From production to market: Uncovering the complexities of COVID-19's impact on fisheries and aquaculture

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Abstract

The emergence of COVID-19 pandemic and associated measures created widespread socio-economic disruptions globally. This review paper thoroughly scans the multifaceted challenges withstood by the fisheries and aquaculture industry during the pandemic. At the production level, fish farms faced troubles in collecting and selling products that affect live fish stock levels, culture duration and ultimately overall profitability. Problematic situations in acquiring essential fishing inputs, coupled with elevating feeding expenses, unavailability of credits created further obstacles. Thus fishing communities encountered adverse economic consequences with lower fishing operations, loss of jobs and disturbance in livelihood maintenance. Fisherwomen, key part of the industry, saw a downfall in catches, impacting their supplemental income. The pandemic's repercussions extended beyond economic aspects, affecting food security, nutrition, education and mental well-being within those fishing families. The aquatic food distribution chain encountered challenges globally from reduced demand, closure of markets and transportation bottlenecks. Local, regional and global perspectives highlight the interconnected challenges faced by the industry leading to stockpiling, increased expenses, and elevated risks. The paper ended by pointing out the urgency of targeted interventions, collaborative efforts and innovative approaches to rebuild and enhance resilience in the post-pandemic era. Addressing access to credit, insurance programs, and gender-specific impacts is crucial for the industry's recovery and future sustainability.

Keywords: COVID-19, Fisheries, Aquaculture, Pandemic

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Introduction

The COVID-19 pandemic, since its first emergence in December 2019, created an unparalleled crisis that was culprit behind the change in shape of the world's social, economic and public health landscapes (WHO, 2020). Because its high infectivity, carriers without notable symptoms, lower level of clinical symptoms, lack of pre-existing human immunity and uncertain incubation period, the World Health Organization (WHO) declared COVID-19 as "Public Health Emergency of International Concern (PHEIC)" in January 2020 (Bouey, 2020; WHO, 2020). In response to the pandemic's threats on human being, various strategies were recommended and adapted including lockdowns, mass quarantines, confinement measures, social distancing protocols, strict border controls, reduced air traffic and disruptions to transportation systems. These unwanted situations unleashed a cascade of complex and interrelated impacts on the socio-economic conditions in several countries (Dente and Hashimoto, 2020). While the disease and associated measures left no sector of the global economy untouched, the fisheries and aquaculture industry emerged as a one of the vulnerable sector (FAO, 2021). Particularly developing nations, often characterized by scarcity in resources, expertise and technology faced profound challenges in managing and mitigating the pandemic's effects (Dente and Hashimoto, 2020). This vulnerable situation was primarily attributed to the perishable nature of fish products, but a vital source of nutrition, protein, fatty acids, and micronutrients for many communities (FAO, 2020a). The worsen scenario risen due to COVID-19 were multifaceted, affecting not only the demand and prices of fish products but also depleting the role of fisheries and aquaculture sector as employment generator (FAO, 2020a; Bhendarkar *et al.*, 2023b). Domestic and international trade in fish products severely hindered, and the supply chain was compromised (FAO, 2020b; Fiorella *et al.*, 2021: Bhendarkar *et al.*, 2023b). Because the hospitality sectors like restaurant and catering sector, representative of substantial portion of fish consumption in many countries, triggered a significant decline in demand due to the closure of restaurants and the cancellation of public and private events (Lombrana, 2020; Khan *et al.*, 2023). In addition to the cessation of fish markets, trade barriers due to border closures and the diminished availability and escalated expenses of air transportation due to the cessation of passenger flights, collectively contributed to the challenges faced by the fisheries and aquaculture industry (Oyenuga, 2021). The primary objective of this review paper is to comprehensively explore and analyze the multifaceted challenges presented by the COVID-19 pandemic and to evaluate their potential ramifications on various facets of the fisheries and aquaculture sector, including supply chains, market access, and environmental sustainability.

