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Impacts of COVID-19 on fish value chains in India

Descriptive Evidence from Andhra Pradesh

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About WorldFish
WorldFish is a nonprofit research and innovation institution that creates, advances and translates scientific research on aquatic food systems into scalable solutions with transformational impact on human well-being and the environment. Our research data, evidence and insights shape better practices, policies and investment decisions for sustainable development in low- and middle-income countries.

We have a global presence across 20 countries in Asia, Africa and the Pacific with 460 staff of 30 nationalities deployed where the greatest sustainable development challenges can be addressed through holistic aquatic food systems solutions.

Our research and innovation work spans climate change, food security and nutrition, sustainable fisheries and aquaculture, the blue economy and ocean governance, One Health, genetics and AgriTech, and it integrates evidence and perspectives on gender, youth and social inclusion. Our approach empowers people for change over the long term: research excellence and engagement with national and international partners are at the heart of our efforts to set new agendas, build capacities and support better decision-making on the critical issues of our times.

WorldFish is part of One CGIAR, the world's largest agricultural innovation network.

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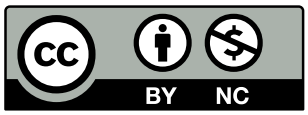

Photo credits
Front cover, Eliya Elika, Seafood Solutions: A dried fish business relocated from a coastal weekly fish market to an inland urban area to reach consumers during the COVID-19 pandemic, Vijaywada, Andhra Pradesh

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CGIAR RESEARCH PROGRAM ON Policies, Institutions and Markets

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1. Executive summary

The COVID-19 pandemic which started at the beginning of 2020 has affected economies of many countries, including India, where the government implemented containment measures such as lockdown regulations and curfews to curb the spread of the pandemic. Understanding the impacts of the COVID-19 pandemic on fish value chains is therefore important to inform policy, and the policy responses chosen by the government have important implications for food and nutrition security, employment, and poverty.

This study aimed at assessing the impacts of the COVID-19 pandemic on fish value chains in India, over two periods between 2019 and 2020 and 2020 to 2021. The specific objectives were to assess the impacts of COVID-19 pandemic on: 1) access by fish value chain actors to inputs for fish production, processing and marketing; 2) fish production and sales; 3) access to markets by value chain actors including impacts on sales, prices and competition; and 4) the welfare of fish value chain actors.

Primary data was collected through a survey of 326 value chain actors conducted in December 2020 in six districts of the Indian state of Andhra Pradesh. In the second round, data was collected from 513 value chain actors in November 2021. The actors surveyed were aquaculture producers, fish processors (mainly involved in drying fish from capture fisheries), and fish traders (trading a mix of farmed and capture fish). The sampling strategy for the value chain actors combined convenience and snowball sampling. Many of the respondents in the first round were also respondents in the second round; however, the second round also included new respondents. Data was collected using computer-assisted telephone interviews, in order to minimize the risk of spreading COVID-19. The objectives of the study are answered through a descriptive statistical analysis.

The COVID-19 pandemic did not have a significant effect on access by fish value chain actors to inputs such as labor, credit, fish feeds and other farming inputs, and processing or marketing inputs. However, the pandemic had a significant negative impact on volumes of fish production and trade in both rounds. Furthermore, it had a significant negative effect on access to output markets, impacting sales volumes, prices, and competition. While trading and processing seemed to rebound slightly in 2021, continued issues in farmers' production may cause long-term supply chain issues. Despite these negative effects, value chain actors, particularly processors, showed some indication of resiliency and adaptation to the conditions of the pandemic in 2021. The pandemic also had a significant negative effect on the welfare and food security of fish value chain actors in both rounds. Farmers' food security was less affected, suggesting the importance of homestead production for household food security.

The study recommends that policy makers develop strategies to mitigate the disruptions and negative outcomes of the COVID-19 pandemic on fish value chain actors and their households, as follows. First, by investing in more data collection and research, to better understand the ongoing short-term and long-term impacts of COVID-19 on fish and other value chains, the adaptation processes in different regions, and what policy response mechanisms to adopt. Second, by promoting and developing programs to boost the fish value chain as it is an important source of livelihoods, employment, income and nutrition security. Third, by developing gender-responsivepolicies and programs which could help mitigate the negative impacts of the pandemic on household welfare. Last, to further mitigate the negative impacts on welfare, scaling up financial aid and subsidized credit by

government and private groups could support value chain actors who have lost out due to the COVID-19 pandemic, particularly farmers and smallholders, to increase competition in markets.

2. Introduction

Fish and other aquatic foods provide 3.3 billion people with 20% of their average per capita dietary animal protein intake (FAO, 2020). India ranks fourth globally in capture fisheries production and second in farmed fish production (FAO, 2020). Since the beginning of the year 2020, the COVID-19 pandemic has affected economies of both developing and developed countries on both the demand and supply side. Efforts to respond to COVID-19 in India has resulted in the government implementing measures including imposing lockdowns and curfews. Understanding the impacts of COVID-19 on India's fish value chains is important for at least two main reasons. First, 92% of the food consumed in the country is purchased and nearly 80% of food supply is perishable and requires continuous replenishing (Reardon et al., 2020). Second, 60% of all food supply chain activities are post-farm gate involving firms and workers in the midstream wholesale, processing, and logistics segments, and downstream in retail and food service (Reardon et al., 2020). These characteristics suggest that COVID-19 and the policy responses chosen by the government have important implications for food and nutrition security, employment, and poverty.

There are several ongoing efforts across the CGIAR to assess the impacts of COVID-19 on food value chains. WorldFish is primarily focusing on impacts of COVID-19 on aquatic foods systems, and is presently implementing surveys of COVID-19 impacts in several African and Asian countries, including India to track change in prices and availability of fish and fish production inputs across value chains. Preliminary results from the surveys have shown that employment fell, ability to access transport for inputs and fish reduced, and consumers' effective demand for fish decreased in 2020 (Middleton et al., 2020; Sheh et al., 2020).

There are new studies on emerging COVID-19 impacts, responses, and lessons for building resilience in the seafood system (Love et al., 2021) and the impacts of COVID-19 on aquatic value chains and policy responses (Belton et al., 2021). However, it is increasingly recognized that the impacts of the COVID-19 pandemic and the response measures on food value chains are complex, heterogeneous and dynamic, which necessitates regular assessments of the impacts (Amjath-Babu et al., 2020). Furthermore, studies on impacts of COVID-19 are often based on small samples raising questions about their external validity.

The current study's objectives are to assess the impacts of COVID-19 on: 1) access by value chain actors to inputs for production, processing, packaging, or marketing of fish; 2) fish production and trade; 3) access to markets by value chain actors including impacts on sales, prices and competition; 4) the welfare of fish value chain actors. The study complements ongoing data collection efforts by increasing sample coverage, including more detailed survey modules, and considering impacts on competition.

This report documents results from the first phase of the project, "Effects of COVID-19 on fish value chains: Descriptive evidence from India". The project is implemented under the CGIAR Research Program on Fish Agri-food Systems (FISH) and funded by the CGIAR Research Program on Policies, Institutions, and Markets (PIM). It contributes to PIM's inclusive value chain flagship priority on increased value capture by producers and increased livelihood opportunities through value chains innovations. It also contributes to the priority on reduced market barriers.

3. Methods

3.1 Description of the study area

The study was conducted in the state of Andhra Pradesh (Figure 1a), which is located in the southeastern part of India. Andhra Pradesh is mainly an agricultural state with three main physiographic regions: the coastal plain to the east, extending from the Bay of Bengal to the mountain ranges; the Eastern Ghats, which form the western flank of the coastal plain; and, in the southwest, the plateau to the west of the Ghats (Wanmali et al., 2021). The coastal plain, also known as the Andhra region, runs almost the entire length of the state and is watered by several rivers, flowing from west to east through the hills into the bay. The deltas formed by the most important of those rivers (the Godavari and the Krishna) make up the central part of the plains, an area of fertile alluvial soil.

Agriculture is dominated by aquaculture, capture fisheries, crop and livestock production. With its long coastline and many rivers, the state has a significant and expanding fishing industry. The state's rivers (Godavari, Krishna, and Penneru) are important for fishing and irrigation, and therefore contribute to the state's agricultural importance. Much of the yield is drawn from freshwater and coastal aquaculture, and open-sea fisheries, with shrimp and carp as the main farmed aquatic products. The main crops cultivated are food grains (rice and maize), pulses (peas, beans, and lentils), peanuts (groundnuts) and cash crops (tobacco, cotton and sugarcane). Livestock kept include cattle, water buffalo, sheep, goats, pigs, and poultry.

Nearly one-third of the population in Andhra Pradesh lives in urban areas. Of the urban dwellers, about half live in the state's 10 most-populous urban areas, notably the industrial and manufacturing regions around Visakhapatnam and Vijayawada in the northeast. Other large cities in Andhra Pradesh include Guntur, Kurnool, and Rajahmundry. In this study, the specific locations in the state of Andhra Pradesh covered by the survey are the districts of East Godavari, Guntur, Krishna, Nellore, Prakasam and West Godavari (Figure 1b).

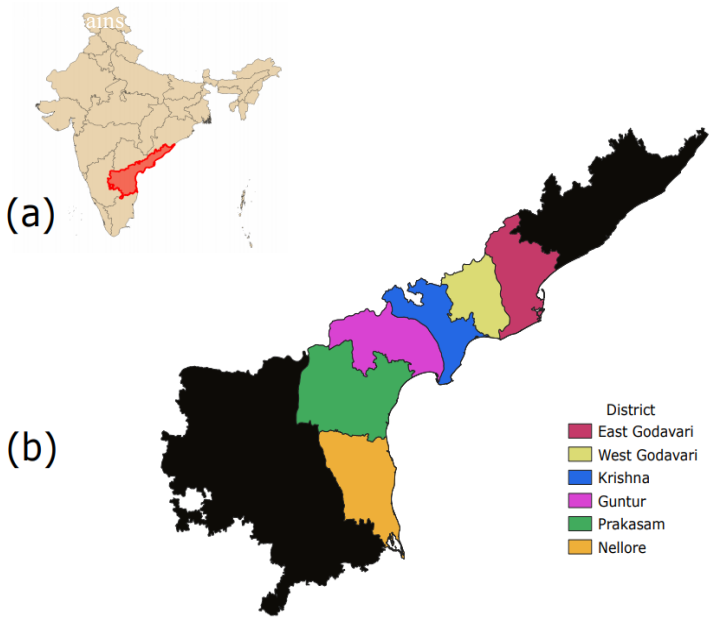


Figure 1. Maps showing the location of the study areas

Notes: (a) map of India showing the location of Andhra Pradesh and (b) the districts selected for the study.

