





Article

Impact of COVID-19 on Smallholder Aquaculture Farmers and Their Response Strategies: Empirical Evidence from Bangladesh

G. M. Monirul Alam ^{1,2}, Md Nazirul Islam Sarker ^{3,*}, Md Abdus Samad Kamal ⁴, Most Nilufa Khatun ¹ and Humnath Bhandari ⁵

¹ Faculty of Agricultural Economics and Rural Development, Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Gazipur 1706, Bangladesh

² School of Commerce, University of Southern Queensland, Toowoomba, QLD 4350, Australia

³ School of Social Sciences, Universiti Sains Malaysia, USM, Pinang 11800, Malaysia

⁴ Division of Mechanical Science and Technology, Graduate School of Science and Technology, Gunma University, Kiryu 376-8515, Japan

⁵ International Rice Research Institute (IRRI), Dhaka 1213, Bangladesh

* Correspondence: sarker.usm@yahoo.com

Abstract: Bangladesh's aquaculture sector has contributed progressively to the nation's economy over the years, but the COVID-19 pandemic has impeded fish farmers' access to markets, reduced their production and sales capacity, resulted in lower income, and increased food security vulnerability. This study assesses how COVID-19 affects smallholder fish farmers and their response strategies by employing data collected from 250 fish farmers and traders from intensive fish-growing areas of Bangladesh. The results reveal that most farmers experienced difficulty obtaining inputs, and the price of those inputs skyrocketed during the COVID-19 period, resulting in several months of decreased production and operations. As a result of COVID-19, farm gate prices for silver carp, ruhu, common carp, grass carp, and tilapia fish dropped by 25%, 23%, 23%, 22%, 23%, and 40%, respectively. On the other hand, fish feed prices were found to increase significantly. Reduced income from fish farming and other sources has triggered a significant drop in capital for farming operations and production capacity improvement, leading to food insecurity. The most common coping strategies include reduced buying from the market (vegetables, fruits, meat, milk, etc.), relying on less expensive or less preferred food, purchasing food on credit, and selling assets. Notably, due to COVID-19, a new mode of marketing has evolved as an adaptation strategy in the fish marketing system, such as the use of the mobile phone (18%) and Facebook/internet to sell fish directly to the customer (16%). The sector requires short-term financial assistance to assist fish actors with production and marketing challenges.

Keywords: agribusiness; agri-food system; fisher community; food value chain; food system; sustainability



Citation: Alam, G.M.M.; Sarker, M.N.I.; Kamal, M.A.S.; Khatun, M.N.; Bhandari, H. Impact of COVID-19 on Smallholder Aquaculture Farmers and Their Response Strategies: Empirical Evidence from Bangladesh. *Sustainability* **2023**, *15*, 2638. <https://doi.org/10.3390/su15032638>

Academic Editor: Francisco José Liébana-Cabanillas

Received: 12 October 2022

Revised: 5 December 2022

Accepted: 29 December 2022

Published: 1 February 2023



Copyright: © 2023 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

1. Introduction

COVID-19 is a severe shock with worldwide consequences, notably for small-scale fishing families, which support livelihoods for approximately 10% of the global population [1]. COVID-19 exposes existing vulnerabilities for small-scale fisheries [2] and endangers their livelihoods by disrupting fish demand, supply, distribution, labor, and production [3]. Early studies on the impact of COVID-19 on small-scale fisheries throughout the world have raised several issues, such as economic vulnerability [4,5], customers' negative attitudes [6], anthropogenic stress [7], and food system disruption [8,9]. Fisheries provide jobs and food security for many people worldwide, and fish farmers are particularly vulnerable to the pandemic [10]. As one of the top traded commodities, the fisheries sector is affected more than other sectors due to COVID-19's mobility restrictions [11,12]. COVID-19 impacted the agriculture and aquaculture sector, the food supply chain, and related peoples' livelihoods

worldwide, particularly in countries of South Asia, such as in India [11,13,14], Nepal [15,16], Pakistan [17,18], Bhutan [19], Sri Lanka [20], and Bangladesh [21–24].

Fish is a valuable and necessary animal food source and crucial to preserving food security. Indicators of the contribution of fish to household food security in developing nations include the nutritious value of eating fish, greater revenue from fish sales, and enhanced financial stability of women due to their engagement in aquaculture [25]. The COVID-19 pandemic might significantly impact every food and nutritional security level, but poor to middle-class households and marginalized urban populations are more at risk [26]. A job loss during the pandemic significantly affects a household, depending on each person's income. The lockdown limits on travel disrupted the food supply chain and reduced the purchasing power of low-income people in metropolitan regions [15,27]. A paradox of unemployment brought on by the shutdown of businesses in the manufacturing and service sectors, on the one hand, and a labor shortage in systems that produce primary foods, on the other, as a result of social and movement restrictions, may have severe economic repercussions that could lead to a global economic recession [28]. Mallik et al. [29] reported that the pandemic caused the entire shutdown of fishing operations, a decrease in fish catches, market disruption, and a shift in customer preferences. Similarly, Nielsen et al. [30] mentioned that, on average, the impact of COVID-19 is negative on the income side, increasing cost and therefore negative with respect to the profit of the aquaculture sector in the European Union. Kobayashi [31] assessed the COVID-19 impact on aquaculture in Japan and reported that the aquaculture and seafood industries in six locations around Japan show how the effects of the pandemic-related economic crisis varied by sector, species, and local populations. Additionally, export restrictions between nations may hinder access to markets and commerce in farm and food products. The restricted freight capacity on commercial planes for agricultural items caused disruptions in the global supply chain [32]. The proclamation of lockdown impacted all operations along the value chain of the food system without preparation [33].

The economy of Bangladesh is predominantly reliant on agriculture because of the dependency of the majority of rural people on it for their livelihood and food security [34].

The first case of COVID-19 was detected in Bangladesh on 8 March 2020, and the government-imposed lockdown at different time intervals [35]. Due to resource, technical, and capacity restrictions, Bangladesh is trying to cope with the negative repercussions of COVID-19. COVID-19 has impacted many sectors of the economy, but fishermen have had the most trouble owing to the perishability of the product, a lack of storage facilities, and weak supply systems [2,3]. Haque et al. [36] analyzed the COVID-19 impact on agriculture in Bangladesh and argued that the middlemen-based business model has impoverished farmers of their earnings since the beginning of the COVID-19 pandemic.

Bangladesh's fisheries sector, particularly aquaculture, has become increasingly important to the economy over the last few decades. The fishing industry directly or indirectly employs approximately 12% of the overall population [37]. Aquaculture helps disadvantaged people to secure their food supply and livelihoods [38]. However, the COVID-19 induced lockdown disrupted the fish supply chain and increased food insecurity among smallholder fish farmers [33,39]. With dispersion effects, the COVID-19 pandemic affected the major pillars of food security, resulting in concurrent or successive forward and backward transmission of disruptions [32,40]. Small-scale fish farmers (pond area with ≤ 0.40 decimal) faced a huge monetary loss due to the inability to sell fish or sell at low prices. Fish farmers could not harvest and restart their production cycle, resulting in decreased fish supply and earning possibilities [35,41]. As a result of COVID-19, there has been a decrease in the demand for fish and other products derived from fisheries [42,43], which has negatively impacted the supply chain [21]. Hatcheries have been forced to close, feed imports have been halted, and many entities along the value chain have experienced a loss of revenue since the beginning of the culture season [44,45].

There is a burgeoning literature on COVID-19 impact studies, particularly in the fisheries and aquaculture sector in many countries, but it is limited in the Bangladesh

context [39,46,47]. Studies on the influence of the COVID-19 pandemic on Bangladesh's fisheries sector [48], on the other hand, have mostly focused on the seafood industry [41,49], finfish aquaculture [50], fish consumption [21], and food security [8], as well as small-scale fishing communities [10,22]. The evidence of the impact of COVID-19, their adaptation strategies, and the effectiveness of government intervention programs is required to guide the policymakers and related stakeholders in planning effective intervention programs for future shocks. However, essentially little research has examined the influence of COVID-19 on small-scale aquaculture and farmers' recovery efforts. Consequently, the purpose of this article is to extend the understanding of the impact of COVID-19 on small-scale aquaculture and how fish farmers' responded to it by using survey data from intensive fish-growing areas of Bangladesh. The research questions set to accomplish this objective are: (i) what are the impacts of COVID-19 on the livelihood and food security of smallholder fish farmers? and (ii) how are the actors in the aquaculture value chains impacted and what are their response (adaptation) strategies? The rest of the paper is ordered as follows. Section 2 represents the methodology; Section 3 describes the results and discussion, and Section 4 concludes the paper with policy recommendations.