Impacts of COVID-19 on fisheries and aquaculture

The COVID-19 outbreak resulted in a variety of problematic situations for the fisheries and aquaculture sector. For example, Freshwater aquaculture faced elevated costs and difficulties in sourcing seed stock for continuation of culture cycle (Alam *et al.,* 2022). Beside there were far-reaching complicated effect on stakeholders at every steps of aquaculture production, including fishermen, farmers, auctioneers and traders. At the industry level, aquaculture faced the need to reduce processed food production due to increased raw material costs, limited sales and constrained international trade due to movement restrictions (Alam *et al.,* 2022). Labour availability further disrupted fish production and distribution because fisheries-related activities in developing nations are highly dependent on labour, predominantly through the engagement of hired workers and self-employment (Hossain *et al.,* 2022). These unwanted, suddenly arise situations limited access to livelihood capital, increased complexity in maintaining a livelihood and elevated food and nutritional insecurity (Workie *et al.*, 2020; Mandal *et al.,* 2021; Simmance *et al.,* 2022).

Global Perspectives at production level of the Pandemic's Effect on aquaculture

The COVID-19 pandemic induced a series of difficulties for fish farms in collecting and selling their products (FAO, 2020a). This resulted in a negative impact on live fish stock levels, resulting extended fish culture timeline and adverse effects on feed conversion ratios, restocking and overall profitability (Alam *et al.,* 2022). Additionally, farmers faced issues like the availability of essential inputs such as seed stock, feed, labour, medicine and chemicals on one hand. Escalating feeding expenses and increased risk of fish mortality as consequence created further obstacles on other hand (Yuan *et al.,* 2022). For instance Bangladesh, because of its heavy dependency on foreign sources for the supply of feed ingredients, led to severe consequences during the pandemic when import restrictions were enforced (Khan *et al.,* 2023). Fish farmers in Bangladesh faced difficulties as it was both time-consuming and expensive to individually procure feed ingredients from local markets, mainly due to restricted market hours and limited transportation options (Khan *et al.,* 2023). Beside, various border restrictions and airport clearing globally made it difficult for hatchery operators and broodstock traders to import or export broodstock for seed production, leading to potential sharp declines in production (FAO, 2020b). Thus Farmers unable to initiate new farming cycles, forcing them to sell their marketable sized products at lower prices ((FAO, 2020a; Sunny *et al.,* 2021). But the impact of the pandemic was not uniform across the fisheries industry. In China, for instance, Channel catfish farmers and traders withstood more severe consequences compared to tilapia farmers. Because delayed harvesting

resulted in fish stocks being held up in ponds, leading to prolonged farming cycles and irregular feeding. International market and demand for processed channel catfish was also more severely affected than domestic markets (Yuan *et al.,* 2022). Some cultivated species in farms for export, such as pangasius, reported significant impacts due to the closure of international markets in China and the European Union (Alam *et al.,* 2022). Shellfish aquaculture also, including oysters faced challenges primarily due to the closure of food services related to tourism, hotels and restaurants, as well as foreign export in the European Union (FAO, 2020b). Fish farmers, grappling with market disruptions, were compelled to stockpile large quantities of live fish due to the inability to sell their produce. This stockpiling resulted in increased expenses, heightened expenditures, and elevated risks for the fisheries sector (Yuan *et al.,* 2022). In India, particularly, challenges were magnified as the peak months for stocking of seeds in ponds by farmers began in April. Closed state borders during lockdown and uncertainty surrounding normal functioning hindered the transportation of fish seed from West Bengal (a state of India) to other parts of India (Bhendarkar *et al.,* 2023b). The government's "Kisan Rath" mobile app aimed at facilitating transportation during lockdowns only partially alleviated the negative impact on transportation facilities (The Hindu, 2020).

Fish farming businesses experienced severe damage even before reaching the marketing stage of harvest. Assam, one of the leading states in fish production in India, a total of INR 185 crore worth of fish sold before emergence of pandemic, providing essential protein to the masses and contributing to the economic growth of fish farmers (Zaman, 2020). However, in 2020, the pandemic has impacted activities in hatcheries and feed manufacturers to some extent because few hatcheries operated in February and only a small percentage (7%) opened in March. Farmgate prices of fish remained relatively stable from February to June 2020, hovering around INR 240/kg, with a slight dip to INR 220/kg in May 2020 when sales were highest (Shieh *et al.,* 2021). Although some hatcheries in West Bengal completed summer breeding of Pangasius, only 10-15% of seed could be stocked before the lockdown (Seshagiri *et al.,* 2020). Few hatcheries that performing breeding of Indian Major Carps had no buyers for fish seed due to the lockdown (Ghosal, 2020). According to the All India Shrimp Hatcheries Association, large numbers of seeds were destroyed during the lockdown, resulting in an estimated loss of 15,000 broodstock and 3.5 billion seeds due to their limited lifespan of only 2–3 days (Krishnakumar, 2020). During the time span of the lockdown, it was observed that the seed quality of shrimp experienced adverse effects. Inadequate monitoring and maintenance of ponds, leading to the occurrence of microbial contamination such as white spot disease