3.2 Sampling and data collection

The state of Andhra Pradesh was selected for the study because of its high level of aquatic food production. In addition, because WorldFish's partner, Seafood Solutions, had pre-existing phone contacts of value chain actors, Andhra Pradesh presented a suitable context for computer-assisted telephone interviews (CATI) to minimize the risk of spreading COVID-19. Six districts were purposively selected within Andhra Pradesh. These include Guntur, Krishna, Nellore, West Godavari, East Godavari, and Prakasam. The sampling strategy for respondents combined convenience and snowball sampling. Using a network of existing contacts from previous projects, the study sample was selected conveniently (due to health precautions and movement restrictions). The study targeted three types of value chain actors including aquaculture producers, fish traders, and fish processors. We targeted to interview at least 100 respondents for each value chain segment. In some cases, especially for processors and traders, we started with the pre-existing contacts list and implemented snowballing technique to identify additional respondents.

Table 1 presents the distribution of study respondents by type of value chain actor and district for 2020 and 2021. The total sample size in round one was 326 value chain actors, including 170 aquaculture producers, 113 traders (including wholesalers and retailers), and 43 processors (mainly involved in drying fish). As shown, majority of the farmers in the study sample are from West Godavari. A large number of the traders are from Krishna and Guntur. Whereas processors in the sample are mainly from Guntur district. The total sample size in round two was 513 value chain actors, including 316 farmers, 150 traders and 51 processors. All original actors from round one were included in the sampling frame, with some attrition due to non-willingness to participate and incorrect contact details. To increase the sample size, new actors were included in round two. Samples sizes vary by question, as some respondents declined to answer certain questions.

Table 1 Sample size of value chain actors by district (%)

	Farmers		Traders		Processors	
District	**2019-2020**	**2020-2021**	**2019-2020**	**2020-2021**	**2019-2020**	**2020-2021**
Guntur	1	1	30	25	60	51
Krishna	22	21	38	29	30	26
Nellore	19	25	12	17	2	14
West Godavari	58	51	16	15		
East Godavari		1	2	1		
Prakasam			3	3	7	8
Total number of actors	**170**	**312**	**113**	**150**	**43**	**51**

Primary data was collected using CATI. The surveys were conducted in December 2020 and DATE by Seafood Solutions. The questionnaire was divided into several modules with questions to capture the impact of the COVID-19 pandemic on fish production, sales, prices, competition between actors, access to inputs and impact on household welfare in terms of income and food security. Prior to implementation, ethics approval was obtained from the WorldFish research ethics panel.

3.3 Data analysis

The objectives of the study are answered through a descriptive analysis of the fish value chain in India. Descriptive summary statistics were computed including means and standard deviations. A *t*-test of differences in means was used to assess changes in variables between 2019 and 2020. We also compared impacts across the three value chain actors by using Analysis of Variance (ANOVA). Data analysis was done in STATA.

3.4 Descriptive summary statistics of survey respondents

Table 2 presents the summary statistics of the respondents. There were significant differences in the age of the owner/manager of the business among the three types of actors. The mean age ranges between 37 years (for traders and processors) and 40 years for farmers. There were significant gender differences, with the majority of the value chain actors being men (99.4% for producers, 84.1% for traders and 65.1% for processors). Men tend to dominate fish farming and trade while women's participation increases from upstream to downstream along the value chain, that is, from the farmer to the trader and then processor.

Most respondents had secondary education and above. On the one hand, there were significantly more processors with some primary education compared with producers and traders. On the other hand, the proportion of producers and traders with some secondary education was higher than that of processors. These results indicate that value chain actors in our sample are probably able to access and process different kinds of information, which may contribute to better response and adaptation to COVID-19 in their businesses.

Table 2 Value chain actors by age, gender and education level of the owner/manager

	Farmers		Traders		Processors	
Variable	2019-2020	2020-2021	2019-2020	2020-2021	2019-2020	2020-2021
Age (years)	40	41	37	40	37	38
Sex is male (%)	99	99	84	80	65	73
No education (%)	11	5	9	13	9	2
Some primary education (%)	6	32	3	7	14	5
Completed primary education (%)	8	27	8	8	5	5
Some secondary education (%)	25	8	31	29	9	21
Completed secondary education	24	7	26	30	30	43
Higher education (%)	26	22	24	14	33	25

4. Results and discussion

4.1 Impact of COVID-19 pandemic on access by fish value chain actors to inputs for production, processing, packaging or marketing of fish – *objective 1*

4.1.1 Labor resources

Value chain actors were asked to indicate if they had any paid employees working for them, including themselves in 2019 (Table 3). The results indicate that it is mainly fish farmers who hired paid labor in 2019 (131 out of 170 farmers, 77.1%), followed by traders (71 out of 113 traders, 62.8%). Processors hired paid labor to a smaller extent (17 out of 43 processors, 39.5%).

Fish farmers mainly hired part-time or casual male workers (a mean of seven employees and a maximum of 120), followed by full-time male workers (mean=2; maximum=40). Similarly, traders mainly hired part-time or casual male laborers (mean=2; maximum=50), and a few full-time male workers (mean=2; maximum=3). In contrast, the very few processors hiring paid labor employed two workers maximum, irrespective of the category.

Looking at labor use in the whole sample in 2019, results show that value chain actors hired mainly part-time or casual male workers (mean=5 employees; maximum=120), followed by full-time male workers (mean=2 employees; maximum=40). These results indicate that fish farming, trading and processing are seasonal activities with peak periods during which part-time or casual labor demand is high. According to Belton et al. (2021), aquatic businesses tend to employ casual workers during the fish farming season, which runs from March to November. Moreover, fish processing (mainly fish drying) is highly dependent on supplies of fish and therefore follows a similar seasonal pattern. The results in Table 3, indicate that employment in the fish value chain is dominated by male actors. Moreover, in most cases, value chain actors employed very few paid female laborers, suggesting an exclusion of women from fish farming activities that generate income.

Value chain actors in the study were then asked to indicate how they thought the amount of hired labor use would change in 2020 compared to 2019. The majority of the actors who had hired paid labor in 2019 reported that they expected labor use in 2020 compared to 2019 to remain about the same (42% farmers, 50.7% traders and 58.8% processors). When asked in another question, none of the value chain actors reported a change in labor use related to the COVID-19 pandemic. Therefore, it seems access to paid labor was not much affected. Despite the COVID-19 pandemic, value chain actors seem rather optimistic about access to labor resources, perhaps because most of them mainly hire part-time or casual laborers.

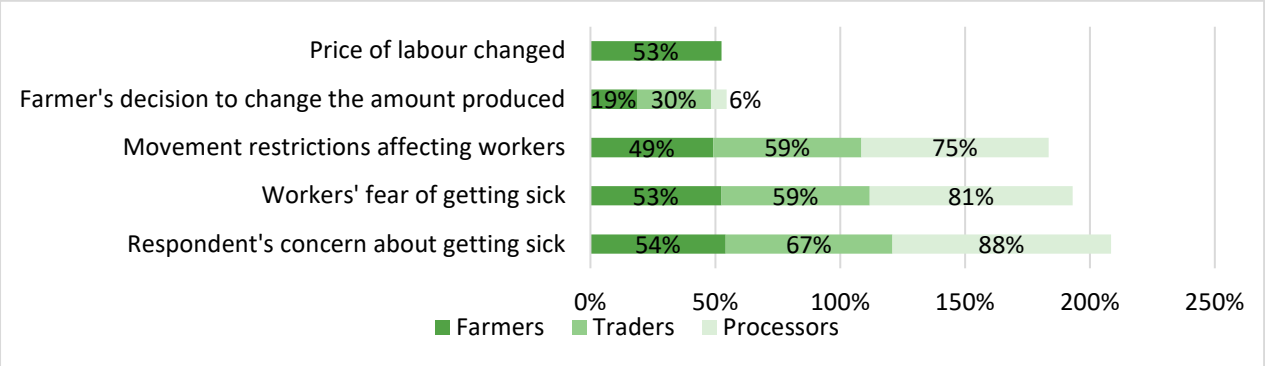
Table 3 Composition of paid labor employed by actor type in 2019

	Round 1 (2019-2020)		Round 2 (2020-2021)	
Category of paid labor employed	Mean	N	Mean	N
Panel A: *farmers*				
full-time, male employees	2.4	74	3.1	134
full-time, female employees	0.2	4	0.3	134
part-time/casual, male employees	7.3	105	12.3	135
part-time /casual, female employees	0.2	5	4.5	135
total number of paid employees	10	131	12.2	134
Panel B: *traders*				
full-time, male employees	0.8	20	233.5	67
full-time, female employees	0.2	2	190.5	68
part-time/casual, male employees	2.3	35	278.2	68
part-time /casual, female employees	0.3	4	198.8	68
total number of paid employees	3.6	71	890	67
Panel C: *processors*				
full-time, male employees	0.4	2	169.7	26
full-time, female employees	0.4	1	136.5	26
part-time/casual, male employees	0.4	2	194.4	26
part-time /casual, female employees	0.4	3	146.2	26
total number of paid employees	2	17	646.8	26
Panel D: *All actors combined*				
full-time, male employees	1.6	96	90.2	227
full-time, female employees	0.2	7	72.6	228
part-time/casual, male employees	4.6	142	111.9	229
part-time /casual, female employees	0.2	12	78.3	229
total number of paid employees	6.7	219	344	227

Note: N here is the number of actors who hired from each category of paid labor.

Most respondents (62% of farmers, 74% of traders, and 69% of processors) believed that the amount of hired labor was 'about the same' in 2020 as in 2021. A smaller portion (22% of farmers, 22% of traders, and 23% of processors) believed that hiring rates were 'somewhat higher' in 2021. Despite this, most farmers reported that they had no plans to hire labor in 2021 (88% of farmers, 81% of traders, and 56% of processors). All actors reported that changes in labor use was either complete or partially related to the COVID-19 pandemic. As shown in figure 2, worries about becoming sick and movement restrictions were the main aspects of the pandemic that influenced the use of labor.