2. Materials and Methods

2.1. Study Areas

Both qualitative and quantitative methods of data collection were employed to fulfill the objective of the study. The study area was chosen based on area coverage and contribution on total aquaculture production. Jeshore district, located in the Southern part of Bangladesh, is a major aquaculture producing area in the country. Therefore, Manirampur upazila of Jeshore district was selected purposively for this study (Figure 1). This area is under the government fish market project where farmers receive help to sell their fish through a government developed website.

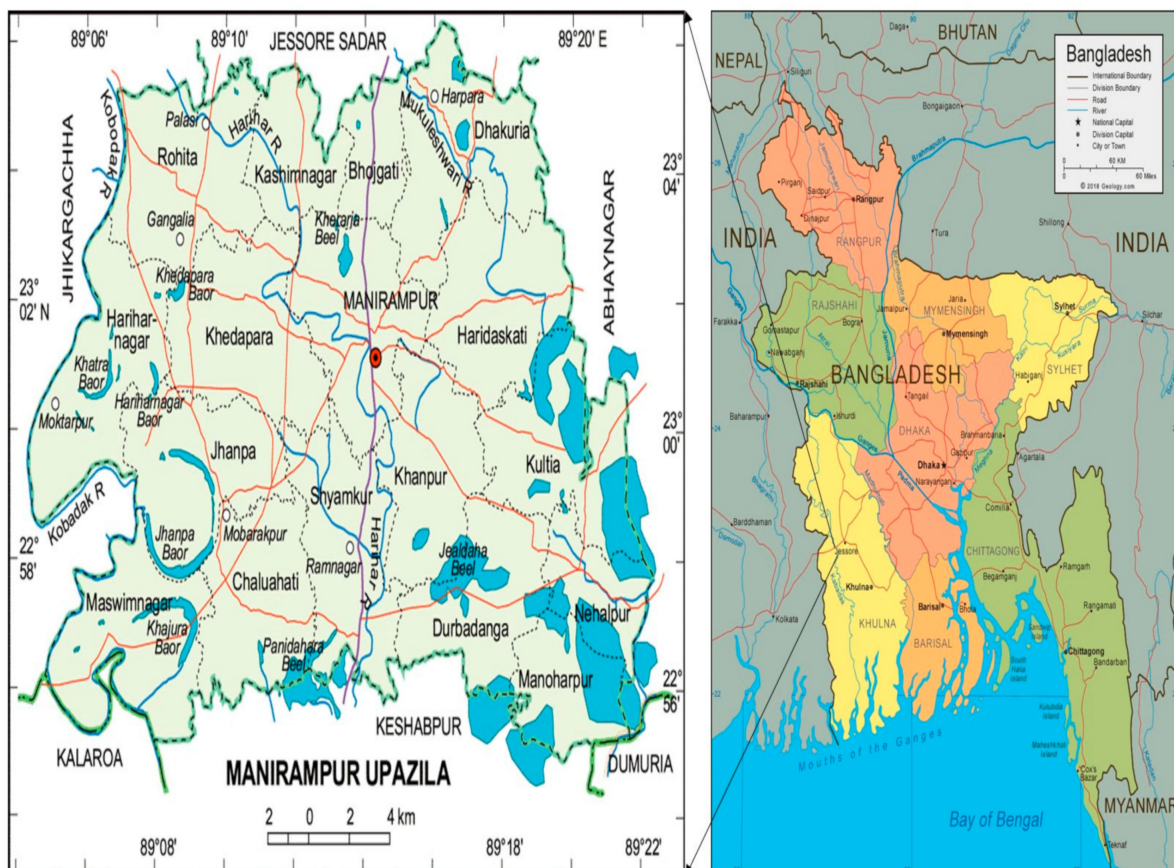


Figure 1. Study areas in Bangladesh.

2.2. Sampling, and Data Collection

This study purposively selected smallholder (The concept of smallholder fish farmers varies across countries. In consultation with the upazila fish farmers, this study considered smallholder fish farmers with ≤ 0.40 decimals of pond area. Smallholder represents more than 50 percent of fish farmers in the study area.) fish farmers as they are the top contributor in fish production. In addition, they are always vulnerable due to their low access to inputs, capital, market, and food supply chain. Due to restrictions of the COVID-19 pandemic, it was assumed that fish farmers' vulnerability was increased. So, the findings of the study can help the policy decision to improve the recovery process. The list of fish farmers was collected from the Upazila Fisheries Office. There were approximately 2450 fish farmers registered with the fisheries office.

For the purpose of this study, a sample size of 250 was chosen, which was determined by selecting more than 10 percent of households from the list. This was done to guarantee that the population under investigation was accurately represented. For the purposes of survey research, it is generally accepted that a sample size consisting of 5 percent of the population is enough to be considered properly representative of the state of the entire population [51]. The rural household served as the unit of analysis, and the head of the household—regardless of whether they were male or female—participated in the survey that was used to gather the data. To guarantee the unpredictability of the data, data were gathered from 250 different fish actors through the use of a lottery technique. In addition, focus group discussions (commonly known as FGDs) and key informant interviews (also known as KIIs) were carried out in order to cross-validate the findings of the survey and get a deeper comprehension of the impact that COVID-19 would have on the fish industry. Data were collected through structured survey questionnaires using face-to-face interviews between October and November 2021. The relevant stakeholders of this study are farmers, Bepari (purchase from farmers and sell to paikar through aratdar), Aratdar (serve as a distribution channel in a large or wholesale market), wholesaler/Paikar (buy in bulk volume), retailer (sell to the consumers) and consumer.

The information related to the families' socio-economic conditions, the households' self-reporting food security status, the impact of COVID-19 on the aquaculture industry, and their response strategies are included in the questionnaire. Descriptive statistics were performed to present the findings of the study. Secondary data on fish price were collected from the Department.

2.3. Measuring COVID-19's Impact on Aquaculture

The impact of COVID-19 has been explored in several aspects, such as the disruption of fish marketing channels, the income of value chain actors, price, and food security. All possible marketing channels have been considered to know the exact effect of COVID-19 on the aquaculture value chain. The respondents were asked to mention the potential channel name for fish marketing. On a four-point scale, the impact on household income was ranked as low, medium, high and very high. Similarly, the impact on various actors in the values has been presented by percentage. COVID-19's impact on the income of value chain actors has been shown based on the category and expressed in the percentage of total income-driven by fish activities. The price during lockdown and restriction has been presented according to date and variety of fish.

3. Results and Discussion

3.1. Fish Marketing Channel

Fish is transferred from the farmer/producer to the final consumer through several market players, such as Bepari, rural Paikar, Aratdar, urban Paikar, and retailer in the research locations. These players are critical in the fish movement from the point of production to the final customer [3]. These market participants have played various roles by adding value in various ways [49]. However, due to the COVID-19-induced lockdown, they could not play their role. Most of the farmers stopped harvesting fish for a couple of

weeks during the first lockdown in March 2020. Then, gradually, the government eased the travel restriction on the movement of actors in the food value chain sectors [21]. Most farmers sell their fish at farm gates, especially to the Bepari and rural Paikar (Figure 2), but they could not travel to the local area due to the pandemic.

