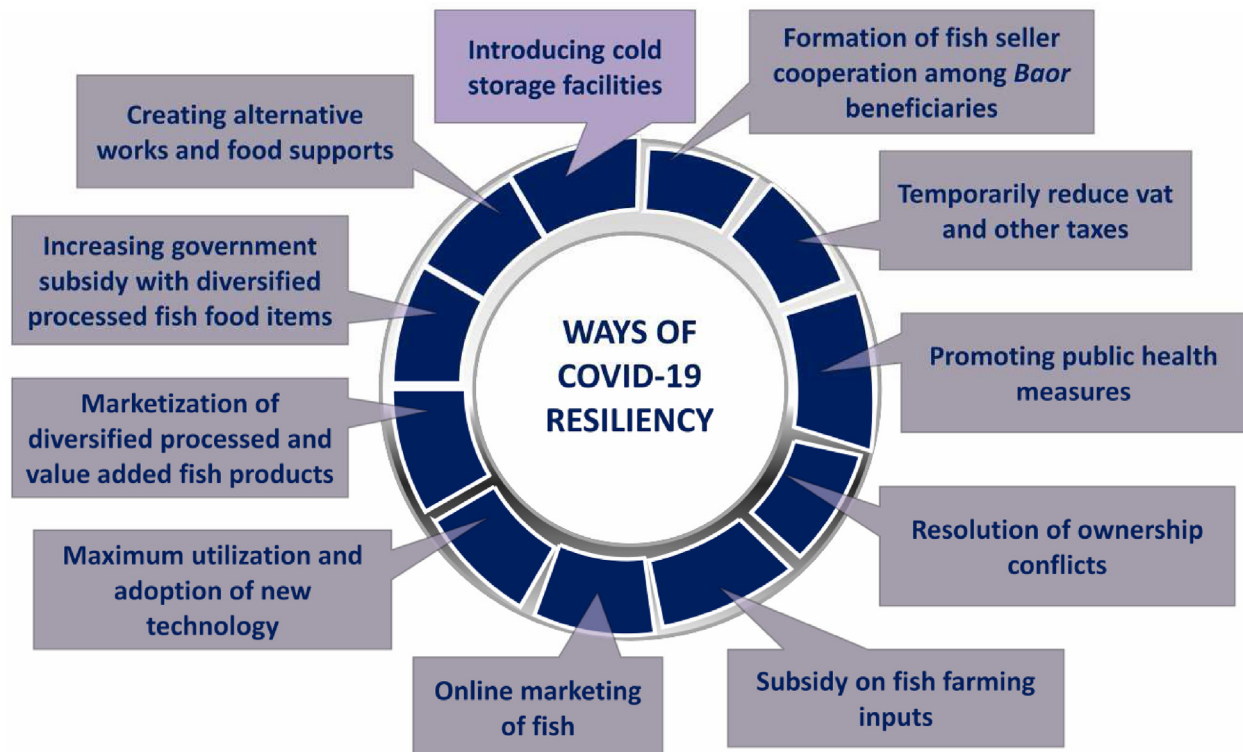


Figure 9. Proposed resiliencies against COVID-19/probable environmental extremes.

transport owner etc.) To ensure the sustainability of the fishing community, government and non-government organizations must develop funds, rural banks, cooperative banks, micro-credit facilities, and credit card facilities to provide funding and refinancing assistance for rural infrastructure improvements, as well as the dissemination of fish processing unit establishment for the smooth management of Baor fisheries.

Mobile marketing and door to door marketing of fish should be developed so that the fish and fish products would reach to their kitchen as their requirements. They should develop -“Go Digital” strategy. For this strategy, they should be trained with using Tracer app, Surokhha app, Fish Advice app, Fish doctor app, Fisheries Act app, e-fish market app etc. for maintaining social distance, avoiding deadly microbes infected peoples, taking technical support associated with culture and business, enhancing productions and ensuring biodiversity conservations and sustainability. As the main attributes of Baor regions (Jashore, Chuadanga, Jhenidah, Kushtia) are used to accustom with consuming fresh and long term preserve freshwater, marine and brackish water fish species. They have to habituate with processed dry fish because of scarcity of fish supply to meet their protein requirement during the probable catastrophic situation. Value added product of fish e.g. fish ball, fish cheap, fish chanachur, and fish noodles etc. should be available to the super shops and online markets.

