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Research Article

SMALL-SCALE FISHERIES AND SUDDEN DISASTER: COVID-19 LOCKDOWN IMPACTS ON CATCH COMPOSITION AND LIVELIHOODS OF ARTISANAL FISHERMEN IN THE BANGLADESH SUNDARBANS

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Abstract

Globally, the COVID-19 pandemic disrupted systems related to food, transportation, and livelihood. The pandemic harmed small-scale fishermen (SSF). However, little is known about the COVID-19's impact on artisanal fishing communities, particularly catch composition. Therefore, this study aimed to evaluate the effects of COVID-19 on artisanal fisheries in Bangladesh, employing Participatory Rural Appraisal (PRA) tools for data collection. Data were collected for 60 days (23 days of pre-lockdown and 37 days of lockdown) from seven landing sites in the southwest coastal zone of Bangladesh in 2020, focusing on fishing, catch, price, and livelihood status of fishermen. Observations revealed lower fishing pressure during lockdown, which benefited fishermen with a higher catch per unit effort (CPUE) than pre-lockdown. However, fishing became less profitable due to declining fish prices (4-83%) and increased transportation costs (average 30%) compared to the pre-lockdown times. These factors, combined with reduced fishing time (5 hours a day, 3 days a week) during the lockdown, significantly reduced the income of small-scale fishermen, compelling over 70% to seek high-interest loans from moneylenders, shopkeeper credits to cover living expenses. Around 22% of fishermen took loans with high interest from local lenders, which may affect them in the future, putting their next generations at risk of exploitation by the money lenders. Moreover, lockdown affected their livelihoods, with the highest impact on food (25%), followed by the economy (23%), health (20%), education (19%), and other social effects (13%). In this study, we propose a framework that can protect small-scale artisanal communities against future crises.

Introduction

Small-scale fisheries (SSF) include a wide range of activities carried out by both males and females in inland and marine fisheries. The role of SSF in developing nations is vital, as 90% of SSF is placed in developing countries (Eriksson et al., 2017). Most of the world's capture fisheries are governed by SSF, which thus plays a significant role in the sustainable use of coastal marine ecosystems (FAO, 2020b). Small-scale fisheries (SSF) produce two-thirds of the world's fish catches intended for direct human consumption, which also creates 90% of the employment in the fisheries sector (Jena & George, 2018). About 500 million people worldwide are at least partially dependent on SSF as their livelihood option. Additionally, 76 million people work post-harvest jobs, and about half are women (World Bank, 2012). Moreover, SSF created more employment than the combined industries of industrial fishing, oil and gas, and tourism (OECD, 2016).

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SSF faces several problems, like declining fish supplies, competition from other sectors (e.g., industry, tourism), limited livelihood options, and poor resource management (FAO, 2021). Additionally, sudden and slow-onset shocks and hazards make this sector vulnerable. For instance, SSF fishers in Asia face various shocks and risks, such as losing their natural capital, physical capital, and lives due to natural disasters. In 2020, COVID-19 adversely impacted the SSF. The pandemic nature of COVID-19 has created a global sanitary crisis with a cascading effect on societies and economies across all sectors, including fisheries (FAO, 2020a). The multidimensional impacts of COVID-19 are evident among the SSF sectors. These include export-based SSF, which faced a radical decline in demand, especially in the United States, Europe, and Asia, due to port closures, poor access to cold storage, and the cancellation of air flights and shipping (Bennett et al., 2020). SSF stakeholders, including fishers, producers, and distributors, are often exposed to the risk of COVID-19 transmission and contamination, forcing them to make difficult decisions about how to support their families. In the context of health issues, accessing health facilities for rural fishermen is difficult even in usual conditions (Bennett et al., 2020), thereby making it more difficult for these locations to access the tests, treatments, and sanitation required to sufficiently report the spread and infection of COVID-19 (CFFA, 2020). As a result, COVID-19's immediate and long-term impact marginalizes many SSF and coastal fishing communities, which are already vulnerable to a wide range of social and environmental changes (Freduah et al., 2017).

Bangladesh is a maritime country with about 118,813 km² of Exclusive Economic Zone (EEZ). This maritime area, which is as vast as our landmass, supports a variety of commercially and ecologically important fisheries resources. Coastal communities are significantly dependent on coastal fishing-related activities for their livelihood. Despite the abundance of marine waters, the marine capture sector contributes only about 16% of the country's total fish production. Small-scale or artisanal fisheries contributed about 82% in 2017–18 (DoF, 2018). Marine fisheries in Bangladesh are mainly dominated by SSF, involving about 1.5 million fishers (Wang et al., 2020). In total, the livelihood of more than 10 million coastal fishermen depends directly or indirectly on SSF (DoF, 2018). Additionally, small-scale fisheries have significantly contributed to providing low-cost and affordable protein sources for the country's poorest communities.

Small-scale fishing activities generally occur in less than 40 meters of water depth. They are carried out using vessels with a carrying capacity of net 15 tons or less in the coastal region of Bangladesh, including the water body of the world's largest unique mangrove forest, the Sundarbans. Small-scale fishing is practiced in both the nearshore and offshore areas of the Sundarbans mangrove forest ecosystem. The inshore fishery takes place in comparatively shallow waters, utilizing small, non-mechanized boats (5–12 meters long) that operate within 2–8 meters of depth, either inside or adjacent to the mangrove forest. On the contrary, the offshore fishery covers the whole Exclusive Economic Zone of Bangladesh, extending up to 200 nautical miles from the coastline.

In Bangladesh, the vast majority of small-scale fishing communities face numerous challenges. These challenges include poverty, degraded fishing resources, owning limited assets, and living and working in vulnerable and dismal conditions, which hinder sustainable livelihoods (Alam et al., 2021; Hoque Mozumder et al., 2018; Rahman et al., 2002). The small-scale fishers are also vulnerable to marginalization, social exclusion, and economic oppression (Rahman Sunny et al., 2021). Various socioeconomic challenges, such as the increase in fisher numbers, insufficient earnings, limited alternative livelihood options, loan complexity, piracy, and price surges, make their lives difficult (Islam et al., 2016; Wahab, 2013). Moreover, Bangladesh's coastal small-scale fishing community is also inclined to climate-induced risks, such as cyclones.