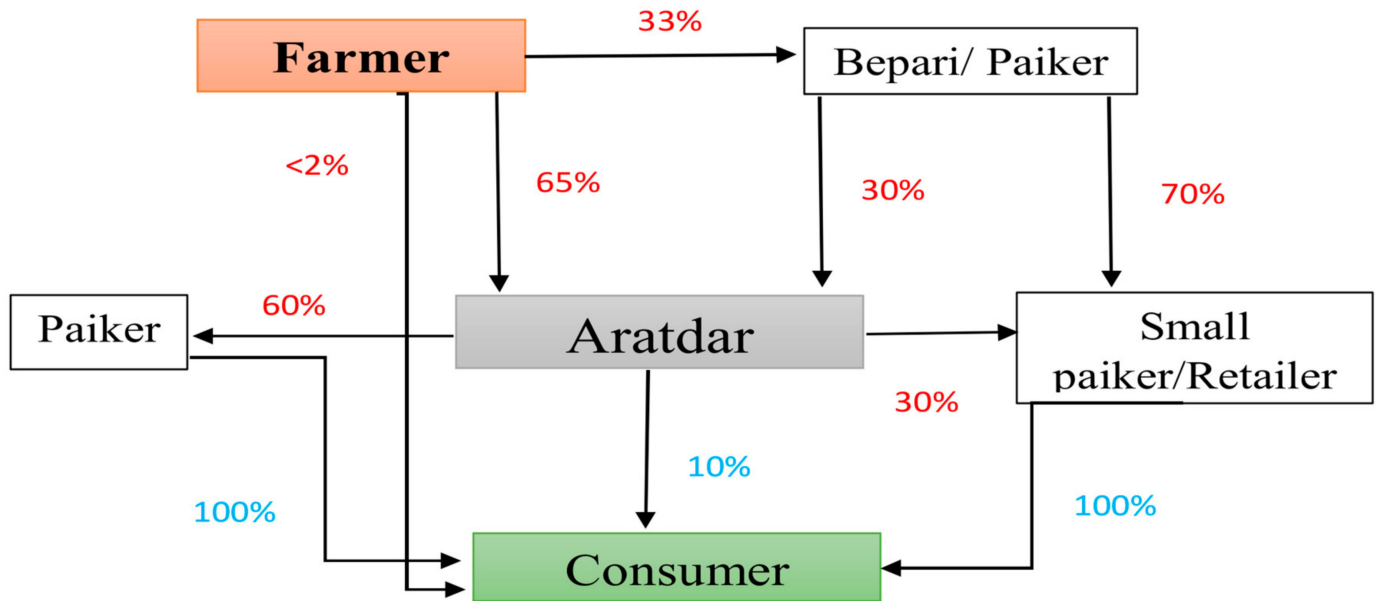


Figure 2. Fish marketing channel in the study area.

3.2. COVID-19 Impacts on the Income of Fish Value Chain Actors

The COVID-19 outbreak caused significant issues for Bangladeshi fishermen, fish laborers, and other participants in the fisheries value chain [52]. During the crisis, their lives and those close to them were more difficult than previously. In the study area, most of the fish farmers were male with increasing involvement of women in feeding, liming, etc. Most farmers have some level of education (average primary level). Education positively impacts farmers' total fish production by allowing them to gain new knowledge about fish farming and to obtain market information [53]. These improve fish production and make the selling process more manageable. Though all the value chain actors are highly dependent on income from fish, many fish farmers were involved in different income-generating activities [54].

Fish is the main source of income for the fish actors. Table 1 indicates that the highest portion of total income (approximately 98%) of fishermen derives from fishing, followed by the fish retailer (90%), fish Bapari/Paiker (85%), and Aratdar (80%).

Table 1. Impact of COVID-19 on household income.

Actors	Percentage (%) of Total Income Driven from Fish Activities	Level of Impact
Fisherman	<98	(−) Very high
Fish Producer	65	(−) High
Fish Hatchery Owner	35	(−) Very high
Feed Dealer	60	(+) High
Fish Aratdar	80	(−) Low
Fish Bapari/Paiker	85	(−) Very high
Fish Retailer	90	(−) Very high

Source: Field Survey, 2021.

However, fish dealers benefited from selling feed at high prices. Based on the self-reported level of impact of COVID-19 on a scale of 4 to 1 (very high to very low), it was identified as a significant effect of COVID-19 on fishermen, fish producers, fish Bapari, and retailers. Fish hatchery owners were also highly impacted because the first lockdown started on 26 March 2020 in Bangladesh, which is the breeding time for fish. Due to movement restrictions, they could not sell fingerlings [7]. COVID-19 had a substantial impact on fishermen, with considerable income reductions for both day and longer fishing excursions owing to reduced time at sea, independent of geographical location. According to Hoque et al. [22], alternative revenue streams, such as crop farming, can help aquaculture farmers to improve their lives and food security. During the COVID-19 epidemic, coastal fishermen were disproportionately impacted, fighting for their livelihoods and food security. A considerable decrease in income and fishing frequency occurred due to COVID-19. Sunny et al. [8] argue that small-scale fishermen and fish growers were barred from operating on open wetlands and ponds to gather inputs, leaving them unable to meet their basic needs by selling their catch in the market.

3.3. Impact of COVID-19 on Fish and Feed Price

The pandemic also hugely impacted the prices of fish and feed [42]. Figure 3 presents that the price of important culture fish followed a decreasing trend in the wholesale market. During COVID-19, there was a rumor that COVID-19 could be transferred to humans by fish, which resulted in a drop in fish prices [55]. The main issue facing fish farmers and traders was the disturbance in the shipping of fish, fingerlings, feed, and other inputs [56]. Figure 3 displays the fish price changes in the wholesale market during COVID-19.

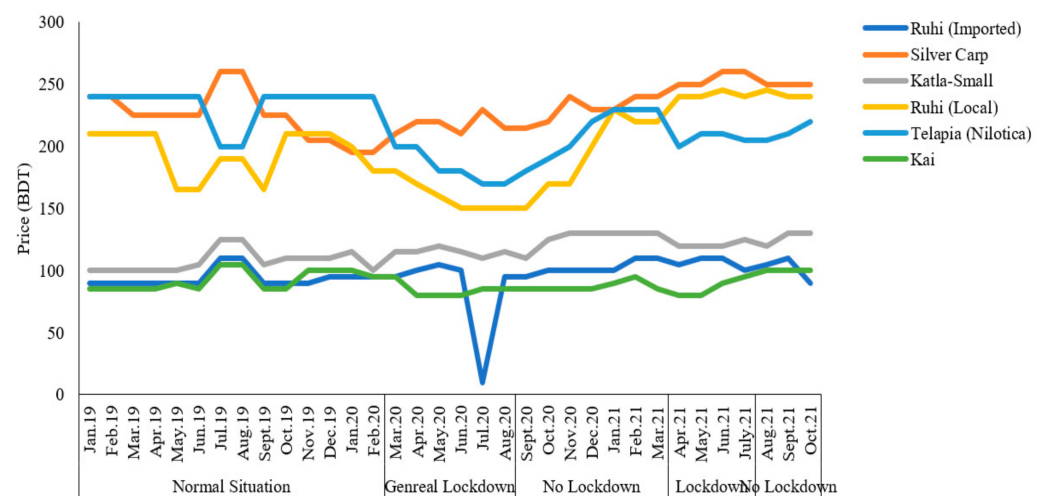


Figure 3. Wholesale market price of fish before and during COVID-19 period.

Before the pandemic, the farm gate price of silver carp, rui (ruhu), katla (common carp), grass carp and tilapia fish were BDT 80, BDT 130, BDT 150, BDT 130 and BDT 100 per kg, respectively. After COVID-19, the prices were BDT 80, BDT 125, BDT 140, BDT 120 and BDT 90 per kg, respectively (Figure 4). The corresponding price drops were 25%, 23%, 23%, 22%, 23% and 40%, respectively. They were also not able to export fish due to COVID-19 restriction. Hasan et al. [50] reported that consumers paid higher costs for pangasius and carp, and somewhat lower prices for tilapia and other catfish, resulting in lower profitability for finfish producers in Bangladesh. On the other hand, the intermediaries raised their selling rates to balance rising expenses and retain profitability.