All of the Baors of Bangladesh is now under management either managed by the government of Bangladesh or the private leaseholders. Sometimes in some Baor cases, it is observed that local political leaders take the opportunity to manage the Baor in the way of community based Baor management (CBBM) but they misuse the power and take benefits from Baor personally in spite of whole benefits to Baor communities. So government should take more constructive steps in Baor in response to management and resolution of ownership. It will be helpful to fight against COVID-19 negative impact in Baor region. Formation of Baor fish farmer society will be necessary for getting the actual price of fish from the side of fishers and to normalize the fish supply chain to the consumer even if during the probable pandemic situation like COVID-19.

The government of Bangladesh needs to take stern measures to disseminate widely more incentive programs as alternative works like providing rickshaw, van, livestock and poultry and supports like vulnerable group feeding (VGF) program, providing foods in exchange of works (kabikha project), a house-a farm project program and measures to provide training to the handicraft of Baor communities. The government and non-government organization should come forward to providing services to protect and maintain human health. Public health measures like providing health protective mask, disinfectants (hand sanitizer, soap and detergent) and family planning schemes should be strengthened through community health clinic and online health service. The government should also take initiatives to announce reducing rate of vat and taxes for the normal survival of this vulnerable community. The reduction of VAT rates would be applicable to electricity, fuels, fertilizers, chemicals and other means of supporting agricultural production and redemption of taxes on the incomes from fish culture activities.

#### 4. Discussion

The targets of this research are to acquire more knowledge on the confounding factors affecting Baor fisher's livelihoods and food security during the ongoing COVID-19 pandemic. Significant threats to immediate food security, health and nutrition were appeared among the many poor and vulnerable people (IFPRI, 2021). Das et al. (2022) reported that the impacts of COVID-19 pandemic on food security have been manifested by declining income. Furthermore, the effects of COVID-19 were projected to have a considerable impact on world fisheries, with projections of possibly negative consequences for small scale fisheries livelihood and income in underdeveloped nations (Bennett et al., 2020; FAO, 2020b).

The abundance of Small indigenous fish species has increased during the entire period of COVID-19 because of harvesting fish disrupted due to

limited access to the market, movement restrictions, and reduced demand of fish and so on. As a result, adult year-class fish have had the opportunity to grow without anthropogenic disturbance and have access to optimal spawning facilities. The current Baor fisheries strategy included both capture and culture fisheries being practiced at the same time and in the same water body. The introduction of aquaculture practices has contributed significantly to increase total fish production and people's incomes as the wetland was previously only used for capture fisheries (Islam et al., 2018). The best time for fish fry release was between April and June (Rashid, 2020). As, the peak season of fish fry releasing into Baor was fallen under pandemic lock down period, they were unable to release fish fry for the following culture season. Even, Baor beneficiaries had to retain the marketable sizes of fish in Baors during those time periods. Furthermore, fish fry stocking was hindered due to inadequacy of transportation facilities during the period of lockdown.

Fishermen of Baor beneficiary community who rely primarily on fishing are unable to harvest fish from Baors. Fishing area limitations arising from the implementation of spatial and temporal lockdowns across the country were a major issue for fishers (Jomitol et al., 2020). As, the complete halts of fisheries and stay-at-home orders prohibiting travel to and within fishing areas during the imposition of harsh policies of lockdown was also a major impaired issue to exert impacts on daily works (Okyere et al., 2020). They occasionally caught fish, but due to the COVID-19 pandemic, they were unable to sell all of them at a reasonable price. Baor fishermen's livelihoods were affected by unsold fish and the additional expenditures of supplying extra feed for the remaining fish (Nazrul, 2020). During the same period, fish feed production fell by 75% (Kibria et al., 2020). Furthermore, the majority of the ingredients in the fish food, particularly proteins, were previously imported from other nations, a position made more difficult by the COVID-19 pandemic-related international embargo (FAO, 2020c). As a result, people working in these fields are at risk of losing their employment and livelihoods (Nazrul, 2020), with fish farming income in the country fallen by 48.32% (Hasnin, 2020). Most of the least developed and lower middle income countries (third world countries) including Bangladesh, profoundly depends on informal employment sectors (Hasan and Tamanna, 2015). In addition, Kar and Marjit (2009) stated that higher than 51% of urban jobs in third world countries are in the informal sector. It also demonstrates that the pandemic has had an impact on the incomes of the majority of families in Baor communities. Therefore, they had to struggle for meeting the basic requirements of their livelihoods.