Furthermore, the COVID-19 pandemic is one of the sudden events closely associated with this sector. Though COVID-19 does not infect aquatic species, it significantly affected fisheries and aquaculture food systems (WHO, 2020). Following the confirmation of the first COVID-19 case in Bangladesh, a nationwide lockdown was declared from March 23 to May 30, 2020. Within a short time of the lockdown declaration, the

real hardship started not only among the small-scale fisher community but also among all the poorest communities of the country in different ways, such as the inability to sell their products on time, transportation problems, fulfilment of the daily needs of their families, etc. The COVID-19-enforced movement restrictions hampered the fishing activities of the fishers and resulted in a significant loss of their income (Khan et al., 2023). According to Sunny et al. (2021), the restriction on movement also affected the market and the distribution system. Although some fishers continued fishing under time and area constraints, they failed to sell their catch effectively, as fewer buyers were in the market due to the lockdown (Uddin et al., 2022). Considering these contexts, the small-scale fisheries sector was placed in a shocking condition during the lockdown. Several studies have been undertaken to understand the socioeconomic impacts of COVID-19, as well as the difficulties in controlling the disease, and to assess the severity of COVID-19 in Bangladesh (Mamun et al., 2021; Rahman et al., 2020). However, there remains a lack of a systematic study on the effect of the COVID-19-induced lockdown on fish catch and the socioeconomic impact of small-scale fisheries. Thus, this study aimed to explore the comprehensive effects of the COVID-19-induced lockdown on small-scale fisheries. In particular, we aimed to explore the impact on fish catch composition and Catch Per Unit Effort (CPUE) due to the COVID-19-induced lockdown effects, as well as lockdown effects on the livelihood, for instance, social, economic, health, food, and education of small-scale fishing communities, and finally, we developed a management framework for sustainable SSF.

Materials and Methods

Study area

The lion's share of the world's largest single-trait natural mangrove forest, the Sundarbans, is positioned in the southwestern coastal part of Bangladesh (Figure 1). The British colonial government declared the Sundarbans a reserved forest under the Forest Act 1927.

Small-scale fishing is the dominant fishing activity in the Sundarbans, where various traditional crafts and gear, including gillnets, estuarine set bag nets, trammel nets, beach seines, push nets, and other hand-operated gears and traps, are used for fishing in this region (Hoq, 2007). Over 150 rivers reach the Bay of Bengal and flow through the Sundarbans (Alam & Chowdhury, 2012). These rivers are habitats for diverse fresh, brackish, and marine fish species. Although the Forest Department (FD) has the authority to control fishing by issuing fishing permits to fishermen (Hoq, 2007), the availability of natural resources, such as fish, and poverty influence the Sundarbans surrounding community to engage in professions like small-scale fishing. However, different shocks and risks make their venture vulnerable and threaten its existence.

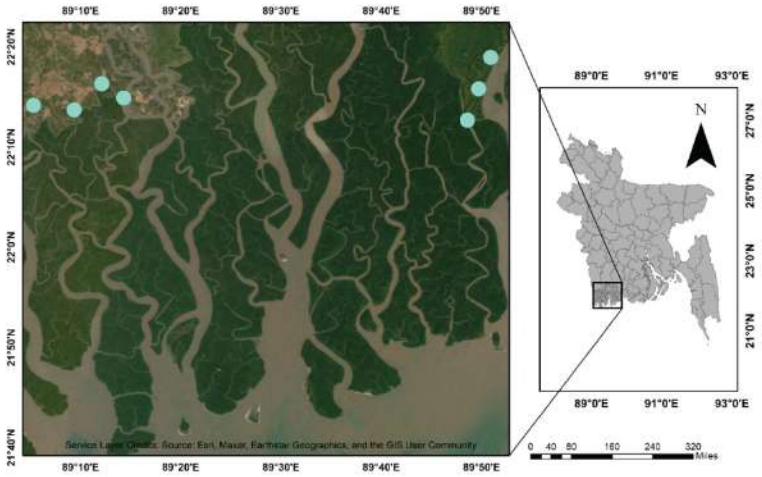

Figure 1. Geographical location of the study area with sampling location.

Data Collection

We collected field data from two adjacent locations of the Sundarbans (i.e., Shyamnagar and Sarankhola, two Upazilas of Satkhira and Bagerhat districts under the Khulna division of Bangladesh). In Shyamnagar, there were four different landing centres (Burigoalini, Kolbari, Horinagar, and Vetkhali), and in Sarankhola, there were three landing centers (Tafalbari Bazar, Sarankhola, and Rayenda). We selected these 07 fish landing centers for fish catch data and boat monitoring. Small-scale fishermen use all seven fish landing centers for their catch landings. We collected fish-to-catch and boat monitoring data for March and April 2020 by directly interviewing fishermen and cross-checking month-wise logbooks of all selected landing centers. We segregate the time frame into two periods: the first was "pre-lockdown" for 23 days, and the second was "during lockdown" for 37 days, to collect daily catch data for a total of 60 days because the lockdown was declared by Bangladesh government on 23 March 2020 during the two periods above, seven fishing boats were selected to monitor the total catch and species compositions, as well as species-wise catch data. We also tracked the number of boats that landed in the selected seven landing centers to observe the daily active fishing boats. In addition, we also conducted a social survey among the fishing community to collect information on the socioeconomic impacts of the COVID-19-induced lockdown on their lives and livelihoods. We applied the participatory rural appraisal (PRA) process, utilizing both structured and semi-structured questionnaires as sources of field data collection.

Data analysis

The data analysis aimed to understand the impact of COVID-19 on small-scale fisheries in the Sundarbans, focusing on two specific periods (i.e., 23 days of pre-lockdown and 37 days during the lockdown). This analysis employed several statistical techniques to evaluate changes in fish catch, operational boat numbers, species composition, and socioeconomic impacts on the fisher community. Regression analysis evaluated the differences in fish catch and selling prices before and during the lockdown. The data were split into two groups—pre-lockdown and during the lockdown—to isolate the impact of the lockdown and allow for period-specific trend identification, ensuring model accuracy. Using a linear or polynomial model based on the Akaike Information Criterion (AIC) involves fitting both models to the data and comparing their AIC values. AIC measures the relative quality of a statistical model for a given set of data, balancing model fit with complexity by penalizing the number of parameters. First, we fit a linear model to the data and calculate its AIC value. Next, we fit a polynomial model and calculate its AIC value. The model with the lower AIC value is preferred, as it indicates a better balance between goodness of fit and model simplicity. This process helps ensure we select the model that best captures the underlying data patterns without overfitting. Cluster analysis was conducted to identify variations in catch composition between the two periods, revealing two significant clades of fish species. Cluster analysis is crucial for segmenting large datasets into manageable subsets, revealing patterns and relationships that simplify complex data for more straightforward interpretation. It aids in decision-making by identifying distinct groups. Additionally, clustering can reduce data storage requirements while retaining essential characteristics, enhancing the performance of other machine learning algorithms.

Results

Lockdown effects on boat operation and fish catch composition

The study found that imposing a lockdown negatively affected the number of functioning boats. During the pre-lockdown period, the number of functioning boats fluctuated between 5 and 6. At the same time, the number of operating boats ranged from 4 to 1 during the lockdown period (Figure 2a). The results also revealed two opposite directions of CPUE for both periods. There was a slow-rising trend in CPUE ranging from 1to 5 kg observed in the pre-lockdown period. On the other hand, an upward trend in CPUE ranged from 4–14 kg found during the lockdown period (Figure 2b), which is threefold higher than the pre-lockdown CPUE. The details of the effects of CPUE are presented in the last paragraph of this section.