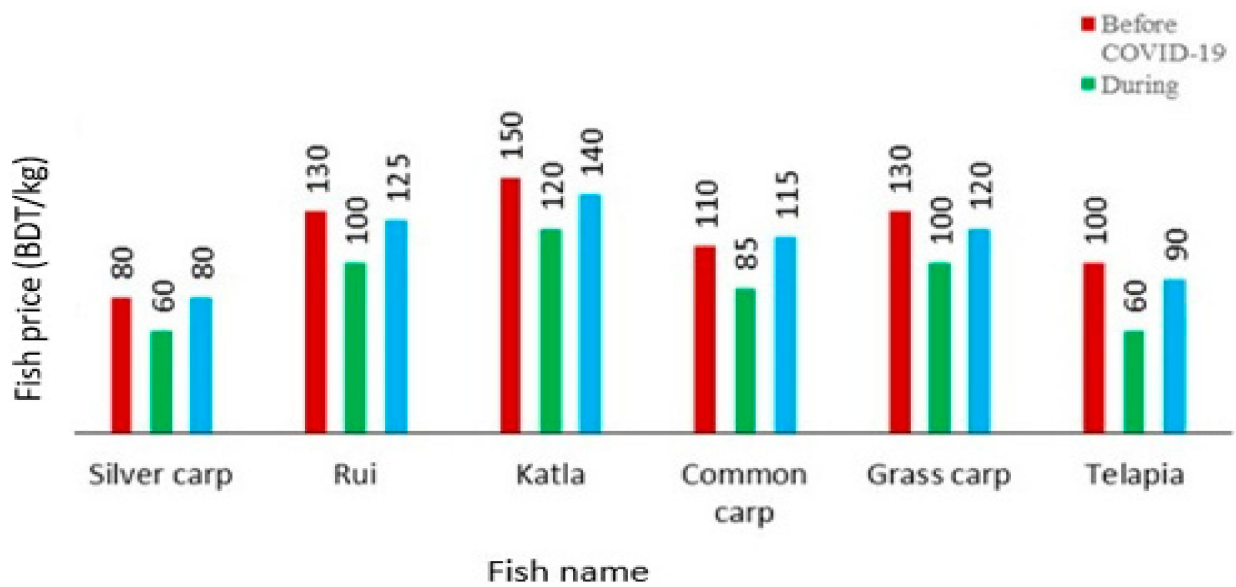


Figure 4. Comparison of fish prices at farm gate level before and during COVID-19 period.

On the other hand, fish feed prices were found to increase significantly. Before the pandemic, important fish feed, such as packaged feed, khail, wheat dust, and rice break, were BDT 45, BDT 35, BDT 30 and BDT 22 per kg, respectively. After the COVID-19 pandemic, the price of all feed items increased by 13–20% (Figure 5).

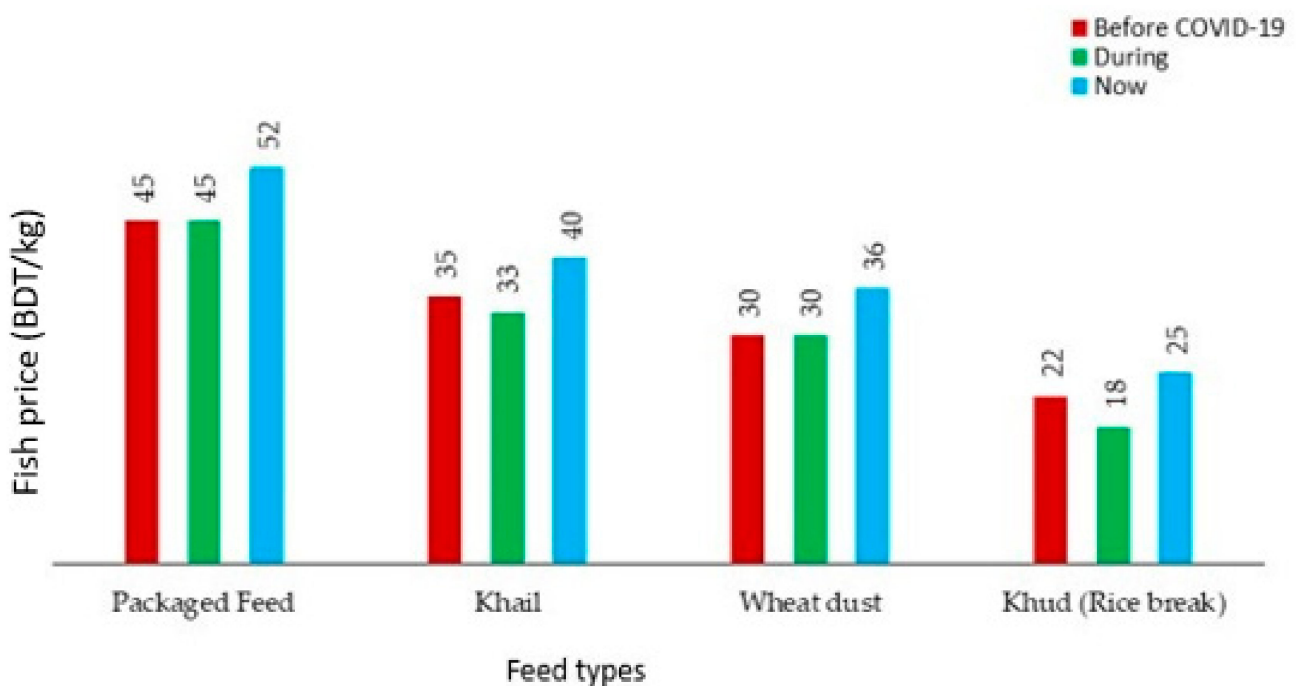


Figure 5. Comparison of feed price at farm gate level before and during COVID-19.

3.4. Impact of COVID-19 on Food Security of Fish Value Chain Actors

The majority of aquaculture farmers' income is derived from fish related activities. Moreover, due to COVID-19, their income from other sources were also negatively impacted, which triggered household food security vulnerability. COVID-19 caused a loss of income and job opportunities, disrupted the food supply chain, increased the price of inputs and other necessities, and the cumulative effects increased household food security vulnerability (Figure 6). Approximately 36% of respondents reported

experiencing or being concerned about their household's food security throughout the COVID-19 period. In the first two months of the COVID-19 outbreak, approximately 17% could not purchase food on credit. Only 21% received some sorts of assistance from external sources (government and others). In such a situation, the most common coping strategies they practiced were reduced buying from the market (vegetables, fruits, meat, milk, etc.), relying on less expensive or less preferred food, purchasing food on credit and selling assets (Figure 6). It is reported that other fish farmers, such as shrimp farmers and coastal fishermen, also experienced food insecurity [37,57,58].