Restrictions on movements, lower demand of fish were responsible for aggravating the situation of fish marketing during the study period. Disruptions were induced by COVID-19 in transportation, marketing, labor, combined with unstable supply and demand trends, and affected perishable food and food stuffs like fish, meat and aquatic food supply chains (CGIAR, 2020). As a result of the transportation crisis, disadvantaged group experienced higher raw material prices and the middleman's interference further exacerbated the situation (Mohammed et al., 2016). Fishing has been decreased by up to 80% in many regions due to the combination of decreased demand, cheaper prices, and lockdowns (Korten, 2020). Furthermore, lower market demand for fish and fisheries products resulted in lower prices for fish and fisheries products; as a result, numerous fishers curtailed their commercial fishing, and some of them stopped completely, as their work became economically unviable (FAO, 2021).

Due to limited access to market and a severe income crisis, the majority of Baor beneficiaries had to adjust their feeding habits. The Baor fishery provides a vital source of income and micronutrients, such as vitamins, iron, calcium, and minerals, to the neighboring inhabitants (Kohinoor et al., 2001). The globe is already dealing with food and nutrition security issues, with the least developed, developing, and lower middle countries being particularly vulnerable (FAO, 2020d). This incorporates not only fishers, but also transportation owners and workers, feed distributors, hatchery proprietors and employees, all of whom rely



on the *Baor* fisheries for their living. Simultaneously, the COVID-19 pandemic is causing a significant decline in these individuals' earnings (Zurayk, 2020).

According to the current study, most families reduced their frequency of grocery shopping significantly during the pandemic because of severe reduction of income. Most people were aware of the pandemic and believed that the virus could be transmitted between humans. People were prevented from leaving their homes due to extensive media coverage, restrictions imposed by the government, and physical trips to the grocery store were reduced. Instead, many people have begun to rely on online marketing platforms or e-commerce sites for their daily needs (Shawki, 2020). Janssen et al. (2021) reported that in the pandemic situation 15–42% respondents lowered their frequency of daily consumption unlike as before. According to Huang et al. (2021), lower income people are likely to decrease their expenditure on grocery during the pandemic situation. There is currently no fisher's association for selling their fish through proper channel. It is, however, critical for dismantling the traditional syndicate-based market and developing an independent fish-marketing system. As a result, Retail consumers had to pay extra charge for groceries and necessary things due to the disturbance of manufacturing and supply channel (Richards et al., 2020; Kim et al., 2020; Farnsworth, 2020). During lock down period in the COVID-19 infection, consumers had converted their grocery marketing pattern due to inaccessibility to shopping mall and restaurant dining.

The entire food supply chain from harvest to consumption, such as food manufacturing, supply and discharge, and consumption, in which people work in different supply chain segments such as fisheries input suppliers, fishers, food manufacturers, wholesalers and vendors, shipping, and various organizations had been disrupted on a massive scale during lockdown period. The lockdown in Bangladesh has interrupted the food supply chain, increasing the risk of food shortages (Alam and Khatun, 2021). Fish products are being forced to sell at a low price due to buyer shortages and the lack of supply channels, and it will take years to recover from this trauma (Zabir et al., 2021). In addition to structural defects, environmental extremes (such as drought, flood, pandemic, or disease) have a significant impact on the food supply chain, resulting in food insecurity (Devereux et al., 2020). OECD (2021) reported that the providing food security and nutrition to a growing global population, ensuring the livelihoods of the people working across the food chain from farm to consumer, and ensuring the industry's environmental protection are all critical goals.

As the supply of fish and other aquatic food was disrupted, the market became less diverse and available, raising market prices. As a result, consumers were unable to obtain desired fish species and other aquatic food products, negatively impacting consumer demand and consumption. Sunny et al. (2021) reported that 56 % respondent limited their daily dietary diversity because of not enabling to afford more diversified food items for their diet if they bought fish at a high price, which had a negative influence on nutritional security. The findings were also in accordance with the international situation, which showed that 820 million people were more vulnerable to hunger and had less access to a nutritious meal (Siche, 2020).

Financial problems (10%) and early marriage (7.5%) were the key problems for school or college dropouts following the pandemic. As a result of job losses and rising economic uncertainty may lead parents to marry their daughters in order to minimize financial problems. According to BRAC (2020), the main problem for rural education in Bangladesh is food scarcity (22%). Additional factors, such as non-supportive families (19%), poor mental health (18%), and a lack of a study environment at home (11%), were also responsible for the students of those communities during the COVID-19 period. Dutta & Smita, (2021) figured out the problems of online education such as a lack of electronic devices, limited access to the internet, high internet costs, slow internet speeds, and difficulties in using online platforms faced by the students in particularly rural and remote areas in Bangladesh.