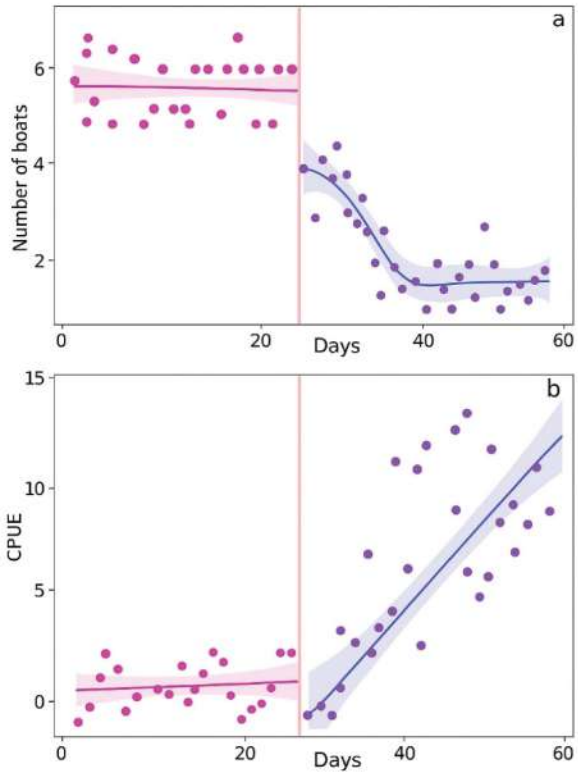

Figure 2. Comparison of the number of operational boats and CPUE between pre-lockdown (pink) and lockdown (violet) periods (a) number of functioning boats for both periods (b) and change in CPUE for both periods.

The dendrogram showed two significant clades (clade one and clade 2) containing the catch data of 22 fish species for two periods (Figure 3). Clade 1 held 14 species, namely *Amblypharyngodon microlepis* (Bleeker, 1854), *Callichrous pabda* (Hamilton, 1822), *Sperata aor* (F. Hamilton, 1822), *Wallago attu* (Bloch & Schneider, 1801), *Pangasius pangasius* (Hamilton, 1822), *Barbonymus gonionotus* (Bleeker, 1850), *Awaous grammepomus* (Bleeker, 1849), *Hydrolycus scomberoides* (G. Cuvier, 1819), *Sarotherodon melanotheron heudelotii* (A. H. A. Duméril, 1861), *Setipinna phasa* (F. Hamilton, 1822), *Coilia dussumieri* (Valenciennes, 1848), *Scatophagus argus* (Linnaeus, 1766), *Lates calcarifer* (Bloch, 1790), *Tenualosa ilisha* (F. Hamilton, 1822). *On the other hand,* Clade 2 consisted of eight fish species named *Penaeus indicus* (H. Milne-Edwards, 1837), *Acanthopagrus morrisoni* (Iwatsuki, 2013), *Otolithoides pama* (Hamilton, 1822), *Bagarius yarrelli* (Sykes, 1839), *Nangra nangra* (Hamilton, 1822), *Mugil cephalus* (Linnaeus, 1758), *Paramugil parmatus* (Cantor, 1849), *and Nibea soldado* (Lacepède, 1802). The major clade one is divided into two sub-clades (1 and 2). Sub-clade 1 contains the first five species of major clade 1, whereas sub-clade 2 holds all nine remaining species of major clade 1. Species in sub-clade one are commonly found for both periods, and there was no significant change in the catch composition between the two periods. In sub-clade 2, we found the most gigantic change in species-wise fish catch composition among all clades. The catch composition of all nine species in sub-clade two increased considerably during the lockdown period compared to pre-lockdown. The dominant species include *Awaous grammepomus, Hydrolycus scomberoides, Sarotherodon melanotheron heudelotti, Setipinna phasa*, and *Coilia dussumieri*. We also found that *Bagarius yarrelli, Paramugil parmatus,* and *Nibea soldado had* a minor decrease during the lockdown period compared to the pre-lockdown period. The study identified that species in the main clade two are commonly distributed during both the pre-lockdown and lockdown periods.

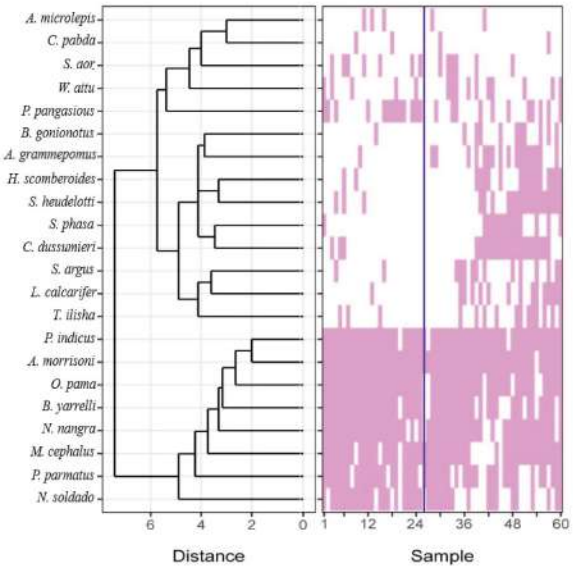

Figure 3. Species-wise sixty-day catch composition (where 0-26 is pre-lockdown and 26-60 is during lockdown, marked by a blue line).

Lockdown effects on boat-based species CPUE

Individual boat-based CPUE for *P. apparatus, A. Morrison, T. ilisha, P. pangasious, O. pama, S. heudelotii,* and *P. indicus* increased gradually during the lockdown period (Figure 4). However, CPUE for *N. soldado, W. attu, N. nangra, and M. cephalus* remained constant. It was revealed that the CPUE of *S. aor* declined during the pre-lockdown period, reaching below 2 kg per boat per day, whereas the CPUE of *S. aor* increased in the lockdown period, reaching more than 5 kg per day per boat. A few days later, the increasing trend slowed, reaching roughly 3 kg per boat daily. C. *dussumierii* exhibited an increasing CPUE during the lockdown period. *S. argus, L. calcarifer, S. phasa, B. gonionotus, C. pabda, H. scomberoides, A. grammepomus, S. argus, L. calcariferr, S. phasa, B. gonionotus, C. pabda, and H. scomberoides* showed a significant increase in CPUE during lockdown. The study also found that the CPUE of *S. argus, B. gonionotus,* and *S. phasa was* 6 kg per day during the lockdown period, compared to 3-2 kg per day in the pre-lockdown period. In addition, the study also observed a steady declining trend in the CPUE of *B. yarrelli*.

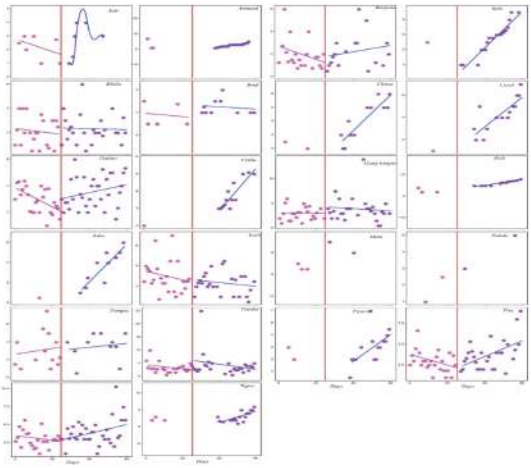

Figure 4. Species-wise CPUE comparison for all 22 species between two periods (X axis – Days and Y axis - CPUE in KG).