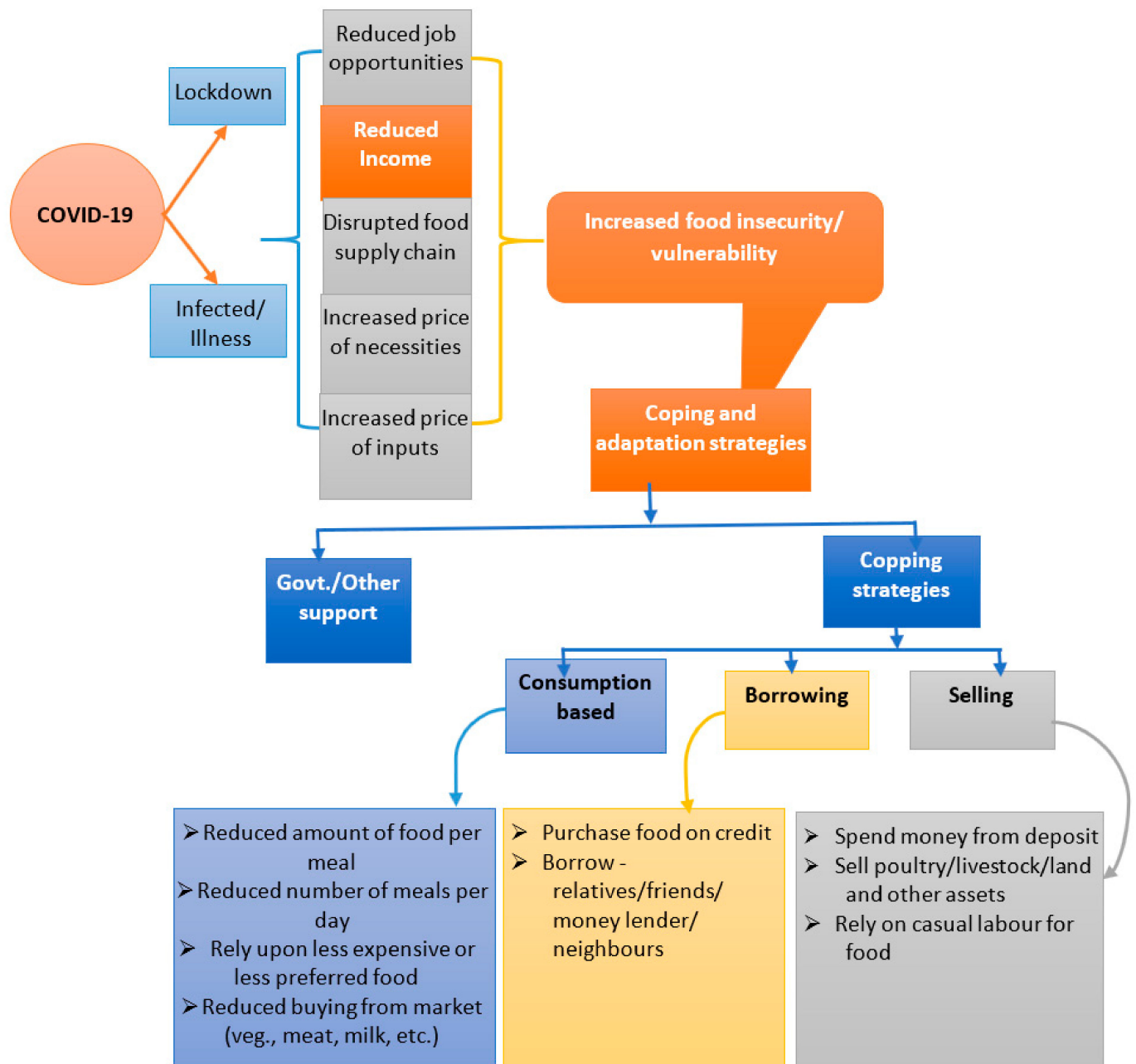


Figure 6. Impact of COVID-19 on household food security and adaptation strategies.

3.5. Adaptation Strategies to COVID-19 Impacts

Different fish value chain actors have administered varying coping and adaptation strategies to reduce the effects of COVID-19 [59]. The study indicated that irrespective of the apparent disadvantages, fish producers have adopted various adaption tactics in response to COVID-19. The primary adaptation strategies comprise reducing market purchase (85%),

and borrowing money (84%). It is also vital to notice that due to COVID-19, a new mode of marketing has evolved in the fish marketing system, such as the use of the mobile phone (18%) and Facebook/internet to sell fish directly to the customer (16%) (Figure 7).

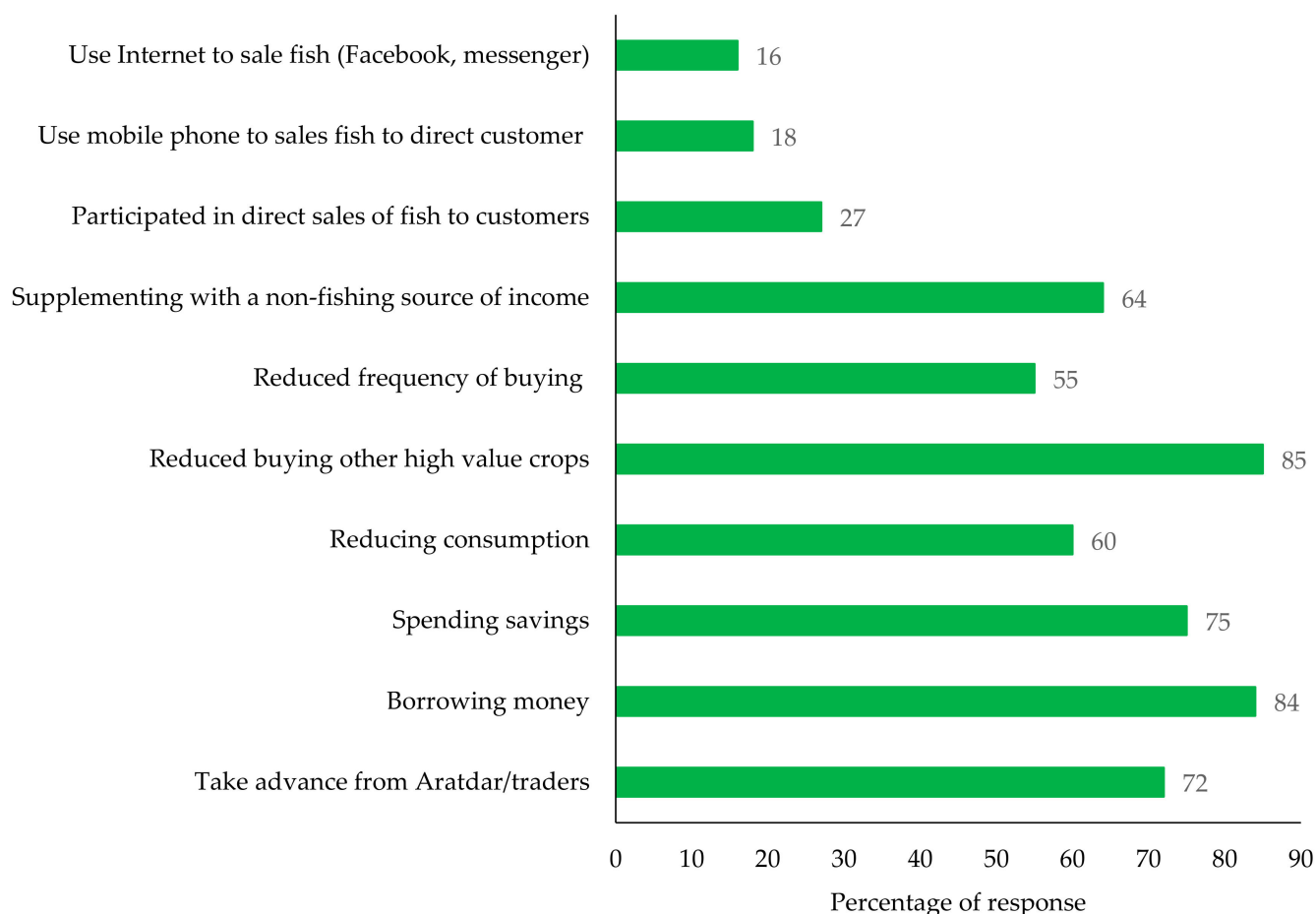


Figure 7. Adaptation strategies of the fish farmers.

Bhowmik et al. [10] argued that all resilience traits that demand specific care to guarantee fishermen's well-being are closely connected to financial capital. Small-scale farmers can benefit from investments in long-term livelihood and asset-building programs. Similarly, Sunny et al. [8] also mentioned that people in need believed that the government's actions should be centered on safeguarding both their health and their food security. Alternative revenue options, rationing, training, and motivating programs might all help to improve the situation [60].

3.6. Government Interventions in Fisheries Sector

The Bangladesh government acted quickly with the onset of the COVID-19 pandemic, and implemented lockdown and public health measures to contain the pandemic. The government also announced a relief package, including cash transfers and food assistance, to help the poor and vulnerable households. Government provided a stimulus package to businesses to assist them in maintaining employment in key sectors. In addition to stimulus packages, the Bangladesh government has attempted to provide fish farmers with additional logistical support to facilitate the sale of their fish. In the first 3 to 4 months after COVID-19 was discovered in Bangladesh, it was challenging for fish producers to sell their catch. The Bangladesh Fisheries Development Corporation (BFDC) has created a website for selling fish online (www.bfdc.gov.bd, accessed on 15 October 2022). Only 22 of the 495 upazilas in Bangladesh are part of this project. They have formed a 'Fish Producer

Organization' (FPO) in the upazila, and members of the group can take advantage of the website for selling fish (Figure 8).

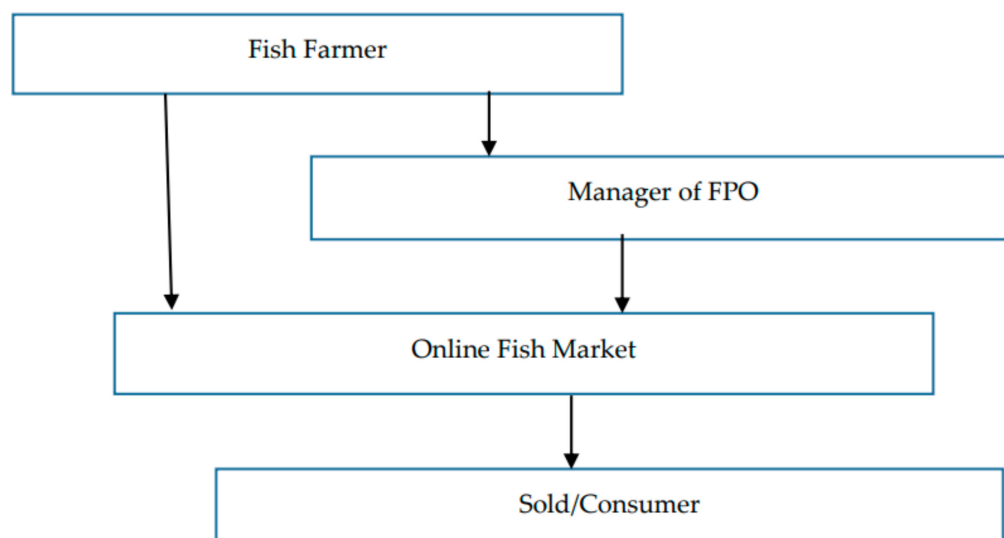


Figure 8. Online fish marketing system.