and infection caused by pathogenic Vibrio species was the primary reasons for that situation. The ornamental fish industry, worth US$ 1.06 million and contributing 0.3% of total exports in 2016, faced substantial challenges. Major consumer cities like Mumbai, Chennai, Delhi, and Bengaluru, being under total shutdown, severely impacted the ornamental fish industry due to a lack of demand (Bhendarkar *et al.,* 2023b). Live food, a crucial component in the ornamental fish retail industry, faced disruptions in supply chains and demand, forcing the industry to adjust production rates for profitability (Sharma, 2020).

Consequences of COVID-19 on fishing communities

Spread of COVID-19 and associated implemented measures, imposed significant challenges on fisheries resulting in far-reaching consequences with profound economic implications (Islam *et al.,* 2021). In response to the wide spreading pandemic, several countries restricted mobility that included a ban on fisheries operations (Bennett *et al.,* 2020). As a consequence demand for fish and related market disruption around world lead to a sharp decline in fish prices, rendering it increasingly difficult for fishing families to maintain their daily livelihoods (Bennett *et al.,* 2020; Sunny *et al.,* 2021; Hidayati *et al.,* 2021). Many workers employed in the harvesting, processing, marketing of aquatic products lost their jobs, resulting in a cessation of income, especially in developing nations (Bennett *et al.,* 2020; Sunny *et al.,* 2021).

Beside the livelihoods of fisherwomen, integral part of fishing industry from the jetty to buyers' tables, have been significantly affected by a decline in catches and reduced market demand due to lockdown restrictions as well. This has led to fewer wage days for fisherwomen communities, impacting the supplemental income crucial for supporting their families. As a result, the sudden lockdown was pushing fishers' community to explore alternative remunerative work opportunities, further jeopardizing the livelihood security and well-being (Bhendarkar *et al.,* 2017a).

In addition, accessing the necessary funds for their fishing activities becomes a formidable challenge for many poor fishermen. They faced difficulty of obtaining bank loans, primarily because they lack the required collateral (Nazir *et al.,* 2018). For those with limited education and market knowledge, relying on middlemen became the primary option not only for securing loans for fishing operations (Tháy *et al.,* 2019; Jomitol *et al.,* 2020) but also for selling their catch (Ruddle, 2011). Middlemen in return also played crucial roles in transporting, processing, and selling the fish in markets (Crona *et al.,* 2010; Arya *et al.,* 2015). These fishermen often entered exclusive agreements with middlemen in exchange for the financial support they provided (Surtida, 2000). Nevertheless, this informal credit system was fraught with problems, including high interest rates and exploitative terms for selling and

pricing fish during the pandemic time. Furthermore, the travel restrictions due to COVID-19 pandemic disrupted the fish market supply chain, leading to a scarcity of loans for fishermen (Ruddle, 2011; Asante *et al.,* 2021). These challenges made it extremely challenging for fishermen to sustain their fishing activities during the pandemic. Despite the adverse circumstances, many fishermen persisted in fishing daily as they had limited alternative means of earning a living (Avtar *et al.,* 2021). Thus the close-knit and migratory nature of fishing communities made fishermen vulnerable to the rapid spread of COVID-19, further intensifying their health concerns (FAO, 2020a).