Socioeconomic Effects

Product price falls

The study examined the market prices of all 22 species for both periods to determine the economic impacts. In the pre-lockdown period, the market price of all 22 species ranged from BDT 62.5 to 70 per kg, whereas the price dropped by roughly 37.5 BDT per kg during the lockdown (Figure 5). This price-decreasing tendency persisted until the end of the lockdown period. This study observed that the market prices for 20 of the 21 fish species have declined substantially (Figure 6) during the lockdown period. The single species, *C. pabda*, exhibited a favorable market price trend during the lockdown, compared to a price range of BDT 150 to 170 in the pre-lockdown period. However, during the lockdown period, all 21 species experienced significant market price declines. Among them, *A. grammepomus, L. calcarifer, B. gonionotus,* and *P. indicus* lost 75%, 83%, 80%, and 80% of their value, respectively, compared to pre-lockdown levels, placing them in the maximum price-loss category (Figure 6).

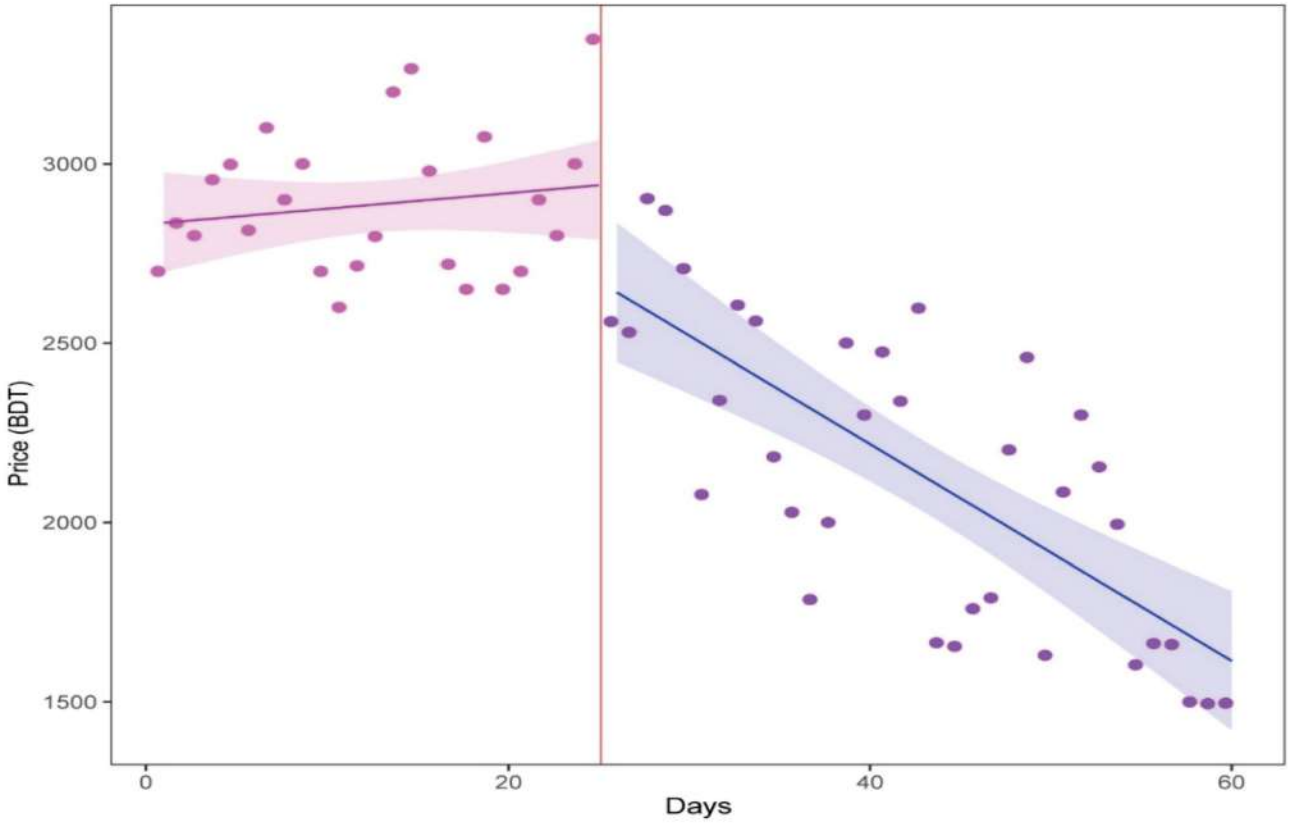

Figure 5. Overall price comparison of all species between the pre-lockdown and lockdown period.