Figure 2 Aspects of the pandemic that changed the use of hired labor, by actor type



4.1.2 Access to credit

The results in Table 4 show that the proportion of farmers who reported having obtained loans for their farm businesses declined by 5.9% in 2020 relative to 2019. There was a modest increase in the proportion of traders (by 0.9%) and processors (by 4.7%) accessing loans for their businesses in 2020 relative to 2019. However, differences in access to credit between 2019 and 2020 were not statistically significant, for all the actors. These results indicate that the covid-19 pandemic may have had differential impacts on access to credit, a negative impact on access to loans by farmers compared to traders and processors, but these differences were not significant.

Table 4 Change in access to loans between 2019 and 2020, and between 2020 and 2021 by actor type

	Round 1 (2019-2020)			Round 2 (2020-2021)		
Loan Access	2019	2020	**Diff**	2020	2021	**Diff**
(% actors reporting obtaining a loan)						
Farmers	49.4	43.5	**-5.9**	62	61	**-1**
Traders	31.9	32.7	**0.9**	32.2	29.6	**-2.6**
Processors	32.6	37.2	**4.7**	29.5	34.1	**4.6**
Number of actors reporting obtaining a loan in each year	*170*	*113*	***43***	*200*	*115*	***44***

Value chain actors were asked about their main sources of credit in 2019 and in 2020, then again in 2020 and 2021. Results on sources of credit (both formal and informal) are presented in Table 5. In 2019, the main sources of credit for farmers and traders were banks (46% of farmers and 56% of traders) whereas processors mostly obtained credit from friends or relatives (50%), indicative of the smaller and less formal nature of processing businesses.

In 2020, the COVID-19 pandemic period, the percentage of farmers' reporting access to credit through banks declined to 43%, while there was a modest increase in access through friends or relatives (from 40% in 2019 to 43% in 2020), indicating a slight switch from formal to informal sources of credit. Hence, it seems that fish farmers had less access to formal credit due to the COVID-19 pandemic situation in 2020, forcing them to switch from formal to informal sources of credit.

For traders, the primary source of credit reported remained banks and this rose to 59% in

2020, indicating that they maintained formal sources of credit. Processors reported continued access to credit mainly through friends or relatives in 2020, although the percentage reporting access through this source declined to the level of formal sources reported (38%).

Other sources of credit such as co-operative and micro-credit institution were not commonly used. Only a few farmers reported co-operative as a source of credit, while only a few processors reported micro-credit institution. Moreover, only 10% of farmers in the study reported that they belonged to an association or co-operative.

Between 2020 and 2021, most respondents of all actor types mainly sourced credit from banks and friends and relatives (please note: as the list of respondents was different in the two rounds of interviews, differences in 2019-2020 and 2020-2021 may be an affect of location or other variables). The main sources of credit for farmers did not change significantly (61% in 2020 to 59% in 2021 used banks, and 34% in 2020 and 37% in 2021 used friends and relatives). The main source of credit for traders was friends and relatives in both years; however, the portion of traders sourcing credit from friends and relatives decreased in 2021 (65% to 56%) and the portion of traders sourcing credit from banks increased in 2021 (24% to 35%). Most processors sourced credit from banks (91% in 2020 and 80% in 2021), but the portion that sourced credit from family and relatives increase in 2021 (8% to 20%).

Value chain actors were then asked to indicate how they thought availability of credit had changed between 2019 and 2020. The majority of the farmers and traders who reported credit access in 2019 reported that availability of credit has been somewhat lower in 2020 (46.4% farmers, 44.4% traders). The majority of processors reported that availability of credit remained about the same in 2020.These results are indicative of differences in access to formal and informal credit sources, with the latter remaining more accessible.

Farmers mostly felt that the availability of credit was ‘somewhat lower’ (45%) or ‘about the same’ (31%), a few felt it was ‘somewhat higher’ (19%). In comparison, traders and processors mostly felt that the availability was ‘about the same’ (51 and 57%, respectively) or ‘somewhat higher’ (35 and 41%, respectively).

Most respondents did not belong to a farmers’ association or cooperative (85% of farmers, 77% of traders, and 68% of processors).

Table 5 Changes in the main sources of credit by actor type

	Farmers						Traders						Processors					
	Round 1			Round 2			Round 1			Round 2			Round 1			Round 2		
Source of credit	2019	2020	Diff	2020	2021	Diff	2019	2020	Diff	2020	2021	Diff	2019	2020	Diff	2020	2021	Diff
(% actors reporting source)																		
Co-operative (%)	5	1	**-4**	4	1	**-3**	0	0	**0**	3	6	**3**	0	0	**0**	0	0	**0**
Trader or processor (%)	8	11	**3**	2	3	**2**	11	3	**-8**	8	3	**-5**	21	19	**-2**	0	0	**0**
Bank (%)	46	43	**-3**	61	59	**-2**	56	59	**3**	24	35	**11**	29	38	**9**	8	20	**12**
Friend or relative (%)	40	43	**3**	34	37	**3**	33	38	**5**	65	56	**-9**	50	38	**-12**	92	80	**-12**
Micro-credit institution (%)	0	0	**0**				0	0	**0**				0	6	**6**			
Others (%)	0	1	**1**				0	0	**0**				0	0	**0**			
Number of actors reporting source of credit in each year	*84*	*74*		*124*	*122*		*36*	*37*		*37*	*34*		*14*	*16*		*13*	*15*	

Note: Diff represents differences between 2019 and 2020, and between 2020 and 2021. Statistical tests conditional on having reported each source of credit in both years were not significant for all actors (results are not reported).

4.1.3 Impact on procurement of fish feeds by farmers

Generally, there were no statistically significant changes in the use of different types of fish feeds by farmers in round one or round two (Table 6). Floating pellets were the major feed type used by farmers in both rounds, although the portion of farmers using floating pellets was less in the second round than in the first round (61% and 71% respectively). This was followed by rice bran, sinking pellets and lastly oil cake. In the second round of interviews, the use of sinking pellets was higher (50% in round two compared to 18% in round one on average). In the first round, farmers reduced their use of floating pellets and sinking pellets between 2019 and 2020, and increased their use of rice bran and oil cake, although the differences were not statistically significant. In the second round, farmers reduced their use of rice bran and oil cake between 2020 and 2021, although again, these differences were not significant.

Farmers were asked about their perceptions on whether the changes in the use of different types of fish feed were related to the COVID-19 pandemic, either completely or partially (Table 6). Of the total number of farmers who reported use of each feed type in 2019, 53.8% attributed change in the use of rice bran to the COVID-19 pandemic (35.4% completely and 18.5% partially). This was followed by the total number of farmers who attributed change in floating pellets (44.9%), oil cake (44.4%) and lastly sinking pellets (38.2%) to the COVID-19 pandemic. In the second round, the total number of farmers who reported use of each feed type in 2020, 89% attributed the change in use of floating pellets to the COVID-19 pandemic (53% completely and 36% partially). This was followed by the total number of farmers who attributed change in sinking pellets (76%), rice bran (50%) and oil cake (50%) to the COVID-19 pandemic.

The results suggest that because of the COVID-19 pandemic situation in 2020, some fish farmers switched from using floating pellets and sinking pellets to rice bran and oil cake, because the latter were relatively cheaper. This is consistent with the findings of Belton et al. (2021) that feed procurement by farms in India was low between February and April 2020, due to seasonality and the effects of COVID-19 (peak of lockdown and movement restrictions during the months of March and April). The procurement of non-pelleted feeds, such as rice bran and oil cake, was highest between April and May 2020. This indicated that farmers adapted by substituting more expensive pelleted feeds with non-pelleted feeds to reduce costs. The results from the second round suggest that farmers have not changed their use of pelleted feeds between 2020 and 2021, while reducing the use of non-pelleted feeds slightly. This indicates a continued financial pressure on farmers with the continuation of the pandemic.

Table 6 Change in procurement of fish feeds by farmers from 2019-2020 and 2020-2021

Round 1 (2019-2020)				
Use by feed type (n=170)	Floating pellets	Sinking pellets	Rice bran	Oil cake
Farmers reporting use of feed type in 2019 (%)	74.7	20	38.2	5.3
Farmers reporting use of feed type in 2020 (%)	72.4	15.9	43.5	7.1
Difference between 2019 and 2020 (%)	-2.4	-4.1	5.3	1.8
Two sample tests of difference in proportions	0.623	0.323	0.321	0.499
(p-values)				
Farmers' perceptions on impact of COVID-19				
Yes, completely (%)	26.8	8.8	35.4	22.2
Yes, partially (%)	18.1	29.4	18.5	22.2
Total who reported yes (%)	44.9	38.2	53.9	44.4
Number of farmers who used feed type in 2019	127	34	65	9
Farmers' perceptions on how COVID-19 affected the use of fish feeds (n=170)				
Less available for sale (%)	17.1	1.2	12.9	1.2
Input vendors closed (%)	18.2	0.6	17.1	2.9
Movement restrictions prevented purchase (%)	31.2	7.7	18.2	3.5
Price increased (%)	18.8	2.4	12.4	0.6
Other reasons (%)	5.3	0.6	0.6	0

Round 2 (2020-2021)				
Use by feed type (n=200)	Floating pellets	Sinking pellets	Rice bran	Oil cake
Farmers reporting use of feed type in 2020 (%)	61.5	49.5	50	7.5
Farmers reporting use of feed type in 2021 (%)	61	49.5	45.5	6
Difference between 2021 and 2020 (%)	-0.5	0	-4.5	-1.5
Two sample tests of difference	0.918	1	0.368	0.55
in proportions (p-values)				
Farmers' perceptions on impact of the covid19 pandemic				
Yes, completely (%)	52.5	37.84	0	25
Yes, partially (%)	36.1	37.84	50	25
Total who reported yes (%)	88.5	75.68	50	50
Number of farmers reporting their perceptions	61	37	2	8
Farmers' perceptions on how covid19 affected the use of fish feeds				
Less available for sale (%)	32.1	35.5	52.9	20
Input vendors closed (%)	30.4	32.3	35.3	60
Movement restrictions prevented purchase (%)	28.6	38.7	41.2	60
Price increased (%)	89.3	83.9	64.7	40
Number of respondents (n)	56	31	17	5

Note: Statistics for farmers' perceptions are conditional on farmers having reported actual use of a feed type in 2019.