The consequences of the pandemic reached far beyond the economic sphere, affecting the very core of fishing families (Macusi *et al.,* 2022). The struggles of fishers directly translated into food insecurity and, in some cases, malnutrition, as food supply chains were disrupted, and essential goods' prices surged d (FAO, 2021). As a result of the restrictions placed on their primary source of income, which is fishing, many families urged of food assistance from local governments to make ends meet (Mukhtar, 2020). Furthermore, the closure of educational institutions and the sudden shift to online education posed a significant hurdle for families with limited educational attainment, making it difficult to ensure their children received a proper education (Chaturvedi *et al.,* 2021). Limited financial resources compounded this issue, as many fisher families lacked access to digital resources and internet connectivity (Lee, 2020). The COVID-19 pandemic also felt deep issues on the mental and emotional well-being of fishing communities, as they faced the challenging task of providing for their families while worrying about their health (Macusi *et al.,* 2022). The pandemic introduced restrictions like social distancing, quarantine, isolation, and uncertainties in income and future concern of fishers and their families, resulting in negative emotional states such as sadness, worry, fear, anger, frustration, and loneliness (Auriemma and Iannaccone, 2020; Mamun *et al.,* 2020; Bhuiyan *et al.,* 2021).

Challenges across the aquatic food supply chain: Local, regional and global perspectives

The global supply chain for fish and fish products, crucial for transporting from suppliers to end consumers, has been extensively grappled with a web of challenges induced by the COVID-19 pandemic (Yuan *et al.,* 2022). During early stages, rumours circulated linking between meat consumption, including fish and spread of COVID-19 infection. This misinformation compounded with lockdown protocols and economic uncertainties triggered enough decline in demand, especially for fish considered delicacies in restaurants (Cariappa *et al.,* 2021). Transportation challenges further disrupted the supply chain, with labour shortages and drivers hesitant to deliver fish, fingerlings, feed and other supplies such as gear, ice, and bait during

lockdown (Chanrachkij *et al.,* 2020; Waiho *et al.,* 2020; Islam *et al.,* 2021; Sunny *et al.,* 2021; Yuan *et al.,* 2022). This, impacted global, regional, and local markets within the aquatic food supply chain, causing empty fish landing centers, wholesale markets and retail markets (Hasan *et al.,* 2021; Mangubhai *et al.,* 2021; Manlosa *et al.,* 2021). As consequence, fishers in poverty-prone regions faced low fish prices and income, exacerbated by the perishable nature of fish and limited storage facilities (Fahlevi *et al.,* 2021; Alam *et al.,* 2022). Establishing cold storage facilities in fishing-oriented areas could improve the drastic situations, but lack of available infrastructures reduced the possibilty (Fahlevi *et al.,* 2021).

In India, The freshwater aquaculture sector in states like Andhra Pradesh and West Bengal, faced the brunt of this supply chain disturbance (Bureau, 2020). Despite having readily marketable fish stocks, lack of transportation facilities were prevent them from reaching the market. Typically, an average of 2,000 tonnes of fish was distributed daily from Andhra Pradesh, India's highest inland fish-producing state. However, during the lockdown period, the transported fish quantity reduced to only 250 to 300 tonnes daily, accounting for only 15.2% of the usual fish transport from Andhra Pradesh (Seshagiri *et al.,* 2020). Movement restrictions and closure of retail marketplaces caused a sharp decline in fish prices by 15-20% (Sally, 2020). A study conducted in Assam, a state of india, the volume of fish sold experienced a significant decrease from February to March of 2020, irrespective of the origin. Both farmed fish and freshwater capture fish sales witnessed a decline of approximately 43%, while shrimp and marine capture fish sales dropped by 20% and 25%, respectively. During the same period, the average prices of farmed fish and freshwater capture fish both saw a reduction of around 10%, decreasing from INR 170/kg to INR 148/kg and from INR 178/kg to INR 160/kg, respectively. Rohu was particularly affected, experiencing a 40% price decrease from INR 174/kg to INR 104/kg. The decline in both sales volume and prices resulted in a roughly 50% decrease in traders' gross income from farmed and freshwater fish in March, with income from rohu plummeting by 84% (Shieh *et al.,* 2021). In Kerala, India, the Central Institute of Fisheries Technology (CIFT) estimates that fishermen lost about Rs. 130 crore, with many stranded at sea on trawlers (The HinduBusinessLine, 2020a). According to CIFT, about 22,000 crafts on the Kerala coast stopped fish catching, resulting in a significant daily loss of Rs 224 crore in the deep-sea marine fishery sector, with a monthly loss estimated at about Rs. 6,838 crore, except counting losses in fish processing and exports (The HinduBusinessLine, 2020b).