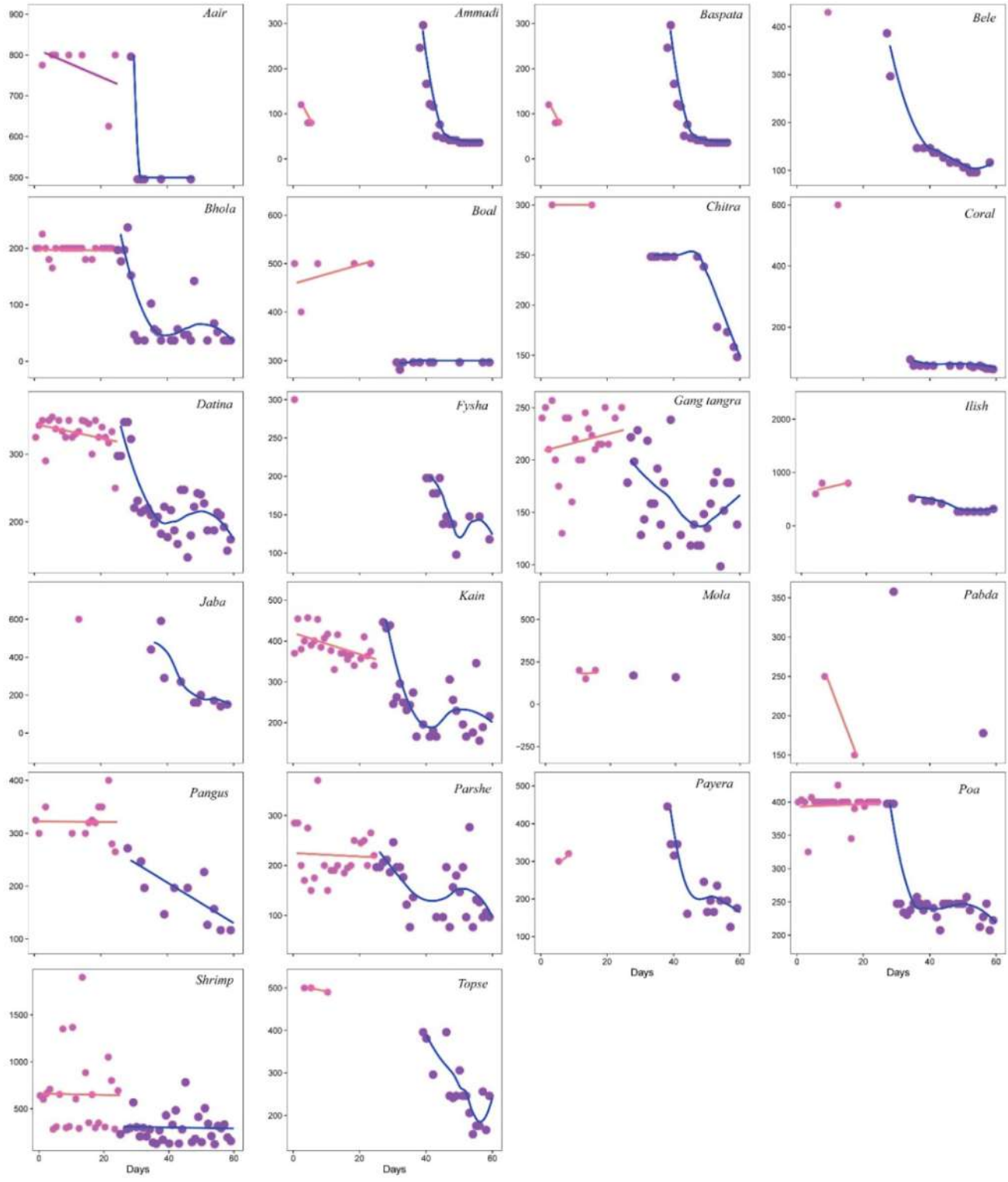

Figure 6. Species-wise market price variation for two periods (X axis – Days and Y axis – Price in BDT).

Compared to pre-lockdown prices, *A. microlepsis*, *N. nangra*, *S.aor*, and *W. attu* experienced declines of 4%, 25%, 38%, and 40%, respectively, during the lockdown period, placing them in the minimum price-loss category. However, this study found that during the lockdown period, the average price loss for all species was 51% compared to the pre-lockdown period (Figure 7).

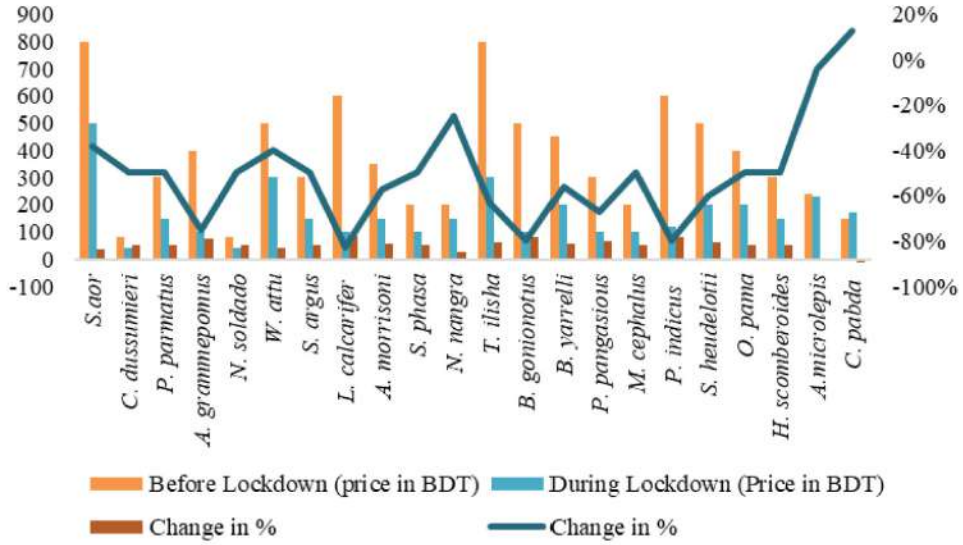

Figure 7. Rate of price loss between periods.

Increasing loan burden

In terms of loans, almost 70% of fishermen received a grocery credit loan from a neighboring shop to feed their families three times a day during the lockdown (Figure 8). At the same time, about 2% of fishermen did not obtain a loan, while about 8% of respondents borrowed money from relatives and neighbors. The most crucial finding was that 22% of fishermen acquired high-interest loans from local moneylenders because they could not find other means to manage their basic needs at the time.

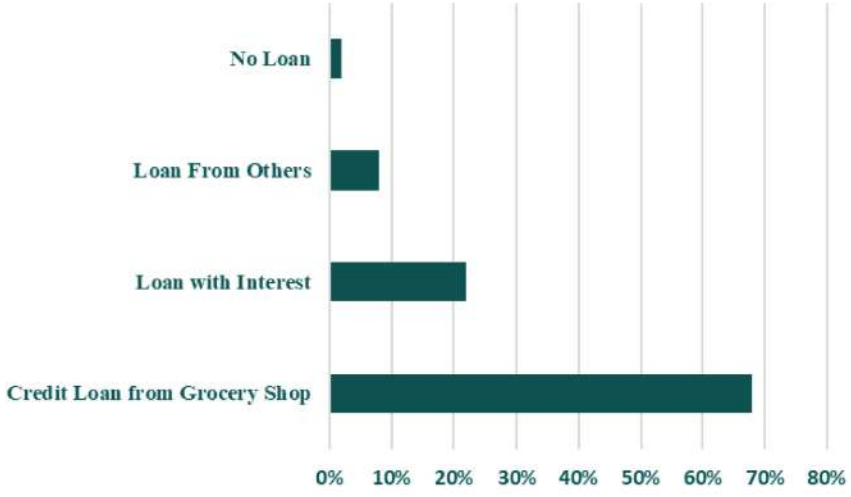

Figure 8. Loan borrowing scenario during lockdown.

Hamper on working hours and transport costs

We found that the fisher group worked for more than 8 hours per day during the pre-lockdown period. On the contrary, they worked for about 5 hours per day during the lockdown period. On the other hand, in the pre-lockdown period, they spent about 6 days a week as productive time, while in the lockdown period, they spent just over 3 days per week as working time (Figure 9a).

Our study on the socioeconomic effects of lockdown on the small-scale fisheries (SSF) community has revealed significant changes in the community's daily life. One of the key findings is the substantial increase in transportation costs due to the halt in vehicle movement during the lockdown. Local fishermen, in particular, experienced a 30% rise in transportation expenses to deliver their goods to the local market (Figure 9b).