The results in Figure 3 are consistent with those for the first round in Table 6, where the majority of the farmers that used feeds in 2019 perceived that their use of different feed types did not change much between 2019 and 2020. The percentage of farmers reporting that use of feed in 2020 was 'about the same' as in 2019 was 55.1% for floating pellets, 70.6% for sinking pellets, 41.5% for rice bran and 55.6% for oil cake. In the second round, the percentage of farmers reporting that the use of feed in 2021 was 'about the same' as in 2020 was only 53% for floating pellets, 67% for sinking pellets, 82% for rice bran, and 64% for oil cake. In the second round, 28% of farmer perceived the use of floating pellets and 18% perceived the use of sinking pellets were 'somewhat lower', in contrast with the data in Table 6, where no change in the use of floating pellets and the ue of sinking pellets increased.

Figure 3 Farmers' perceptions on how use of fish feeds had changed between 2019 and 2020, and between 2020 and 2021

Note: The percent of farmers reporting (n) is conditional on having used a feed type in 2019.

Among farmers reporting a change in fish feed use, the primary reason was that movement restrictions prevented purchase of fish feeds in the first round. The percentage of farmers reporting this reason as the main driver of change in feed use was 31.2% for floating pellets, 18.2% for rice bran, 7.7% for sinking pellets and 3.5% for oil cake. Other COVID-19 related

reasons include increased prices, input vendors being closed and less available for sale. In addition, some farmers indicated they did not culture fish because of lockdown restrictions, while others cultured only a single crop because of the pandemic.

4.1.4 Procurement of fish farming inputs by farmers

Fish farmers in the study reported that their main source of inputs were primarily agricultural input vendors (70.6%), followed by processors or buyers (18.8%), and fellow farmers (6.5%). Very few farmers reported obtaining inputs from co-operative (1.2%) or government agency (1.2%). Farmers were asked how the number of vendors from which they could buy fish farming inputs has changed in 2020, compared to 2019. The majority of farmers reported that the number of vendors remained about the same (48.2%) in 2020, compared to 2019.

The survey further asked farmers whether they thought COVID-19 caused the change in the number of vendors of fish farming inputs. Most farmers reported no change in the number of vendors of fish farming input. (48.8%). This finding suggests that the COVID-19 pandemic did not affect much the procurement of fish farming inputs by farmers in 2020. This is consistent with the findings of Belton et al. (2021) from a survey in India and other countries between February and September 2020, that input prices remained relatively stable during their study period.

In the second round, farmers reported purchasing inputs mainly from agricultural input vendors (71%) and processors (20%). A small portion purchased inputs from cooperatives (5%) and other farmers (4%). Farmers generally felt that the number of vendors selling inputs was ‘about the same’ (46%) or ‘somewhat higher’ (41%) in 2021 than in 2020. Only 9% felt there were fewer input venders. Most farmers felt the changes in input venders was related to COVID-19 (61% completely and 33% partially).

4.1.5 Procurement of inputs by fish traders and processors

Traders and processors were asked how they thought the number of their potential suppliers changed between 2019 and 2020. The majority of traders reported that they thought the number of their potential suppliers was somewhat lower in 2020 compared to 2019 (41.6%). Looking at the sub-sample that had observed a change in the number of potential suppliers, the majority of the traders attributed the change completely to the COVID-19 pandemic (59.3%). On the other hand, most of the processors reported no change (46.5%) in the number of potential suppliers between 2019 and 2020. Hence, it seems that the COVID-19 pandemic affected procurement of inputs more severely for traders than processors.

Traders reported purchasing inputs mainly from farmers (48%), whereas processors mainly purchased inputs from cooperatives (52%). As a secondary source, traders also bought inputs from cooperatives (24%), whereas processors bought inputs from farmers (18%). Procesors also bought inputs from other processors, including millers (16%) and from other small traders (14%), but not from fishermen. Traders also purchased inputs from other small traders (10%), and fishermen (8%). Most traders and processors felt the number of input suppliers was ‘about the same’ in 2020 and 2021 (59% and 77%, respectively). Fewer traders and processors felt that the number of input suppliers was ‘somewhat higher’ (30% and 18%, respectively). Most traders and processors felt that the change in input suppliers was related to COVID-19 (44% completely and 42% partially for traders, and 90% completely and 10% partially for processors).

4.1.6 Trade agreements with suppliers and other services

The results in Table 7 show that a very small proportion of traders and processors had any formal or informal agreements (contracts) with their suppliers in 2019 or 2020. Moreover, of those who reported having agreements with suppliers, the sample did not change significantly in 2020, compared to 2019. Traders from round two reported also reported this; however, processors in round two had lower rates of having agreements with suppliers (25-28% in round one, versus 4-7% in round two). This may be due to the different sample of respondents rather than the affects of the pandemic. Overall, having contractual agreements with suppliers by traders and processors did not change much over either study period and was not much affected by the COVID-19 pandemic.

The proportion of traders who reported having agreements with suppliers increased by 0.9% in 2020 and 1.7% in 2021, although the increases were not significant. On the other hand, the proportion of processors who reported having agreements with suppliers decreased by 2.3% in 2020 and 2.3% in 2021, although this was also not statistically significant.

Table 7 Trade agreements with suppliers by actor type comparing 2019 and 2020, and 2020 and 2021

	Round 1 (2019-2020)				Round 2 (2020-2021)			
Agreements (% with a formal/informal agreement with supplier)	**2019**	**2020**	**Diff**	**n**	**2020**	**2021**	**Diff**	**n**
Traders	16.8	17.7	**0.9**	113	11.3	13	**1.7**	115
Processors	27.9	25.6	**-2.3**	43	6.8	4.5	**-2.3**	44

Traders and processors were asked whether they offer any technical assistance in production to their suppliers. Only a small proportion (23.9% of the traders and 11.6% of the processors) reported that they offer technical assistance to their suppliers.

Traders and processors were also asked whether they offer any credit in-kind (such as by advancing inputs) to their suppliers. Similarly, only a small proportion of traders and processors (31.9% of the traders and 11.6% of the processors) reported offering any credit in-kind to their suppliers.

Furthermore, only a small proportion of traders and processors (27.4% of the traders and 9.3% of the processors) reported offering any credit in cash to their suppliers when asked.

4.2 Impact of COVID-19 pandemic on fish production and trade – *objective 2*

4.2.1 Impact on types of fish produced, traded or processed

Both rounds of surveys asked value chain actors about the most important fish type they produced/ traded/processed in 2019 and 2020 in round one and in 2020 and 2021 in round two. In the first round, the most important types of fish that were produced/sold/processed were captured under the category “other fish” (Table 8). Discussions with enumerators revealed that ”other fish” usually referred to a mixture of fish, with no one species dominant. For farmers, the second and third most important fish types produced/sold/processed in both 2019 and 2020 were Rohu and Catla, respectively. In the second round, the most important type of fish for farmers was Catla in both years (29% on average), followed by Rohu (20% on average), pangasius (15% on average) and shrimp (15% on average). This suggests that farmed carps were important throughout both study periods.

For traders, sardines and mixed small marine fish were the most important types in both years, and shrimp in 2019. In the second round, shrimp were also the most important type over both years (32-33%), followed by Rohu (16%) and ‘other marine fish’ (14%).

For processors, sardines and other marine fish were the most important types in the first round. In the second round, sardines (46%) followed by shrimp (18%) were the most important types. This indicates some differences in the types of fish produced/sold/processed by different value chain actors. However, the statistical tests showed no significant changes in the types of fish produced/sold/processed in 2019 compared to 2020, or for 2020 compared to 2021, for all fish types.

The only significant change was in the production of shrimp – a high value crop grown for export - among farmers between 2019 and 2020. The finding that shrimp production by farmers declined in 2020 relative to 2019 corroborate Middleton et al. (2021) who recorded a fall in the total quantity of shrimp sold by farmers in another WorldFish survey conducted in Andra Pradesh in March 2020. Middleton et al. (2021) also documented that after the fall in March, total quantity of shrimp sold rose again in the months of April and May 2020, and then remained stable in June 2020.

Table 8 Most important types of fish produced/traded/processed in 2019 and 2020 and in 2020 and 2021 (%)

	Farmers						Traders						Processors					
	(n=170)			(n=200)			(n=113)			(n=115)			(n=43)			(n=44)		
Fish type	**2019**	**2020**	**Diff**	**2020**	**2021**	**Diff**	**2019**	**2020**	**Diff**	**2020**	**2021**	**Diff**	**2019**	**2020**	**Diff**	**2020**	**2021**	**Diff**
Catla	16.5	17.7	**1.2**	29.5	27.5	**-2**	8	7.1	**-0.9**	13	9.6	**-3.4**	4.7	4.7	**0**	6.8	6.8	**0**
Tilapia				2.5	2	**-0.5**				5.2	4.3	**-0.9**				0	0	**0**
Other fish	32.4	35.9	**3.5**	2	5.5	**3.5***	38.9	36.3	**-2.7**	3.5	6.1	**2.6**	65.1	60.5	**-4.7**	0	0	**0**
Pacu				8	11	**3**				0	0	**0**				0	0	**0**
Pangasius	14.1	14.1	**0**	15.5	13.5	**-2**	0.9	0.9	**0**	3.5	5.2	**1.7**			**0**	6.8	6.8	**0**
Rohu	24.1	28.2	**4.1**	21	19	**-2**	0.9	1.8	**0.9**	15.7	16.5	**0.8**			**0**	11.4	11.4	**0**
Shrimp	12.9	4.1	**-8.8***	14	15	**1**	12.4	9.7	**-2.7**	33	32.2	**-0.8**			**0**	18.2	18.2	**0**
Mixed small marine				0	0	**0**	12.4	12.4	**0**	3.5	3.5	**0**	7	7	**0**	2.3	2.3	**0**
Other marine fish				7.5	6.5	**-1**	6.2	7.1	**0.9**	13.9	13.9	**0**	9.3	7	**-2.3**	9.1	9.1	**0**
Sardines				0	0	**0**	20.4	24.8	**4.4**	8.7	8.7	**0**	14	20.9	**7**	45.5	45.5	**0**

*Note: Diff is the difference in fish types produced/processed/traded between 2019 and 2020 and between 2020 and 2021. * Statistical tests of proportions showed a significant difference in farmers' shrimp production/sale between 2019 and 2020 at 1% level of significance. For all the other types of fish, the statistical tests showed no significant differences between 2019 and 2020 or between 2020 and 2021.*

4.2.2 Impact on volume of fish produced, traded or processed

In round one, value chain actors were asked how much fish they produced/traded/processed in 2019, depending on the type of actor, and/or what they expected to produce/trade/process in 2020 across all seasons (Table 9). Round two respondants were asked about 2020 and 2021. The results show that the overall mean volume of fish produced/traded/processed by all value chain actors declined significantly by about 5.2 metric tons between 2019 and 2020, but not for actors reporting on the 2020 to 2021 period.