In the study area, less than 5% of farmers benefited from using the website to sell their fish. The main reasons for not using the website were the inability to sell large quantities of fish (98%), a lack of website information (91%), and a lack of technical knowledge to use it (90%). Although a few farmers have been discovered using Facebook/the internet to sell their fish directly to customers under their own arrangement. Furthermore, the government provided FPO with a subsidized pickup van for transporting fish and fingerlings, which helped them to save money on transportation. During the travel restriction, the Upazila fisheries office also provided a striker/pass for free movement of the fish value chain actors. The government should provide the aquaculture farmers with vulnerable group feeding (VGF) support. The VGF was the main social assistance program for registered fishermen to support their livelihoods during the fish catching restriction period. The fishermen had no other way to obtain institutional support. During the COVID-19 pandemic and other shocks, however, it is critical to guarantee that the VGF is delivered on time.

4. Conclusions and Policy Recommendations

COVID-19 has exposed vulnerabilities in small-scale fisheries and jeopardized their well-being by disrupting supply and demand, distribution of fish and feed, labor, and production. The study revealed that during the COVID-19 pandemic, the majority of fish farmers had difficulty obtaining inputs, and the price of those inputs increased, resulting in several months of decreased productivity and operations. As a result of COVID-19, silver carp, ruhu, common carp, grass carp, and tilapia fish farm gate prices dropped by 25%, 23%, 23%, 22%, 23%, and 40%, respectively. COVID-19 caused aquaculture fish producers to lose money in two ways: lower fish prices but higher input prices, or unavailable inputs. As a result, small-scale fish farmers might be less motivated to produce fish in the near future, resulting in lower yields and production. Reduced income from fish farming and other sources, along with cuts to capital for farming activities, contribute to food insecurity. The common adaptation strategies adopted by the fish farmers were taking advances from Aratdar, reducing consumption, increased home consumption and distribution of fish, direct sale of fish to the consumer, and use of a mobile phone to sell fish to the consumer.

The government should support small-holder fish farming through subsidies on inputs or loans to build back better from the adverse impacts of COVID-19 and future shocks. Unlike rice, the aquaculture industry has not reaped the benefits of government programs, such as subsidies and other public investments. COVID-19 has constrained

the availability of capital by reducing income from business, employment and livelihood sources. Short-term financial assistance is required to assist fish producers with production and marketing issues. In times of uncertainty, input support can be quite beneficial to farmers. This assistance should assure that small-scale producers can continue their farming. The future development of Bangladesh's aquaculture sector will require low-cost quality feeds, effective supply chains with good transport, extension services to improve farm management, improvement of the fish storage system, cold chain infrastructure, access to information, and more investment in development of the value chain for the export market.

Author Contributions: G.M.M.A., M.N.I.S. and H.B. initiated the study. G.M.M.A. and M.N.I.S. collected the data. G.M.M.A., M.N.I.S., M.N.K. and H.B. processed the data and performed analysis. G.M.M.A., M.N.I.S., M.A.S.K., M.N.K. and H.B. wrote and revised the manuscript. All authors have read and agreed to the published version of the manuscript.

Funding: This study was conducted under the CGIAR COVID-19 Hub which is supported by contributors to the CGIAR Trust Fund.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Informed consent was obtained from all respondents involved in the study.

Data Availability Statement: Data will be available on request.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. FAO. *Summary of the Impacts of the COVID-19 Pandemic on the Fisheries and Aquaculture Sector*; FAO: Rome, Italy, 2020; ISBN 978-92-5-132789-0.
2. Ferrer, A.J.G.; Pomeroy, R.; Akester, M.J.; Muawanah, U.; Chumchuen, W.; Lee, W.C.; Hai, P.G.; Viswanathan, K.K. COVID-19 and Small-Scale Fisheries in Southeast Asia: Impacts and Responses. *Asian Fish. Sci.* **2021**, *34*, 99–113. [[CrossRef](#)]
3. Alam, G.M.M.; Sarker, N.I.; Gatto, M.; Bhandari, H.; Naziri, D. Impacts of COVID-19 on the Fisheries and Aquaculture Sector in Developing Countries and Ways Forward. *Sustainability* **2022**, *14*, 1071. [[CrossRef](#)]
4. Hamzah, A.; Nurdin, H.S. Economic Resilience of Fishermen Community during COVID-19 Pandemic. *IOP Conf. Ser. Earth Environ. Sci.* **2021**, *715*, 012062. [[CrossRef](#)]
5. Mangubhai, S.; Nand, Y.; Reddy, C.; Jagadish, A. Politics of Vulnerability: Impacts of COVID-19 and Cyclone Harold on Indo-Fijians Engaged in Small-Scale Fisheries. *Environ. Sci. Policy* **2021**, *120*, 195–203. [[CrossRef](#)] [[PubMed](#)]
6. Kashem, A.; Tasnim, N.; Rahman, M.; Abu, M.; Bapary, J.; Akanda, A. Consumer's Attitudes toward Fish Consumption during Pandemic COVID-19 in Bangladesh. *Int. J. Nat. Sci.* **2021**, *11*, 15–22.
7. Sarà, G.; Mangano, M.C.; Berlino, M.; Corbari, L.; Lucchese, M.; Milisenda, G.; Terzo, S.; Azaza, M.S.; Babarro, J.M.F.; Bakiu, R.; et al. The Synergistic Impacts of Anthropogenic Stressors and COVID-19 on Aquaculture: A Current Global Perspective. *Rev. Fish. Sci. Aquac.* **2022**, *30*, 123–135. [[CrossRef](#)]
8. Sunny, A.R.; Sazzad, S.A.; Prodhon, S.H.; Ashrafuzzaman, M.; Datta, G.C.; Sarker, A.K.; Rahman, M.; Mithun, M.H. Assessing Impacts of COVID-19 on Aquatic Food System and Small-Scale Fisheries in Bangladesh. *Mar. Policy* **2021**, *126*, 104422. [[CrossRef](#)]
9. Fiorella, K.J.; Bageant, E.R.; Mojica, L.; Obuya, J.A.; Ochieng, J.; Olela, P.; Otu, P.W.; Onyango, H.O.; Aura, C.M.; Okronipa, H. Small-Scale Fishing Households Facing COVID-19: The Case of Lake Victoria, Kenya. *Fish. Res.* **2021**, *237*, 105856. [[CrossRef](#)]
10. Bhowmik, J.; Selim, S.A.; Irfanullah, H.M.; Shuchi, J.S.; Sultana, R.; Ahmed, S.G. Resilience of Small-Scale Marine Fishers of Bangladesh against the COVID-19 Pandemic and the 65-Day Fishing Ban. *Mar. Policy* **2021**, *134*, 104794. [[CrossRef](#)]
11. Das, A.; Datta, D.; Samajdar, T.; Idapuganti, R.G.; Islam, M.; Choudhury, B.U.; Mohapatra, K.P.; Layek, J.; Babu, S.; Yadav, G.S. Livelihood Security of Small Holder Farmers in Eastern Himalayas, India: Pond Based Integrated Farming System a Sustainable Approach. *Curr. Res. Environ. Sustain.* **2021**, *3*, 100076. [[CrossRef](#)]
12. Tian, X.; Zhou, Y.; Wang, H. The Impact of COVID-19 on Food Consumption and Dietary Quality of Rural Households in China. *Foods* **2022**, *11*, 510. [[CrossRef](#)]
13. Kumaran, M.; Geetha, R.; Antony, J.; Vasagam, K.P.K.; Anand, P.R.; Ravisankar, T.; Angel, J.R.J.; De, D.; Muralidhar, M.; Patil, P.K.; et al. Prospective Impact of Corona Virus Disease (COVID-19) Related Lockdown on Shrimp Aquaculture Sector in India—A Sectoral Assessment. *Aquaculture* **2021**, *531*, 735922. [[CrossRef](#)]
14. Giri, S.; Daw, T.M.; Hazra, S.; Troell, M.; Samanta, S.; Basu, O.; Marcinko, C.L.J.; Chanda, A. Economic Incentives Drive the Conversion of Agriculture to Aquaculture in the Indian Sundarbans: Livelihood and Environmental Implications of Different Aquaculture Types. *Ambio* **2022**, *51*, 1963–1977. [[CrossRef](#)]
15. Poudel, K.; Subedi, P. Impact of COVID-19 Pandemic on Socioeconomic and Mental Health Aspects in Nepal. *Int. J. Soc. Psychiatry* **2020**, *66*, 748–755. [[CrossRef](#)]