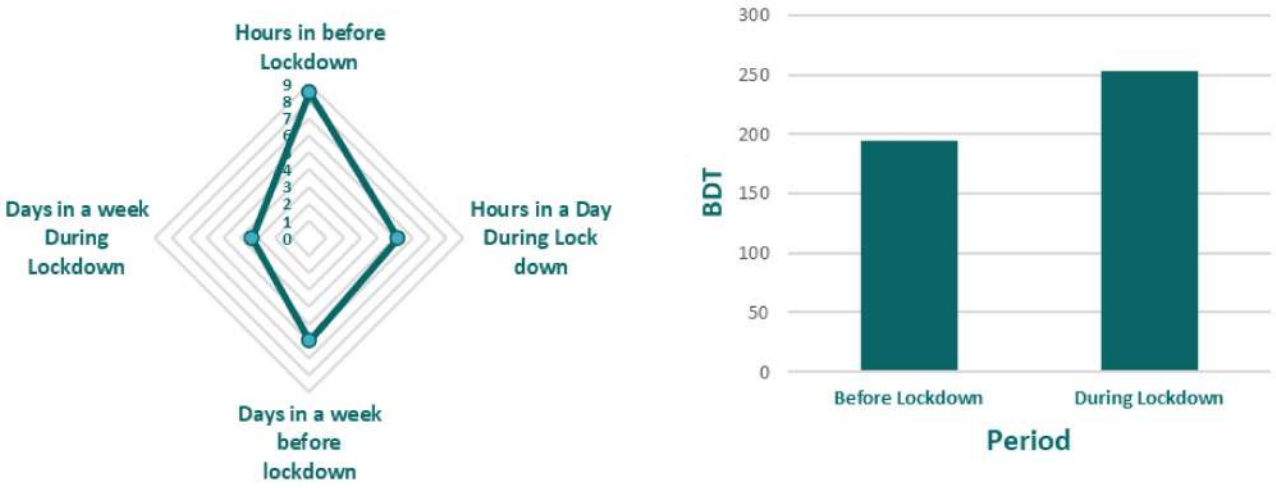

Figure 9. (a) shows the difference in working hours between the two periods. (b) Fluctuation of product transport costs between the two times.

Overall socioeconomic effects

The Sankey graph below is prepared to show the total socioeconomic consequences of the daily life of the SSF community (Figure 10). The five main socioeconomic consequences of the SSF community's daily life were categorized as social, economic, health, education, and food. The study revealed that the food category was the most affected, contributing 25% of the total impacts. Among these, difficulties in accessing food once daily affected the most significant portion of the population, while problems occurring three times a day affected the fewest. The second most common issue was the daily two-time food crisis. We also observed that the lockdown affected food shortages for children and cattle. The economic category had the second-largest impact on the life of the SSF community, accounting for about 23% of the total effects. Cash problems, loan access problems, neighbors' problems, and loans from others' problems were ranked first, second, third, and fourth, respectively. The health sector accounted for 20% of total effects, with mental stress issues ranking highest, followed by treatment, medicine purchasing, and medicine availability. The lockdown had a significant impact on the education sector. We found that children in the SSF community's education problems accounted for 19% of overall effects, with schooling and online study-related problems ranking first and private tutor and education materials-related problems ranking second and third, respectively. Other societal consequences were discovered under the social effects category. We found 13% of the total effects in this category. Physical meetings, problem-sharing with others, and interaction with neighbors are ranked first, second, and third, respectively.

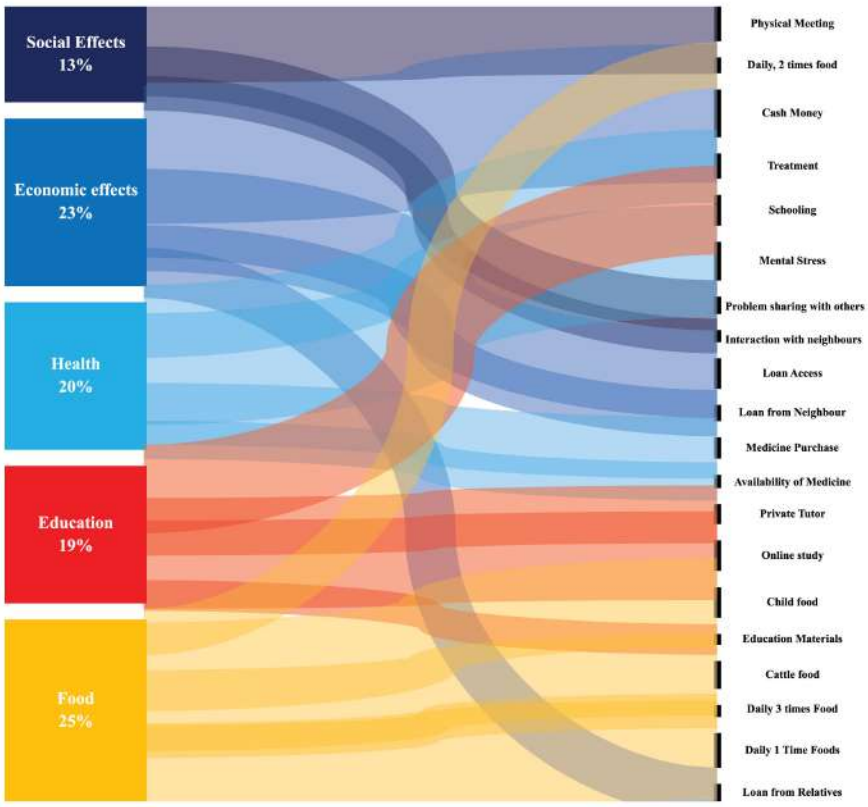

Figure 10. The overall socioeconomic effects on local fishermen due to the lockdown.

Discussion

This study aimed to explore the effect of lockdown—a measure introduced to prevent the spread of COVID-19—on catch composition and the livelihood of a small-scale fishing community around the Sundarbans region, Bangladesh. Therefore, data were collected in the pre-lockdown (1–23 March) and lockdown (24 March–30 April) period from 7 fish landing stations in the Sundarbans. At the beginning of the lockdown, fewer boats went fishing, which might result in high CPUE. As the lockdown continued, the number of operating boats fell even more, and the CPUE increased sharply. This increase in CPUE may be an immediate result of less fishing pressure in the coastal area. In Bangladesh, fishermen's interviews also reported reduced fishing activities and high yields (Islam et al., 2021). A similar effect of low fishing pressure was seen in Indonesia, where the average catch per trip increased from 20 to 30 kg (Campbell et al., 2021). Due to the COVID-19 pandemic, fishing activity has been reported to have decreased globally. Some countries also observed a reduction in fishing by around 80% due to lower demand, lower prices, and fishing closures (Global Fishing Watch, 2020). The number of active fishermen fell by over 90% in Indonesia due to the onset of the pandemic (Campbell et al., 2021). This may result in both short-term and long-term benefits for small-scale fishers. In the short term, fishers are relieved of competition with industrial-scale fishing as lockdowns, health safety measures, and labour shortages keep the industrial fleet in port (Minahal et al., 2020). In the long term, this unplanned fishing closure creates an opportunity to recover marine stocks, as predicted by many studies (Bennett et al., 2020; Korten, 2020). Evidence of such recovery was reported in China by the increased number of small fish on the sea surface and the absence of feeding migration of tuna from the South China Sea (Korten, 2020). Some relate the lockdown effect to the impact of World War II on fisheries, where fisheries closures in certain areas led to marine population recovery and improved catch per unit effort (Holm, 2016).