As an alternative to fish, households became reliant on other foods such as eggs, lentils, and chicken. Five types of foods were consumed by *Baor* fisher's community in place of fresh fish: poultry, eggs, domestic hens and ducks, lentils, and vegetables in our study. According to Akhtar et al. (2018), the consumption of eggs increased the most, followed by chicken and fish. Moreover, Belton and Toufique (2014) discovered that over a period of 14-days, consumers in Bangladesh consumed the most fish, followed by vegetables, fruits, eggs, milk, and meat. During corona pandemic lower class consumers expended their income on low cost staple foods like rice flour as a substitute of high cost food items such as meats, eggs, milk and other aquatic foods (Headey and Ruel, 2020). According to the Global Alliance for Improved Nutrition (Pe'rez-Escamilla et al., 2020), lower-income households struggled with more capital difficulties so that they can reduced spending to purchase fundamental goods and needs for covering inflated food prices. Pe'rez-Escamilla et al. (2020), speculate that this may require them to make concessions in terms of food quality or quantity, or to substitute canned goods for fresh vegetables. Specifically, the U.S. Bureau of Labor Statistics found that, while the price of vegetables and fruits increased in August in 2020, the purchasing cost was relatively lower in January of the same year (US BLS, 2020).

These negative emotion effects are typical among marginalized communities, such as these fishers community, but if the government can give secure economic and food aids, the fishermen will follow authorities' cautions and stay in the house (Sheek-Hussein et al., 2021). *Baor* fisher's community has been able to adjust their distribution techniques to maintain their output constant as demand for direct delivery to household's surges, generating and developing direct links with local domestic consumers (Smith, 2020). Ivanov (2020b) assumed that implementation of digital technologies in feasible supply chain on the basis of dexterity and sustainability can reclaim and manage the long term effects of the pandemic. To minimize the crisis, new local market initiatives are forming indifferent countries including Seattle Ghana, and the United Arab Emirates, for example, home delivery systems and online fish sale platforms have developed (Hama, 2020; CFFA, 2020a, 2020b). Furthermore, fish seller cooperation team among *Baor* beneficiaries sold fishes directly to the consumer for getting the actual price of fish from the side of fishers in several developed countries (Shaaban and Al Khaimah, 2020). It would be pragmatic decision to form a fish seller cooperation team among the *Baor* beneficiaries to sell fishes to the approved agencies to get their actual fish prices and thus by continuing and promoting safe fish production systems in oxbow lake to keep continuing the contributions to achieve local, regional and national food security.

## 5. Conclusion

*Baor* fisheries play a pivotal role in meeting the needs for the livelihoods of *Baor* beneficiaries with supplying safe food. However, the COVID-19 pandemic has been changing the overall scenario of livelihood aspects of the *Baor* fisher's community experienced decreased food intake and frequency of fish consumption and overall food insecurity during the pandemic periods. This was mainly due to loss of income, loss of jobs, price hike of edible food stuffs and fish farming inputs and disorder of food supply chains along with restrictions on movements and public transportations. Moreover, the financial crisis in turn induced the dropout rate of students either from school or college and early marriage of daughters. However, COVID-19 pandemic taught human to invent and adopt alternative ways of continuing personal, educational, institutional, national and international activities and services. The aforementioned resiliencies are thought to be considered to be very practical ways to minimize the challenges induced by COVID-19 in the lives and livelihoods of all types of members of society, particularly the *Baor* fisher's community.

## Declarations

### Author contribution statement

Md. Abdus Samad, Md. Ataur Rahman, Syeda Maksuda Yeasmin, Sarower Mahfuj, Md. Habibur Rahman, Md. Yeamin Hossain: Conceived and designed the experiments; Performed the experiment; Analyzed and interpreted data; Wrote the paper.

Mst. Farzana Sultana, Md. Ashekur Rahman, Tarun Sen, Md. Anisur Rahman, Md. Sherazul Islam: Contributed reagents, materials, analysis tools or data; Analyzed and interpreted data; Wrote the paper.

### Funding statement

This work was supported by World Bank (IDA and IFAD) [PIU-BARC-NATP-2-PBRG-Sub-Project ID: 154].

Md. Abdus Samad was supported by BSTFT-GoB.

### Data availability statement

Data will be made available on request.

### Declaration of interest's statement

The authors declare no conflict of interest.

### Additional information

Supplementary content related to this article has been published online at <https://doi.org/10.1016/j.heliyon.2022.e11326>.

## Acknowledgements

We would like to acknowledge local fishermen community for their kind assistance during sample collection.

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