16. Christian, M.; Dewi, D.; Rembulan, G.D.; Indriyarti, E.R.; Yuniarto, Y. Business Performance Determinants of Salted Fish Distribution in Kapuk during the COVID-19. *J. Distrib. Sci.* **2021**, *19*, 29–39. [[CrossRef](#)]
17. Minahal, Q.; Munir, S.; Komal, W.; Fatima, S.; Liaqat, R.; Shehzadi, I. Global Impact of COVID-19 on Aquaculture and Fisheries: A Review. *Int. J. Fish. Aquat. Stud.* **2020**, *8*, 42–48.
18. Pirasteh-Anosheh, H.; Parnian, A.; Spasiano, D.; Race, M.; Ashraf, M. Haloculture: A System to Mitigate the Negative Impacts of Pandemics on the Environment, Society and Economy, Emphasizing COVID-19. *Environ. Res.* **2021**, *198*, 111228. [[CrossRef](#)]
19. Dorji, N.; Yamazaki, S.; Thinley, P. How Has the COVID-19 Pandemic Response Impacted Small-Scale Fish Farmers in Bhutan? *Aquaculture* **2023**, *562*, 738781. [[CrossRef](#)]
20. Amaralal, K.H.M.L.; Edirimanna, E.M.A.P.; Lakmini, W.A.S.W.; Chamodi, K.K.D.; Kuragodage, A.U.; Sanuja, R.G.; Bandara, E.G.K.Y.C.; Maheepala, M.M.A.S.; Abeykoon, M.N.D.F.; Sadaruwan, K.P.G.L.; et al. Impacts of COVID-19 Pandemic on the Fisheries Sector of Sri Lanka. *Mar. Policy* **2023**, *147*, 105339. [[CrossRef](#)]
21. Islam, M.M.; Khan, M.I.; Barman, A. Impact of Novel Coronavirus Pandemic on Aquaculture and Fisheries in Developing Countries and Sustainable Recovery Plans: Case of Bangladesh. *Mar. Policy* **2021**, *131*, 104611. [[CrossRef](#)]
22. Hoque, M.S.; Bygvraa, D.A.; Pike, K.; Hasan, M.M.; Rahman, M.A.; Akter, S.; Mitchell, D.; Holliday, E. Knowledge, Practice, and Economic Impacts of COVID-19 on Small-Scale Coastal Fishing Communities in Bangladesh: Policy Recommendations for Improved Livelihoods. *Mar. Policy* **2021**, *131*, 104647. [[CrossRef](#)]
23. Samad, M.A.; Rahman, M.A.; Yeasmin, S.M.; Mahfuj, S.; Rahman, M.H.; Sultana, M.F.; Rahman, M.A.; Sen, T.; Rahman, M.A.; Islam, M.S.; et al. Implications of COVID-19 on Oxbow Lake (Baors) Fisher's Community, Bangladesh: Resilience to Food Security against Probable Natural Calamities. *Heliyon* **2022**, *8*, e11326. [[CrossRef](#)] [[PubMed](#)]
24. Khan, M.A.; Hossain, M.E.; Rahman, M.T.; Dey, M.M. COVID-19's Effects and Adaptation Strategies in Fisheries and Aquaculture Sector: An Empirical Evidence from Bangladesh. *Aquaculture* **2023**, *562*, 738822. [[CrossRef](#)] [[PubMed](#)]
25. Farrell, P.; Thow, A.M.; Wate, J.T.; Nonga, N.; Vatucaawaqa, P.; Brewer, T.; Sharp, M.K.; Farmery, A.; Trevena, H.; Reeve, E.; et al. COVID-19 and Pacific Food System Resilience: Opportunities to Build a Robust Response. *Food Secur.* **2020**, *12*, 783–791. [[CrossRef](#)] [[PubMed](#)]
26. Gosh, K.; Chowdhury, S.; Acharjee, D.C.; Mamun, A.-A.; Ghosh, R. Assessing the Economic Impacts of COVID-19 on the Aquaculture and Fisheries Sectors in Relation to Food Security: A Critical Review. *Sustainability* **2022**, *14*, 8766. [[CrossRef](#)]
27. Okyere, I.; Chuku, E.O.; Ekumah, B.; Angnuureng, D.B.; Boakye-Appiah, J.K.; Mills, D.J.; Babanawo, R.; Asare, N.K.; Aheto, D.W.; Crawford, B. Physical Distancing and Risk of COVID-19 in Small-Scale Fisheries: A Remote Sensing Assessment in Coastal Ghana. *Sci. Rep.* **2020**, *10*, 22407. [[CrossRef](#)]
28. Oyenuga, A. Perspectives on the Impact of the COVID-19 Pandemic on the Global and African Maritime Transport Sectors, and the Potential Implications for Africa's Maritime Governance. *WMU J. Marit. Aff.* **2021**, *20*, 215–245. [[CrossRef](#)]
29. Mallik, A.; Chakraborty, P.; Bhushan, S.; Nayak, B.B. Impact of COVID-19 Lockdown on Aquatic Environment and Fishing Community: Boon or Bane? *Mar. Policy* **2022**, *141*, 105088. [[CrossRef](#)]
30. Nielsen, R.; Villasante, S.; Polanco, J.M.F.; Guillen, J.; Llorente Garcia, I.; Asche, F. The Covid-19 Impacts on the European Union Aquaculture Sector. *Mar. Policy* **2023**, *147*, 105361. [[CrossRef](#)]
31. Kobayashi, M. The COVID-19 Impacts and Challenges to Achieving Sustainability in Japan's Fisheries and Aquaculture. *Mar. Policy* **2022**, *143*, 105161. [[CrossRef](#)]
32. Mangano, M.C.; Berlino, M.; Corbari, L.; Milisenda, G.; Lucchese, M.; Terzo, S.; Bosch-Belmar, M.; Azaza, M.S.; Babarro, J.M.F.; Bakiu, R.; et al. The Aquaculture Supply Chain in the Time of Covid-19 Pandemic: Vulnerability, Resilience, Solutions and Priorities at the Global Scale. *Environ. Sci. Policy* **2022**, *127*, 98–110. [[CrossRef](#)]
33. FAO. *The Impact of COVID-19 on Fisheries and Aquaculture Food Systems, Possible Responses*; FAO—Food and Agriculture Organization of the United Nations: Rome, Italy, 2021; ISBN 978-92-5-133768-4.
34. Alam, G.M.M.; Alam, K.; Mushtaq, S.; Sarker, M.N.I.; Hossain, M. Hazards, Food Insecurity and Human Displacement in Rural Riverine Bangladesh: Implications for Policy. *Int. J. Disaster Risk Reduct.* **2020**, *43*, 101364. [[CrossRef](#)]
35. Alam, G.M.M.; Khatun, M.N. Impact of COVID-19 on Vegetable Supply Chain and Food Security: Empirical Evidence from Bangladesh. *PLoS ONE* **2021**, *16*, e0248120. [[CrossRef](#)]
36. Haque, M.K.; Zaman, M.R.U.; Rahman, M.A.; Hossain, M.Y.; Shurid, T.I.; Rimi, T.A.; Arby, H.; Rabbany, M.G. A Review on Impacts of COVID-19 on Global Agricultural System and Scope for Bangladesh after Pandemic. *Environ. Sci. Pollut. Res.* **2022**, *29*, 54060–54071. [[CrossRef](#)]
37. Rahman, M.S.; Majumder, M.K.; Sujan, M.H.K.; Manjira, S. Livelihood Status of Coastal Shrimp Farmers in Bangladesh: Comparison before and during COVID-19. *Aquac. Reports* **2021**, *21*, 100895. [[CrossRef](#)]
38. Macusi, E.D.; Siblos, S.K.V.; Betancourt, M.E.; Macusi, E.S.; Calderon, M.N.; Bersaldo, M.J.I.; Dugal, L.N. Impacts of COVID-19 on the Catch of Small-Scale Fishers and Their Families Due to Restriction Policies in Davao Gulf, Philippines. *Front. Mar. Sci.* **2022**, *8*, 770543. [[CrossRef](#)]
39. Mandal, S.C.; Boidya, P.; Haque, M.I.M.; Hossain, A.; Shams, Z.; Mamun, A. Al The Impact of the COVID-19 Pandemic on Fish Consumption and Household Food Security in Dhaka City, Bangladesh. *Glob. Food Sec.* **2021**, *29*, 100526. [[CrossRef](#)]
40. Rejeb, A.; Rejeb, K.; Appolloni, A.; Iranmanesh, M.; Treiblmaier, H.; Jagtap, S. Exploring Food Supply Chain Trends in the COVID-19 Era: A Bibliometric Review. *Sustainability* **2022**, *14*, 12437. [[CrossRef](#)]