During both the pre-lockdown and lockdown period, 22 species comprised the catch composition, among which nine species (*Barbonymus gonionotus, Awaous grammepomus, Hydrolycus scomberoides, Sarotherodonmelanotheron heudelotti, Setipinna phasa, Coilia dussumieri, Scatophagus argus, Lates calcarifer, and Tenualosa ilisha*) were abundantly present during the lockdown period, while other species remained more or less static. These findings suggest that when fishing pressure is low, these nine species can recover their populations more quickly than others. This comparison cannot be made directly due to the lack of previous information on the population recovery of this species during short-term fishing closures. However, a similar positive effect of reduced fishing activities was seen in the landing per unit effort of hake, anchovy, Atlantic horse mackerel, and red mullets in the Northwestern Mediterranean Sea (Coll, 2020). In addition, as tropical fish breed more than once a year and many are continuous breeders, the recovery of fish populations in the coastal waters of Bangladesh is possible. Seven *species, Awaous grammepomus, Scatophagus argus, Lates calcarifer, Setipinna phasa, Barbonymus gonionotus, Callichrus pabda, and Hydrolycus scomberoides,* showed a sharp increase in CPUE catch; seven other species, *P. parmatus, A. morrisoni, T. ilisha, P. pangasious, O. pama, S. heudelotii, and P. indicus* showed a gradual rise; only one species *Coilia dussumieri* showed an gentle increase; the remaining four species *N. soldado, W. attu, N. nangra,* and *M. cephalus* showed no change after a brief rise during the lockdown. . The CPUE of *Amblypharyngodon microlepis* increased sharply during the initial days of lockdown but later decreased gradually. Overall, the catch of 20 species showed an increasing trend during the lockdown compared to the pre-lockdown period. As discussed, this is a result of reduced fishing pressure during the lockdown period. However, two species, *Sperata aor* and *Bagarius yarrelli*, showed a declining pattern before the lockdown began and failed to increase their population even when fishing pressure was low. The CPUE of *Sperata aor* showed an initial increase but then fell to pre-lockdown catch status, and the CPUE of *Bagarius yarrelli* showed a similar declining pattern during lockdown as it did in the pre-lockdown period. These findings indicate that the population of these two fish in Bangladesh was reportedly declining. Therefore, they are listed as vulnerable and critically endangered species in the IUCN Red List (IUCN, 2015).

We observed that while increasing CPUE helped fishermen who fished during the lockdown, the lower market price of the catch meant that this benefit did not significantly boost their financial gain. A price comparison in this study, conducted between pre-lockdown and lockdown times, showed that prices for nearly all species decreased, ranging from 4% to 83%. A decrease in the average fish price was also found in Indonesia, where it sometimes reached up to 70% and, therefore, sometimes did not cover the fishing cost (Campbell et al., 2021; Hidayati et al., 2021). A similar picture was seen in Cyprus, where a significant price drop for tuna and swordfish left fishing a non-viable business (Giannakis et al., 2020). A fall in fish prices was also seen in Myanmar (Diao et al., 2020), the Philippines, Thailand, Vietnam, Malaysia (Ferrer et al., 2021), Europe, the USA, Mexico (Lopez-Ercilla et al., 2021), and Canada (Asante et al., 2021). In Bangladesh, fish prices were reduced primarily due to the lower purchasing ability of consumers, a consequence of the lockdown measures, which resulted in many people losing their jobs or experiencing reduced income, leading to lower demand for fish (Islam et al., 2021). A preliminary study revealed a 76% reduction in average household income in Bangladesh, and 62% of the low-income or day labor population lost their jobs (BRAC Bangladesh, 2020). Many termed this situation of low market prices and consumer demand a "twin disaster" for fishers (Bennett et al., 2020). However, other reasons for the decreased fish price include disruptions to the market chain and exports, transportation halts, reduced access to cold storage, and shortened local market hours (Bassett et al., 2021; Islam et al., 2021). Such adverse effects of market disruption and reduced access to cold storage on the livelihoods of the fisher community were also reported globally (Purkait, 2020).

In addition to the difficulties mentioned above, fishermen had to incur 30% higher transportation costs than in the pre-lockdown period (Islam et al., 2021). They also reported that fishermen in Bangladesh had to spend nearly double on transportation compared to the pre-lockdown time. A similar rise in transportation costs was also seen in Indonesia (Ferrer et al., 2021). The decreased price of fish and increased transportation costs led to poor financial returns from fishing, ultimately demotivating the fishermen to continue fishing.

It is evident in the reduced fishing hours (5 hours a day) and the number of fishermen (3 days a week) during lockdown. Fewer fishing days in a week (3.72 ± 2.5 days) and a reduced number of fishing hours in a day (4.63 ± 2.9 h) during the lockdown period were also reported in Kenya (Fiorella et al., 2021). Similarly, a reduced frequency of fishing activity and a reduced number of crew to adjust fishing costs were seen in Indonesia (Hamzah & Nurdin, 2021). However, although fishing was not profitable, Indonesian fishermen were found to continue fishing as a coping strategy because of the absence of any other alternative livelihood option (Campbell et al., 2021; Hidayati et al., 2021)

All these factors significantly reduced the fishing community's income, forcing them to borrow money from various sources to provide food for their families. Similar findings were also reported by (Sunny et al., 2021), who showed that around 88.5% of fishers in Bangladesh depend on fishing alone for their livelihood. Thus, most small-scale fisher communities are highly vulnerable regarding financial safety during the COVID-19 pandemic. The pandemic-associated reduction in the income of fishers was reported globally, with variations ranging from 20% (in the USA) to 100% (in Indonesia) (Lopez-Ercilla et al., 2021). However, in Bangladesh, the reduction in fishermen's income was significant, forcing them to take out loans to make a living. This tendency to take loans may ultimately seriously impact their present and future livelihoods, especially for those who took loans from local moneylenders. These moneylenders are very exploitative, with a very high interest rate on their money, ranging from 100 to 240% per year (Deb & Haque, 2011). Many fishermen remain unable to repay such a loan for life, and the burden of the loan goes from generation to generation (Deb & Haque, 2011). Fishermen falling into this vicious cycle of hunger, unemployment, and high-interest loans due to the lockdown measures were also reported in India (Avtar et al., 2021)

The present study found that lockdown measures and their consecutive financial losses affected various aspects of the lives of fishermen: food, education, health, economics, and socialization. However, the worst effect was on the food and nutrition of the fisher's family. Most of the family either skipped a meal a day or struggled to prepare it. A small percentage of families even struggled to arrange any meal of the day.