More specifically, the volume of fish produced by farmers in the first round declined by 7.4 metric tons (statistically significant at 1% level). Whereas the volume of fish traded by traders declined by 3.5 metric tons (only significant at 10% level). On the other hand, there was no significant change in the volume of fish processed between 2019 and 2020. This indicates that fish farmers were the most affected by the COVID-19 pandemic, followed by traders and lastly processors. The results corroborate Belton et al. (2021) who found that volumes of fish sold by farms in India declined between February and May 2020. They also find that trader and retailer sales were heavily impacted in these months. They attributed the trends to the severity of lockdown measures, particularly the restricted interstate movements and market closures during the months of March to May 2020.

Processors produced mainly dried fish, which can be stored for extended periods, unlike the fresh fish sold by farms and most traders, which is sold immediately. Moreover, processors operated smaller businesses than farms and traders, and relied mainly on family labor to do so. These characteristics may have made processors more resilient to the shock of COVID-19 than either farmers or traders.

Value chain actors were asked if they thought that the change in production or trade of fish was related to the COVID-19 pandemic. In the first round (n=170), forty percent of farmers and 72% of processors did not observe any change in fish production or sales. Forty-six percent of the traders attributed the change in fish sales completely to the COVID-19 pandemic. Farmers were then asked to give reasons for differences in their production yields of fish between 2019 and 2020. The majority of farmers reported that weather (34.7%) was the leading cause of the differences in fish production, which highlights the negative impact of cyclone Amphan on fish production. The cyclone hit Andhra Pradesh in May 2020. The second major reason for differences in fish production among farmers between 2019 and 2020 was change in area under cultivation (23%), followed by quality of fish seed (fingerlings) (17%), difficult access to markets (3%), other reasons (3%) and changes in availability of labor (1%). Reported changes in the area cultivated leading to lower production could indicate that farmers reduced the number of ponds utilized to save costs or reduce risk. Other reasons reported by some farmers for differences in fish production were that they were cultivating only shrimp in 2020, others were culturing only a single crop, and one farmer reported that the fish pond got contaminated.

Traders and processors were also asked to give reasons for differences in the volume of fish traded or processed, respectively. Fifty-three percent of the traders and 28% of the processors reported that movement restrictions due to COVID-19 pandemic was the leading cause of the differences in volume of fish traded and processed, respectively. According to traders, besides movement restriction, there were other reasons, including ‘change in demand for fish’ (35%), ‘change in cost of transportation’ (28%), ‘change in fish supply’ (17%), ‘change in cost of operations’ (7%) and ‘other reasons’ (1%). Processors indicated that apart from movement restrictions, other reasons for differences in the volume of fish processed between 2019 and 2020 included ‘change in cost of transportation’ (7%), ‘change in demand for fish’ (5%) and ‘change in fish supply’ (2%).

In the second round, the volume of fish produced by farmers decreased from 98 to 72 metric tons between 2020 and 2021, although this was not significant. Farmers reported that this reason was mostly due to 'yields different because of weather' (76%), 'quality of seed' (52%), followed by 'changes in areas under cultivation' (22%), 'availability of labor' (18%), 'access to markets' (8%), and 'amount of fertilizer use' (4%). The reasons for reduced production between 2020 and 2021 were mainly not related to the pandemic.

In contrast to farmed fish, the volume of traded fish increased significantly from 59 to 86 metric tons between 2020 and 2021. The volume of process fish also increased, from 22 to 53 metric tons, although this was not significant. Regardless, the increased volume of traded and processed fish indicates possible rebound or improvement between 2020 and 2021. Traders and processors reported that the main reason for changed volumes were 'changes in movement restrictions' (69% and 100% respectively). Increased ability to travel may have supported the increased volumes. Traders also reported that changes in volumes were also due to 'change in demand for commodity' (66%), 'change in supply of commodity' (36%), 'change incost of operations' (36%), and 'change in cost of transportation (26%). Processors reported that changes in volumes were also due to 'change in cost of transportation' (75%), 'change in supply of commodity' (50%), 'change in cost of operations' (25%) and 'change in demand for commodity' (25%). These data suggest that although trade and processing may be recovering, continued decrease in farmers' production may be causing supply chain issues.

Table 9 Changes in the fish market across all seasons, between 2019 & 2020 and between 2020 and 2021 in metric tons

Volume of fish produced/traded/processed	Mean	Paired t-tests mean diff	p-value
Farmers (n=170)			
Fish production in 2019	32.3		
Fish production in 2020	24.9	-7.4	0.002**
Traders (n=113)			
Fish traded in 2019	26.6		
Fish traded in 2020	23.1	-3.5	0.053*
Processors (n=43)			
Fish processed in 2019	13.7		
Fish processed in 2020	12.7	-1	0.502
Total (All actors) (n=326)			
Fish produced/traded/processed in 2019	27.9		
Fish produced/traded/processed in 2020	22.7	-5.2	0.000**

Volume of fish produced/traded/processed	Mean	Paired t-tests mean diff	p-value
Farmers (n=200)			
Fish production in 2020	98.4		
Fish production in 2021	72.5	-25.9	0.183
Traders (n=115)			
Fish traded in 2020	59.1		
Fish traded in 2021	86.4	27.3	0.030*
Processors (n=44)			
Fish processed in 2020	22.4		
Fish processed in 2021	52.5	30.2	0.197
Total (All actors) (n=359)			
Fish produced/traded/processed in 2020	76.5		
Fish produced/traded/processed in 2021	74.5	-2.0	0.868

Note: ***, ** and * indicate statistical significance at 1%, 5% and 10% level, respectively.

4.3 Impact of COVID-19 pandemic on access to markets by value chain actors including impacts on sales, prices and competition – *objective 3*

4.3.1 Fish sales by farmers

Farmers were asked whether they sold any fish in 2019 and 2020 and in 2020 and 2021 (Table 10). The results show that 90% of the farmers sold fish in 2019. However, in 2020 in the first round (the beginning of the COVID-19 pandemic period), the share of farmers who sold any fish dropped sharply to 51%. Fish sales dropped by 39% in 2020 (statistically significant at 1%), indicating a negative impact of the COVID-19 pandemic on fish sales. Belton et al. (2021) report similar findings that fish sales by traders and retailers in India were depressed from March 2020 onwards. In the second round, the portion of farmers who sold fish decreased from 95 to 59% between 2020 and 2021, a significant drop of 37%.

Table 10 Fish sales by farmers in 2019 and 2020 and in 2020 and 2021.

	Round 1 (2019-2020)				Round 2 (2020-2021)			
Fish Sales (% of farmers who sold fish)	**2019**	**2020**	**Diff**	**n**	**2020**	**2021**	**Diff**	**n**
Farmers	90	51	**39***	170	95	59	**-37***	200

*Note: * indicates statistical significance at 1% level.*

About 53.5% of the farmers reported no sales in either or both years 2019 and 2020. 20.6% and 19.4% of farmers reported that their fish sales were somewhat lower, and much lower in 2020 compared to 2019, respectively. Only 5.3% reported that their fish sales were about the same in 2020, and just 1.2% reported that their fish sales were somewhat higher in 2020.

Farmers attributed the change in fish sales mainly to movement restrictions (53.5%) due to the COVID-19 pandemic. Other reasons reported for the change in fish sales include 'cycle not yet completed' (12.9%), 'differences in production in 2020' (11.2%), 'differences in the number of buyers' (7.1%), 'did not cultivate fish' in 2020 (2.9%), and floods (1.2).

In the second round, 38% of farmers (n=115) reported that their volume of sales was 'somewhat higher' in 2021 than in 2020, where as 36% reported that it was 'about the same' and 21% reported that it was 'somewhat lower'. Only 4% reported that it was 'much higher' and only 1% reported that it was 'much lower'. They reported that the main reason for this change was 'different number of buyers' (43%), followed by 'different production this year' (39%), 'concerned about health risk (11%), 'movement restrictions' (5%), and 'other' (1%).

4.3.2 Fish selling prices

Value chain actors were asked whether the selling price of fish had changed from 2019 to 2020 and from 2020 to 2021. In the first round, the majority of farmers reported that the selling price of fish was 'much lower' in 2020 (47.1%) whereas traders indicated that the selling price of fish was 'somewhat lower; in 2020 (45.1%). In contrast, the majority of the processors reported that the selling price of fish remained 'about the same' in 2020 (44.2%). In the second round, many farmers (n=200) reported that the selling price of fish was

somewhat higher in 2021 (41%), while others felt it was 'somewhat lower' (32%) or 'about the same' (18%). Traders (n=115) reported that the selling price was 'about the same' (51%) or 'somewhat higher' (42%). Processors (n=44) also reported that the selling price was 'about the same' (57%) or 'somewhat higher' (39%).

Hence different value chain actors perceived the negative impact of COVID-19 pandemic on fish sales prices differently. In the first round, farmers and traders reported depressed fish prices, whereas processors mainly reported that prices had remained about the same. This is consistent with Belton et al. (2021), who reported a fall in fish prices for farmers and traders in India between February and September 2020. These findings could reflect differences in demand for different product types during the pandemic. Processors sold dried fish that may have retained higher demand due to their long shelf life and relatively low cost, as compared to the highly perishable and more expensive fresh fish sold by farmers and many traders. Most respondents were more positive about the changes between 2020 and 2021, generally reporting that prices were mostly the same or higher. This may be an indication of some resilience or recovery in 2021.

4.3.3 Main types of buyers

In 2019, all three types of value chain actors reported that the main type of buyer of their fish were traders or wholesalers, and this arrangement did not change in 2020 for traders and processors (Table 11). Moreover, for traders and processors, none reported inability to make sales, and there was no significant change in their types of buyers between 2019 and 2020.

However, for farmers, fish purchases by traders or wholesalers reduced significantly in 2020 (42%), compared to 2019 (85%), and this reduction was statistically significant at 1% level. In contrast, fish purchases by retailers increased significantly in 2020 (7%), compared to 2019 (2%), and this increase was statistically significant at 5% level. A possible explanation is that farms redirected some of their sales to local retailers when it became difficult to transport fish to traders located further away, due to movement restrictions. Purchases by processors, and consumers were not significantly impacted.