41. Love, D.C.; Allison, E.H.; Asche, F.; Belton, B.; Cottrell, R.S.; Froehlich, H.E.; Gephart, J.A.; Hicks, C.C.; Little, D.C.; Nussbaumer, E.M.; et al. Emerging COVID-19 Impacts, Responses, and Lessons for Building Resilience in the Seafood System. *Glob. Food Sec.* **2021**, *28*, 100494. [[CrossRef](#)]
42. Hossain, M.T.; Lima, T.R.; Ela, M.Z.; Khan, L.; Ahmed, F.; Shovo, T.E.A.; Al Masud, A.; Rahman, K.S.; Jahan, N.; Rahman, S.M.; et al. Livelihood Challenges and Healthcare-Seeking Behavior of Fishermen amidst the COVID-19 Pandemic in the Sundarbans Mangrove Forest of Bangladesh. *Aquaculture* **2021**, *546*, 737348. [[CrossRef](#)]
43. Kusumanti, I.; Oyinlola, M.A.; Nanda, M.; Pangestu Putu Hamka, M. Aquaculture and Its Impact of The COVID-19 Pandemic on The Fish Processing Industry: Case Study from Local Community. *E3S Web Conf.* **2022**, *348*, 00022. [[CrossRef](#)]
44. Chang, Y.C.; Zhang, X.; Khan, M.I. The Impact of the COVID-19 on China's Fisheries Sector and Its Countermeasures. *Ocean Coast. Manag.* **2022**, *216*, 105975. [[CrossRef](#)] [[PubMed](#)]
45. Mirto, S.; Montalto, V.; Mangano, M.C.M.; Ape, F.; Berlino, M.; La Marca, C.; Lucchese, M.; Maricchiolo, G.; Martinez, M.; Rinaldi, A.; et al. The Stakeholder's Perception of Socio-Economic Impacts Generated by COVID-19 Pandemic within the Italian Aquaculture Systems. *Aquaculture* **2022**, *553*, 738127. [[CrossRef](#)]
46. Sunny, A.R.; Mithun, M.H.; Prodhan, S.H.; Ashrafuzzaman, M.; Rahman, S.M.A.; Billah, M.M.; Hussain, M.; Ahmed, K.J.; Sazzad, S.A.; Alam, M.T.; et al. Fisheries in the Context of Attaining Sustainable Development Goals (SDGs) in Bangladesh: COVID-19 Impacts and Future Prospects. *Sustainability* **2021**, *13*, 9912. [[CrossRef](#)]
47. Bennett, A.; Basurto, X.; Virdin, J.; Lin, X.; Betances, S.J.; Smith, M.D.; Allison, E.H.; Best, B.A.; Brownell, K.D.; Campbell, L.M.; et al. Recognize Fish as Food in Policy Discourse and Development Funding. *Ambio* **2021**, *50*, 981–989. [[CrossRef](#)]
48. Talukder, B.; VanLoon, G.W.; Hipel, K.W.; Orbinski, J. COVID-19's Implications on Agri-Food Systems and Human Health in Bangladesh. *Curr. Res. Environ. Sustain.* **2021**, *3*, 100033. [[CrossRef](#)] [[PubMed](#)]
49. Ruiz-Salmón, I.; Fernández-Ríos, A.; Campos, C.; Laso, J.; Margallo, M.; Aldaco, R. The Fishing and Seafood Sector in the Time of COVID-19: Considerations for Local and Global Opportunities and Responses. *Curr. Opin. Environ. Sci. Health* **2021**, *23*, 100286. [[CrossRef](#)]
50. Hasan, N.A.; Heal, R.D.; Bashar, A.; Bablee, A.L.; Haque, M.M. Impacts of COVID-19 on the Finfish Aquaculture Industry of Bangladesh: A Case Study. *Mar. Policy* **2021**, *130*, 104577. [[CrossRef](#)]
51. Bartlett, J.E., II; Kotrlik, J.W.; Higgins, C.C. Determining Appropriate Sample Size in Survey Research. *Inf. Technol. Learn. Perform. J.* **2001**, *19*, 43–50.
52. Amjath-Babu, T.S.; Krupnik, T.J.; Thilsted, S.H.; McDonald, A.J. Key Indicators for Monitoring Food System Disruptions Caused by the COVID-19 Pandemic: Insights from Bangladesh towards Effective Response. *Food Secur.* **2020**, *12*, 761–768. [[CrossRef](#)]
53. Khan, A.U.; Ema, I.J.; Afsana, A.S.; Khan, A.U.; Faruk, R.; Rahman, S. Effects of Coronavirus Disease (COVID-19) on Agricultural Sectors in Bangladesh: A Review. *Int. J. Asian Contemp. Res.* **2020**, *1*, 89–97.
54. Ragasa, C.; Agyakwah, S.K.; Asmah, R.; Mensah, E.T.D.; Amewu, S.; Oyih, M. Accelerating Pond Aquaculture Development and Resilience beyond COVID: Ensuring Food and Jobs in Ghana. *Aquaculture* **2022**, *547*, 737476. [[CrossRef](#)]
55. Belton, B.; Rosen, L.; Middleton, L.; Ghazali, S.; Mamun, A.A.; Shieh, J.; Noronha, H.S.; Dhar, G.; Ilyas, M.; Price, C.; et al. COVID-19 Impacts and Adaptations in Asia and Africa's Aquatic Food Value Chains. *Mar. Policy* **2021**, *129*, 104523. [[CrossRef](#)]
56. Fernández-González, R.; Pérez-Pérez, M.I.; Pérez-Vas, R. Impact of the COVID-19 Crisis: Analysis of the Fishing and Shellfishing Sectors Performance in Galicia (Spain). *Mar. Pollut. Bull.* **2021**, *169*, 112463. [[CrossRef](#)]
57. Webb, C. Giving Everyone a Fish: COVID-19 and the New Politics of Distribution. *Anthropologica* **2021**, *63*, 1–16. [[CrossRef](#)]
58. Campbell, S.; Jakub, R.; Valdivia, A.; Setiawan, H.; Setiawan, A.; Cox, C.; Kiyoo, A.; Djafar, L.; de la Rosa, E.; Suherfian, W.; et al. Impact of COVID-19 on Small-Scale Coastal Fisheries of Southeast Sulawesi, Indonesia. *Researchsquare* **2020**, *1*, 39895. [[CrossRef](#)]
59. Chiwaula, L.S.; Chirwa, G.C.; Simbeye, J.; Katundu, M. Household Resilience among Fish Value Chain Actors during the COVID-19 Pandemic in Malawi. *World Dev. Perspect.* **2022**, *26*, 100411. [[CrossRef](#)]
60. Mamun, A.A.; Shieh, J.; Belton, B. *Qualitative Assessment of COVID-19 Impacts on Aquatic Food Value Chains in Bangladesh*; Program Report; CGIAR Research Program on Fish Agri-Food Systems: Penang, Malaysia, 2020.

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.