This also considerably affected children's and livestock's food security. Similar adverse food security effects were observed in other countries in past pandemics like Ebola, SARS, and MERS (Sunny et al., 2021). Some predict that the global number of people suffering from food insecurity will double due to the COVID-19 pandemic (Bennett et al., 2020). Our study confirmed these predictions, revealing that the COVID-19 pandemic's most significant impact is food insecurity (23%), among other effects, particularly among small-scale fishermen. A similar effect was also reported in Kenya (Fiorella et al., 2021), where a moderate dietary impact due to the pandemic was noted, with a chance of worsening in combination with other existing stressors.

Proposed management framework

This study developed a framework to manage the shocking situation of small-scale fisher communities (Figure 11). For the suggested framework, we concentrated on five key sectors: economics, health, safety net, savings, and transportation and storage. Immediate incentives, interest-free loans, grant help from developing agencies, and financial support from exporters are part of the economic sector. All of these are essential for small-scale fishermen, as they confront major financial issues during and after shocks, such as COVID-19. Occasionally, they lose their assets and cannot continue fishing even after such shocking incidents. Given these contexts, financial assistance in various forms plays a demanding role for SSF communities in the situation above. In addition, grant support from developing agencies can also play an imperative role in reviving them. During the pandemic, the government of Bangladesh provided financial help in the agriculture and fisheries sectors to help them build resilience (Hossain, 2020). Similarly, the Indonesian government allocated 18% of its 2020 budget to help small-scale fishers and fish and salt farmers (Campbell et al., 2021). The government of the Philippines established a loan facility to support the agriculture and fisheries sectors in response to a shock. Providing financial assistance to fishermen when fishing is limited was also considered a rational approach in Canada (Asante et al., 2021).

People in small-scale fishing (SSF) communities often lack access to essential education, healthcare, and safe water (Islam et al., 2014; Iwasaki et al., 2009; Olago et al., 2007). For any medical necessity, they must travel a long distance due to the absence of hospitals near their location (Islam et al., 2014). These people, lacking even primary healthcare, are more susceptible to any disease, let alone a pandemic. Moreover, due to their low literacy level, they often believe in various superstitions, making them more susceptible to diseases. For example, fishermen in Ghana believe that living close to saline water makes them immune to COVID-19, and thus, they are not very keen to maintain physical distance to remain safe from the virus (Okyere et al., 2020). Therefore, the proposed framework emphasizes the establishment of functional community hospitals near the SSF community, given that all community hospitals are located in distant areas of the country, and many of them are not operational owing to a lack of doctors, medications, and treatment facilities. Furthermore, the mobile health assistance system could benefit them when no hospital is nearby. During and after shocking events, free medicine and protective materials (gloves, sanitizer, vaccines, etc.) must be provided, as well as harassment-free hospitalization facilities, because everyone is affected in some way during the shocking period, rich and poor alike, but poorer people are unable to access hospitalization facilities due to a lack of money and social status.

The safety net scheme might be highly beneficial to the SSF community. Even though the nation's poor have access to some safety net services, the cruel truth is that many of the poorest of the poor are not protected by these programs. There are no life insurance facilities for the country's SSF population, which is critical for the country's resilient SSF. Furthermore, disaster-prone zones in the country should implement a crop and asset insurance scheme, possibly through a public-private partnership.

Savings are also significant to the SSF community. When the SSF fishing community catches more fish than they expected, they can save a portion of their catch based on each boat's performance. They can also save a fixed amount of money each month, which will be helpful in the event of unexpected expenses.

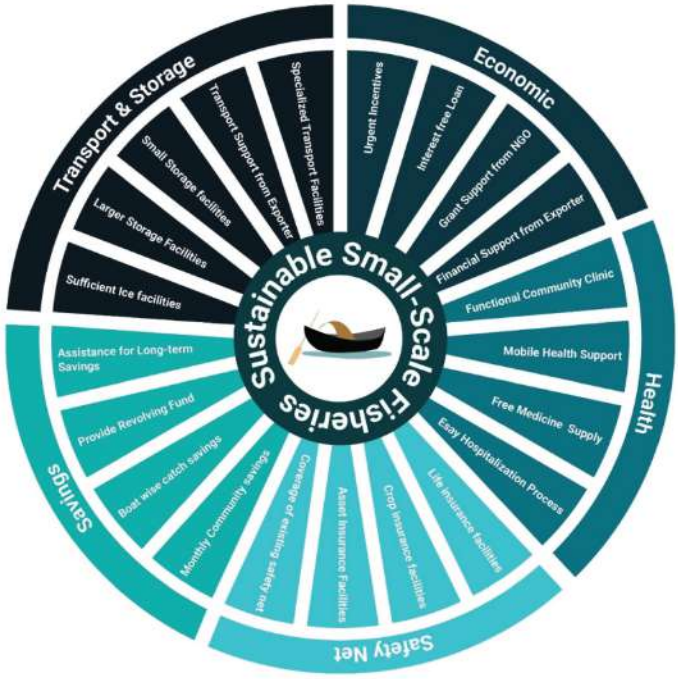

Figure 11. Management framework work for the shock-resilient SSF community.

Furthermore, certain revolving funds and guidance from NGOs on saving techniques could help them improve their saving efforts. The financial inclusion of small-scale fishermen through savings, credit, and insurance increased their resilience against shocks (Ferrer et al., 2021; Pomeroy, 2012).

Due to the uncertainty and irregularity surrounding transportation services during the pandemic, many SSF communities are unable to access health treatment or a fair price for their catch (Islam et al., 2021). As a result, during and after a disaster or other unexpected circumstances, emergency and special transportation facilities are much needed. In this regard, the suggested framework highlights the importance of specialized transportation facilities provided by government departments, such as the Navy and Army, for transporting SFF communities to deliver goods and access medical care. Moreover, the exporter or business community bears some responsibility by providing transportation for products during those disastrous situations.

Another sector that is inevitably improving is storage and icing facilities. The pandemic in many countries highlighted the importance of cold storage facilities in many studies (Ferrer et al., 2021). As the capacity of currently available storage facilities in the country's coastal region is less than the demand, the proposed framework suggests ensuring smaller and larger cold storage facilities near the SSF community.

Conclusion

The consequence of the COVID-19-induced lockdown has multi-dimensionally impacted small-scale fisheries. Most interestingly, the positive impact of the lockdown on this sector is the richness of fish species composition and the increasing trend of catch composition. Although fishermen went for limited-scale fishing during the lockdown, this indicates that overfishing pressure is responsible for reducing fish catch in the Sundarbans region. The lockdown had a positive impact on the catch rate but a negative impact on the fish price. The SSF community faced social, economic, health, education, and food issues because of the lockdown. Among the many negative consequences of lockdown for small-scale fishermen, the two worst were chronic food insecurity, which may have led to malnutrition, and taking loans from exploitative moneylenders. However, increased transportation expenses and reduced market prices of fisheries products were the main culprits behind the financial breakdown of small-scale fishing communities. The COVID-19 pandemic has negatively affected the livelihoods of small-scale fishermen, a situation that may last for generations. This situation further demonstrated the high vulnerability of small-scale fishing communities to adverse conditions and highlighted the need for special care during and after the pandemic.

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