It is also important to note that the share of farmers who did not make any fish sales, and therefore could not report any buyers increased significantly from 10% in 2019 to 49% in 2020 (statistically significant at 1% level), indicating a significant negative impact of COVID-19 on fish marketing. Belton et al. (2021) also report disruptions in fish marketing in India between February and September 2020, characterized by a fall in the share of value chain actors who attempted to purchase inputs or sell products, with reduced access to buyers.

In the second round, farmers reported selling mainly to traders or wholesellers (78%), whereas traders and processors reported selling mostly to consumers (44% and 66%, respectively). No significant changes were found between 2020 and 2021. This was in contrast with the first round, where all actors mainly sold to traders or wholesalers. As no changes were found between 2020 and 2021, this difference is likely due to different sets of respondents rather than an affect of the COVID-19 pandemic.

Table 11 Changes in the types of fish buyers

	Farmers			Traders									Processors					
	170			117			113			115			43			44		
Fish buyer (% actors reporting buyer)	**2019**	**2020**	**Diff**	**2020**	**2021**	**Diff**	**2019**	**2020**	**Diff**	**2020**	**2021**	**Diff**	**2019**	**2020**	**Diff**	**2020**	**2021**	**Diff**
Trader or wholesaler	85	42	**-44*** **	79	78	**-1**	46	46	**0**	17	16	**-1**	65	65	**0**	5	5	**0**
Processor or miller	2	1	**-1**	16	14	**-2**	11	11	**0**	25	25	**0**	7	7	**0**	16	16	**0**
Retailer	2	7	**5****	3	4	**1**	3	4	**1**	12	12	**0**	16	14	**-2**	11	16	**5**
Consumer	0	0	**0**	0	1	**1**	40	39	**-1**	44	44	**-1**	12	14	**2**	68	64	**-5**
Other	1	1	**0**				1	1	**0**				0	0	**0**			
Farmer				2	3	**1**				2	4	**2**				0	0	**0**
The were no sales	10	49	**39*** **				0	0	**0**				0	0	**0**			

*Note: Diff represents differences between 2019 and 2020. *** indicates statistical significance at 1% level (p-value = 0.000). ** indicates statistical significance at 5% level (p-value = 0.018). For all the other types of fish buyers, the statistical tests of differences in proportions showed no significant differences between 2019 and 2020 or between 2020 and 2021 (p-values are not presented).*

4.3.4 Trade agreements with buyers and other services

Table 12 presents results of changes in formal or informal agreements between value chain actors and their buyers. A small share of value chain actors reported that they had formal or informal agreements (contracts) with their buyers in 2019 (2% farmers, 18% traders and 30% processors) or 2020 (1% farmers, 18% traders and 28% processors). Moreover, there was no statistically significant change in the share of actors with formal or informal agreements with their buyers in 2020, compared to 2019. However, comparing all three actors, processors had relatively more agreements with their buyers, followed by traders and lastly farmers in both years. In the second round, a very small portion value-chain actors had formal or informal agreements with buyers in 2020 or 2021.

Table 12 Trade agreements with buyers by actor type

Agreements	Round 1 (2019-2020)				Round 2 (2020-2021)			
(% with a formal/informal agreement with supplier)	2019	2020	Diff	n	2020	2021	Diff	n
Farmers	2	1	**-1**	170	1.6	0	**-1.6**	190
Traders	18	18	**0**	113	6.1	5.2	**-0.9**	115
Processors	30	28	**-2**	43	4.5	4.5	**0**	44

Value chain actors were also asked about the terms in their agreements with buyers. The majority of the actors who reported having an agreement with buyers in 2019 and 2020 indicated that the terms of the agreement remained the same (100% farmers, 95% traders and 92% processors). Furthermore, value chain actors were asked whether they received some specific marketing services from their buyers, to which a modest share of farmers reported “yes” (Table 13). In order of importance, these included credit in cash (28%) or in-kind (21%), assistance in purchase of inputs (mostly floating pellets reported by 15% of farmers), and technical assistance in production (9%). In the second round, overall more famers reported receiving specific marketing services from their buyers, particularly credit in kind (52%), followed by credit in cash (21%), technical assistance (20%) and purchase of both floating and sinking pellets (13% and 15% respectively).

Table 13 Marketing services offered by buyers to fish farmers (n=170)

Marketing service	Reporting yes (%)	
	2019-2020	2020-2021
(a) Buyer assisted in purchasing inputs		
Floating pellets	15	13
Sinking pellets	8	15
Rice bran	9	5
Oil cake	2	2
(b) Buyer offered technical assistance in production	9	20
(c) Buyer provided credit in kind (pay for inputs	21	52
(d) Buyer provided credit in cash	28	21

Some traders and processors also received marketing services from their buyers in both the first and second round (Table 14). In the first round, in order of importance, they received a commission or better price from their buyers (54% traders and 26% processors), they received credit or advance payment (20% traders and 14% processors), and 1% of traders reported that they received other services or terms. Compared to the first round, more processors reported that their buyers provided commission or better price and that the buyer provided credit or advance payment in the second round.

Table 14 Marketing services offered by buyers to traders and processors

Marketing service	Traders		Processors	
(% actors reporting yes)	(n=113)	(n=115)	(n=43)	(n=44)
	2019-2020	2020-2021	2019-2020	2020-2021
Buyer provided commission or better price	54	46	26	52
Buyer provided credit or advance payment	20	26	14	25
Buyer provided any other services	1	0	0	0

4.3.5 Trade and profits

Value chain actors were asked whether the number of potential buyers changed between 2019 and 2020 and between 2020 and 2021. In the first round, the most common response by farmers was that the number of potential buyers had remained about the same in 2019 and 2020 (45.3%), or was somewhat lower in 2020 compared to 2019 (36.5%). Processors also commonly responded that the number of potential buyers had remained about the same in 2019 and 2020 (46.5%), or was somewhat lower in 2020 compared to 2019 (25.6%). Traders (38.9%), on the other hand, mostly reported that the number of potential buyers was somewhat lower in 2020, compared to 2019, or had remained about the same (30.1%).

In the second round, farmers reported that the number of potential buyers was ‘about the same’ (49%) and ‘somewhat higher’ (33%) in 2021 compared to 2020. This may be indicative of increased market activity and adaptations to the conditions of the pandemic.

A follow up question asked how the different actors expected their profit (or total income) to change in 2020 compared to 2019 and in 2021 compared to 2020. The most common responses by farmers in the first round were that they expected that their profit would decrease by more than 10% in 2020 (50.6%) or decrease by less than or equal to 10% in 2020 (23.5%). Similarly, the most common responses by traders were that they expected that their profit would decrease by more than 10% in 2020 (29.2%) or decrease by less than or equal to 10% in 2020 (28.3%). Whereas, most processors expected that their profit would decrease by less than or equal to 10% in 2020 (30.2%) or be similar to last year 2019 (27.9%). This confirms that all types of value chain actors perceived a negative impact of COVID-19 pandemic on their profits, but with farmers most heavily impacted, followed by traders, with processors least badly affected.

In the second round, farmers expected that their total profit would ‘decrease by more than 10% (35%) and ‘increase, but less than or equal to 10% (25%). Traders expected that their total profit would ‘increase, but less than or equal to 10%) (49%) and ‘decrease by more than 10% (24%). Processors also expected their profit would ‘increase, but less than or equal to 10% (80%). This may indicate that increased market activity is increasing the

profitability of traders and processors moreso than farmers, possibly due to factors impacting on production as listed earlier in the report.

Furthermore, value chain actors were asked to indicate what percentage of actors similar to them had stopped operating since the start of the pandemic. In the first round, the majority of farmers (56.5%) reported that none of the other fish farmers similar to them had stopped operating. Most farmers who reported that other fish farmers had stopped operating believed that only 1-2% had stopped operating. 30.9% traders reported that no other traders similar to them had stopped trading fish. Most traders who reported that other traders had stopped operating believed that around 2-5% had stopped operating. Only 9.3% of the processors reported that no other processors similar to them had stopped operating. However, most processors who reported that other processors had stopped operating believed that only 3-6% had done so. In the second round, farmers estimated that 14% of other fish farmers similar to them had stopped producing since the start of the pandemic. Traders and processors estimated that 6% and 5%, respectively, of other actors similar to them had stopped trading. Hence, according to these perceptions, while the COVID-19 pandemic was widely recognized to have impacted businesses negatively, it appears to have resulted in rather few business closures.

4.3.6 Competition among value chain actors

Different indicators of the degree of market concentration are computed in order to assess the level of competition among the value chain actors in the study (Table 15). The Gini index measures the extent to which the distribution of fish trade among the actors deviates from a perfectly equal distribution. The Gini index measures the area between the Lorenz curve and a hypothetical line of absolute equality, expressed as a percentage of the maximum area under the line (Farris, 2010). Thus, the Gini index ranges between 0% and 100%, with inequality increasing with an increasing index. A value of 0% indicates perfect equality, meaning a completely equal distribution of fish trade among actors; a value of 100% indicates maximum inequality, and refers to an extreme situation of one actor holding the total volume of fish traded, and all the rest having no fish traded at all. The Gini indices presented in Table 15 indicate that fish trade was not equitably distributed among the value chain actors in both years for both rounds. Generally, inequality was highest among traders, followed by processors and then farmers in both years. Inequality decreased slightly among farmers and processors in 2020 compared to 2019, but increased slightly among traders in the same period. This indicates that unequal competition particularly among traders might have been aggravated by the COVID-19 pandemic situation.

Table 15 Measures of competition, 2019 and 2020 (%)

	Gini coefficients				CR4 ratios				CR8 ratios			
	2019	2020	2020	2021	2019	2020	2020	2021	2019	2020	2020	2021
Farmers	60	57	73	66	17	14	37	22	29	24	47	34
Traders	74	76	76	77	37	36	34	32	57	59	57	52
Processors	61	59	61	78	55	55	49	69	67	64	69	84

The CR4 and CR8 ratios are quantitative measures of concentration commonly employed to measure the level of competition within an industry (Dillon and Dambro, 2017; Aker, 2010;

Kohls and Uhl, 1985). In this study, we use these measures to assess the level of competition between each category of value chain actors. The CR4 ratio is the percentage of traded volume accounted for by the four actors with the greatest volumes, whereas the CR8 is the percentage of traded volume accounted for by the eight actors with the greatest volumes. The CR4 and CR8 statistics must be interpreted with reference to some scale that connects them to levels of market competition. The higher the ratios, the greater the degree of concentration. Kohls and Uhl (1985) suggest that a CR4 less than or equal to 33% is indicative of a competitive market structure, while a CR4 of 33–50%, and above 50%, may indicate weak and strongly oligopolistic market structures, respectively. Whereas, a market is highly concentrated when CR8 is greater than 50% (Chen, 2002). A high CR4 suggests possible market power, however it is not positive evidence that farmers receive prices below the competitive level. Moreover, anti-competitive behavior can coexist with a low value of the CR4, although it would be difficult to maintain in equilibrium (Dillon and Dambro, 2017).