The fisheries and aquaculture sector heavily relies on the food service industry, which itself has been severely impacted by lockdowns. Closure of restaurants, hotels, and canteens has resulted in reduced activity for fish

wholesalers (Zabir *et al.,* 2020). Logistical challenges, including transportation bottlenecks and delays, have made raw materials for frozen, pre-packed, and canned fish and fish products unavailable. This has led to losses, quality changes, and increased costs for exporters, processors, merchants, and importers (Fiorella *et al.,* 2021). Due to limited income and a shortage of capital, numerous fish processing plants have faced temporary or permanent closures. Additionally, the demands of workers for improved health and safety conditions have contributed to disruptions in processing activities (Khan *et al.,* 2023). Similar to the situation in Bangladesh, many countries have witnessed the closure or downsizing of fish processing plants due to the spread of COVID-19 among workers (Xuemin, 2020). Consequently, there has been a decline in processing capacity and production, posing economic challenges and jeopardizing food security for processors (Khan *et al.,* 2023).

These challenges were almost same globally, affecting everyone in the fisheries sector, from fishers and farmers to different players in the aquatic food supply chain. The fisheries industry in countries, such as Turkey and Indonesia, experienced significant drop in trade volume, active fishers and fish dealers during pandemic . Costa Rica, heavily dependent on exports, saw drastic reductions in production, processing, prices and exports (Can *et al.,* 2020; Wiradana *et al.,* 2021). The United States, a major market for Costa Rican seafood, experienced waves of COVID-19, closing fish imports for most of 2020. The pandemic, coinciding with the Chinese New Year, resulted in a reduced demand for luxury seafood, causing market disruptions for Canadian and American lobsters, Australian crayfish, Vietnamese shrimp, and various other fisheries (Dao, 2020; Johnson, 2020; Taunton and Cropp, 2020; Tester, 2020). The salmon fish industry faced significant challenges, particularly with substantial air freight costs and numerous flight cancellations (Minahal *et al.,* 2020). These developments served as early indicators of profound and life-altering changes that were imminent in coastal fishing communities worldwide. As a result, several fishing enterprises ceased activities in 2020 as a result of perceived lack of profitability or economic impracticality (Marschke *et al.,* 2021).

Discussion

To counter the pandemic, several imposed restrictions on mobility, including lockdowns, mass quarantines and social distancing protocol, created a profound and multifaceted impact on the fisheries and aquaculture industry. From hatcheries facing difficulties in seed marketing to the disruption of fish markets and trade barriers, each aspect of the fisheries and aquaculture sector encountered obstacles. Shut down in hospitality sectors, a well-known consumer base of fish products was responsible for decline in demand, affecting both prices and income for those involved in the industry.

Fishing communities, especially those heavily dependent on inland capture fisheries; most affected by the economic consequences of the pandemic. Loss of jobs, income and restricted market access left many fishermen and fisherwomen facing food insecurity, financial distress and other lots of challenges that extend beyond economic concerns. The struggles of fish farmers, too, were evident in the disruptions to the supply of essential inputs, challenges in marketing and the prolonged impact on profitability.

The consequences of the pandemic extended to the global aquatic food supply chain, affecting everyone from fishers and farmers to processors and exporters. The disruptions in transportation, labour shortages, and changes in consumer demands created a decline in trade volume and economic activities within the industry. Even ornamental fish retail and the live food segment had not been immune to these challenges.

Analyzing these challenges, there is urgent need for immediate and targeted interventions. Ensuring the availability of Safeguard transportation, supporting alternative avenues for marketing and providing financial supports to impacted stakeholders are crucial steps. Ensuring the resilience of the supply chain, from seed production to market access, requires collaborative efforts and innovative solutions. Widening access to credit, implementing insurance programs, and addressing gender-specific impacts are essential considerations for the industry's recovery and future resilience.

In the post-pandemic period, it is important for the fisheries and aquaculture industry to harmonize with emerging conditions, adopt sustainable methodologies and build resilience against future disturbances. The comprehensive analysis presented in this review tries to shed light on the difficulties brought about by the COVID-19 outbreak and provides a foundation for formulating approaches to navigate and revitalize the sector during unparalleled worldwide disruptions.

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