In the first round, the results of the CR4 ratios show evidence of varying levels of competition among the value chain actors. The CR4 ratios suggest that the fish market is fairly competitive among farmers, as the CR4 ratios were below 33 in both years. The largest four farmers accounted for 17% of fish traded in 2019, and this declined to 14% of all fish traded by farmers in 2020. On the contrary, the CR4 ratios suggest that the fish market among traders and among processors is oligopolistic or non-competitive, as the CR4 ratios were more than 33%. The largest four traders accounted for 37% of fish traded in 2019, and this declined slightly to 36% of all fish traded by traders in 2020. Whereas, the largest four processors accounted for 55% of fish traded by processors in 2019, and this did not change in 2020. This indicates that the fish processing market is strongly oligopolistic.

Similarly, the CR8 ratios show evidence of varying levels of competition among the value chain actors. The CR8 ratios also indicate that the fish market is fairly competitive among farmers, as the CR8 ratios were below 50% in both years. The largest eight farmers accounted for 29% of all farmed fish traded in 2019, and this declined to 24% in 2020. In contrast, the CR8 ratios indicate that the fish market among traders and among processors is oligopolistic or non-competitive, as the CR8 ratios were more than 50%. The largest eight traders accounted for 57% of all fish traded by traders in 2019, and this increased slightly to 59% in 2020. This indicates that fish trade became relatively more concentrated in the hands of the largest eight traders. On the other hand, the largest eight processors accounted for 67% of all fish traded by processors in 2019, which declined slightly to 64% in 2020.

In the second round, CR4 ratios showed that the largest four farmers accounted for 37% in 2020 and 22% in 2021, suggesting increased competition in the market. The largest four traders accounted for 33% in 2020 and 32% in 2021, indicating that the market is less competitive, and tending towards a weak oligopolistic structure; however, this did not change between the two years. The four largest processors accounted for 49% of the market in 2020, increasing to 69% in 2021, suggesting an increasingly strong oligopolistic market structure among processors.

CR8 ratios of farmers showed that the largest eight farmers accounted for 47% and 34% of all fish traded in 2020 and 2021 respectively, again suggesting increasing competition in the marketplace. The largest eight traders accounted for 57% and 52% of fish traded in 2020 and 2021 respectively, suggesting a non-conpetitive market. The largest eight processors accounted for 69% and 84% of fish traded in 2020 and 2021, strongly indicating non-competitive and strongly oligopolistic markets, which intensified between 2020 and 2021.

4.4 Impact of COVID-19 pandemic on the welfare of fish value chain actors – *objective 4*

4.4.1 Household food security

The survey assessed subjective perceptions of how the COVID-19 pandemic had affected respondents' household welfare, in terms of food security and income, and the coping mechanisms they deployed (Table 16). The first question was linked to food availability. Value chain actors were asked, "during the last 12 months, was there a time when you or others in your household worried about not having enough food to eat because of lack of money or other resources?" The majority of farmers (48%) reported yes, followed by traders (35%) and processors (16%). Hence, in terms of food availability, farmers were more negatively affected, followed by traders and then processors. Respondents in the second round reported better food availability for farmers (34%), but worse food availability for traders (53%) and processors (77%). This may be due to differences in respondents between the two rounds, or food availability may have worsened for traders and processors.

The next two questions were linked to food and nutrition security. First, value chain actors are asked, "still thinking about the last 12 months, was there a time when you or others in your household were unable to eat healthy and nutritious food because of a lack of money or other resources?" In the first round, the majority of farmers (46%) reported yes, followed by traders (35%) and processors (19%). In the second round, fewer farmers reported yes (29%), whereas more traders (51%) and processors (73%) reported yes. Second, "was there a time when you or others in your household ate only a few kinds of foods because of lack of money or other resources?" In the first round, the majority of farmers (38%) reported yes, followed by traders (32%) and processors (19%). In the second round, fewer farmers reported yes (19%), whereas more traders (34%) and processors (73%) reported yes. Again, in terms of food and nutrition security, farmers were more negatively affected in the first round, followed by traders and then processors. In the second round, processors were more negatively affected, followed by traders then farmers.

Table 16 Welfare impacts of COVID-19 pandemic on value chain actors in 2020

	Farmers		Traders		Processors	
	(n=170)	(n=200)	(n=113)	(n=115)	(n=43)	(n=44)
Food security indicators and coping strategies (% actors reporting yes)	2019-2020	2020-2021	2019-2020	2020-2021	2019-2020	2020-2021
Food availability						
Worried about not having enough food to eat	48	34	35	53	16	77
Food nutrition						
Were unable to eat healthy and nutritious	46	29	35	51	19	73
Ate only a few kinds of foods	38	19	32	34	19	59
Food consumption						
Had to skip a meal	12	3	18	19	21	43
Ate less than they thought they should	30	16	33	33	16	52
Food access						
Ran out of food	9	7	15	11	14	30
Were hungry but did not eat	14	11	20	17	16	43
Went without eating for a whole day	12	4	22	10	14	36

Another two questions linked to food consumption were asked: first, “was there a time when you or others in your household had to skip a meal because there was not enough money or other resources to get food?” Here the pattern changes for round one actors; processors reported yes the most (21%), followed by traders (18%) and farmers (12%). In round two, processors reported ‘yes’ the most (43%), followed by traders (19%) and farmers (3%). Second, “still thinking about the last 12 months, was there a time when you or others in your household ate less than you thought you should because of a lack of money or other resources?” Here the pattern was also different in round one, traders reported ‘yes’ the most (33%), followed by farmers (30%) and then processors (16%). In round two, processors reported ‘yes’ the most (52%), followed by traders (33%) and farmers (16%). Hence, in terms of food consumption, the responses were mixed, but it seems that processors and traders were more negatively affected compared to farmers in both rounds

The last three set of questions asked were linked to food access. The questions were as follows: First, “Was there a time when your household ran out of food because of a lack of money or other resources?” In the first round, traders reported ‘yes’ the most (15%), followed by processors (14%) and then farmers (9%). In the second round, processors reported ‘yes’ the most (30%), followed by traders (11%) and farmers (7%). Second, “was there a time when you or others in your household were hungry but did not eat because there was not enough money or other resources for food?” The pattern here is similar to the previous one in round one - traders reported ‘yes’ the most (20%), followed by processors (16%) and then farmers (14%). In the second round, processors reported ‘yes’ the most (43%), followed by traders (17%) and farmers (11%). Third, “was there a time when you or others in your household went without eating for a whole day because of a lack of money or other resources?” The pattern here is also similar to the previous one in the first round, with mostly traders who reported yes (22%), followed by processors (14%) and then farmers (12%). In the second round, processors reported ‘yes’ the most (36%), followed by traders (10%) and farmers (4%). In the first round, the patterns on food access show that traders were more affected, followed by processors reported ‘yes’, and lastly farmers. In the second round, processors were more affected, followed by traders and lastly farmers.

Hence, the COVID-19 pandemic had a negative effect on household food security as reported by the value chain actors. In terms of food availability, farmers were more negatively affected, followed by traders and then processors in the first round. Whereas in terms of food consumption, processors and traders were more negatively affected compared to farmers. In terms of food access, traders followed by processors were more negatively affected, and then farmers. In the second round across all areas, processers were more negatively affected, followed by traders then farmers. These findings possibly suggest that farmers are more likely to access and consume their own production as a coping strategy, compared to mid-segment actors (traders and processors). This corroborates Belton et al. (2021) who found that some lower-income respondents (such as small-scale fish farmers) were able to maintain normal levels of food consumption by utilizing part of their own food production.

While market activity of processors seemed to recover in 2021, the Gini coefficients suggested that the processing market is increasingly dominated by a few actors. Increased market activity, decreased market competition, and worse food security among processors may indicate that smaller processors are unable to compete and their livelihoods and food security are impacted as a result.

4.4.2 Household income

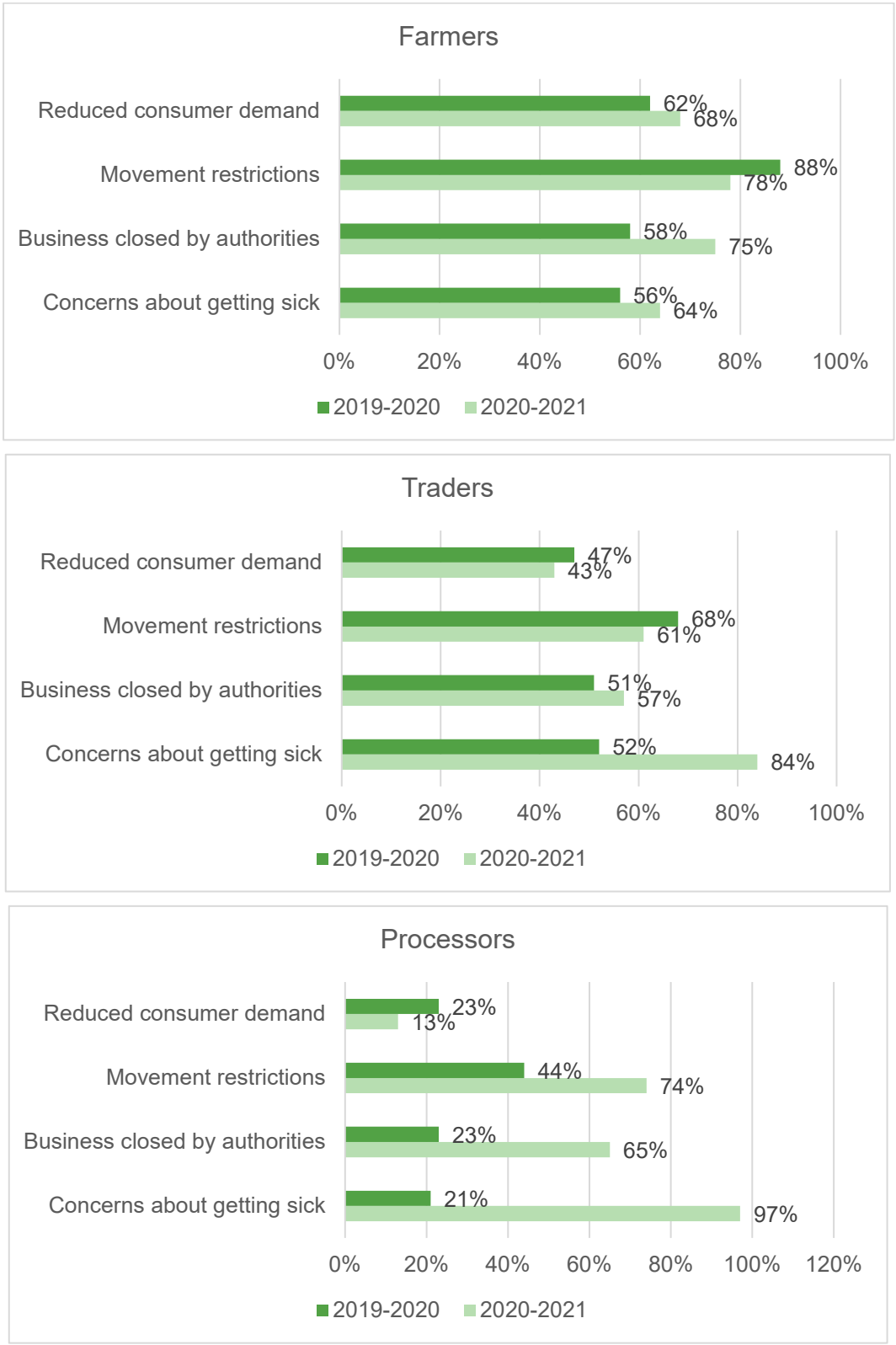
Value chain actors were asked whether and how their overall household income had changed in 2020, compared to 2019 and in 2021 compared to 2020. In the first round, the farmers perceived that their household income was 'much lower' in 2020 (47.6%) whereas the majority of traders perceived that their household income was 'somewhat lower' in 2020 (40.7%). In contrast, the majority of processors perceived that their household income had remained 'about the same' in 2020 (40.7%). Among respondents reporting a change in household income between 2019 and 2020, 89.4%, 77.0%, and 46.5% of farmers, traders, and processors, respectively, attributed the change to the COVID-19 pandemic.

In the second round, farmers disagreed somewhat, responding that their overall household income was 'somewhat lower' (33%), 'about the same' (27%), or 'somewhat higher' (32%). Traders reported that their household income was 'somewhat higher' (42%) or 'about the same' (40%). The majority of processers reported that their household income was 'somewhat higher' (61%), and less reported that it was 'about the same' (22%). Most respondents believed the changes were due to COVID-19, including 86% of farmers, 88% of traders, and 91% of processors.

Value chain actors were then asked to indicate what aspect of the pandemic changed their household income (Figure 4). In the first round, among respondents observing a change in household income, farmers (55.9%) and traders (52.2%) reported inability to work because of concern about getting sick. Farmers (58.2%) and traders (51.3%) also reported inability to work because authorities closed businesses. Furthermore, farmers (88.2%) and traders (68.1%) reported that movement restrictions affected ability to earn income. Additionally, the pandemic reduced consumer demand for fish commodity of farmers (62.4%) and traders (46.9%), but no change for processors (53.5%). Hence, the perceptions reported indicate that in terms of household income, farmers were the most negatively affected by the COVID-19 pandemic, followed by traders. Processors on the other hand were not much affected.

In the second round, farmers reported an inability to work due to movement restrictions (78%), business closed by authorities (75%), reduced consumer demand for the commodity (68%) and concerns about getting sick (64%). Traders reported an inability to work due to concerns about getting sick (84%), movement restrictions (61%), business closed by authorities (57%), and reduced consumer demand for the commodity (43%). Processors reported an inability to work due to concerns about getting sick (97%), movement restrictions (74%), business closed by authorities (65%), and reduced consumer demand for the commodity (13%). Traders and processors may have been more concerned about the becoming sick due to the more social nature of their jobs: traders interact with many different buyers and sellers, while processors may work alongside other processors in markets or enclosed areas. In contrast, farmers' work is outdoors with less people, exposing themselves to a lower risk of COVID-19 transmission than traders and processors. Across all three groups, movement restrictions were listed as major barriers to work, further indicating that the conditions of the COVID-19 pandemic may be continuing to impact on peoples' income into 2021.

Figure 4 Perceptions on impacts of COVID-19 pandemic on household income by actor type



4.4.3 Aid

Value chain actors were asked if they had received any form of aid for their family or business from the government or private organization over the past 6 months. In the first round, 40%, 61%, and 88% of farmers, traders, and processors, respectively, had not received any form of aid. Among those that received aid, 38% of farmers, 33% of traders and 12% of processors obtained mainly from the government. Some actors also reported receiving aid from organizations such as NGOs and religious institutions (18% farmers and 4% traders). Moreover, some actors received aid from both government and non-government organizations (5% farmers and 3% traders). In the second round, fewer respondents received aid: only 42% of farmers, 34% of traders, and 39% of processors had received aid in the past 6 months. Farmers (n=200) received aid from the govnerment (15%), private organizations (19%) and both sources (8%). Traders (n=115) received aid from the government (17%) and from both sources (17%). Processors (n=44) received aid from the govnerment (25%) and from both sources (14%). Fewer recipients of aid in round two may be an indication of recovery (a reduced need for aid), less availability or accessibility of aid as the pandemic continued, or simply an effect of the different sample of respondents.

When asked about what types of aid they had received (Table 17), 59% of farmers, 38% of traders and 12% of processors reported that they received in kind provisions in round one. This was followed by cash transfers (18% farmers, 23% traders and 9% processors), and other forms of aid that were not specified (2% farmers and 2% processors). None of the actors reported having received subsidized credit. The results are consistent with the findings of Belton et al. (2021) for the survey in India, where between 12% and 24% of respondents in their study reported receiving assistance between May and September 2020. That assistance was mainly from government and trade associations.

In round two, farmers received aid mostly from in kind provision (64%), and some from cash transfers (36%). In contrast, aid received by traders and processors was mostly from cash transfers (77% and 94% respectively).

Table 17 Types of aid received by value chain actors

Types of aid	Farmers		Traders		Processors	
	(n=170)	(n=83)	(n=113)	(n=39)	(n=43)	(n=17)
Food security indicators and coping strategies (% actors reporting yes)	2019-2020	2020-2021	2019-2020	2020-2021	2019-2020	2020-2021
In kind provision	59	64	38	18	12	6
Cash transfer	18	36	23	77	9	94
Subsidized credit	0	1	0	10	0	0
Others	2	29	0	44	2	35

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4.4.4 Perceptions about the COVID-19 pandemic

Value chain actors were asked to rate their own feelings about the pandemic using Likert scale statements (Figure 5). First, they were asked to rate their level of concern related to the pandemic, from 1 (not at all concerned) to 5 (very concerned). Then, they were also asked to rate their level of optimism, from 1 (very pessimistic) to 5 (very optimistic).

In the first round, the majority of actors reported that they were concerned about the pandemic. In general, processors were more concerned about the pandemic (69.8%), followed by traders (44.2%), and lastly farmers (38.2%).

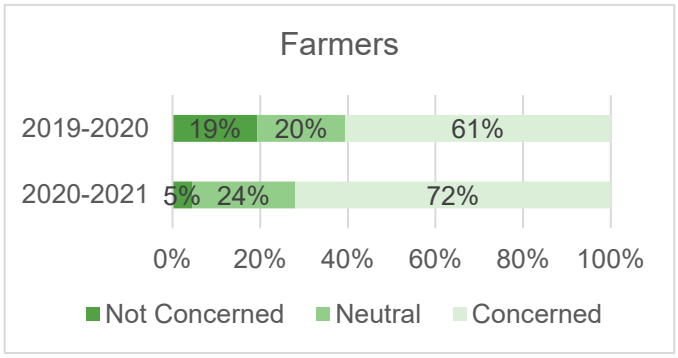
The majority of the value chain actors rated their level of optimism as neutral. In general, processors were more optimistic about the pandemic (60.5%), followed by traders (44.2%), and lastly farmers (38.2%).

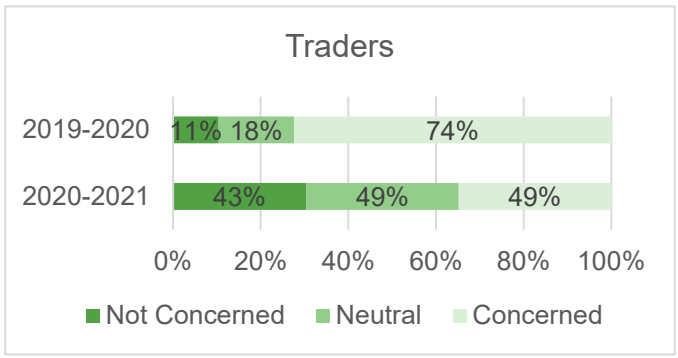
In the second round, processors were generally the least concerned about the pandemic, whereas farmers were generally the most concered about the pandemic. Farmers and traders continued to be concerned about the pandemic. In comparison, the majority of processors were not concerned.

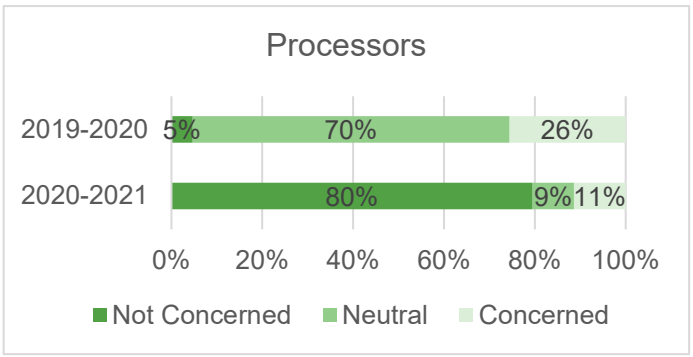
All respondents were generally pessimistic about the pandemic.

Figure 5 Perceptions of fish value chain actors about the COVID-19 pandemic: a) level of concern and b) level of optimism.

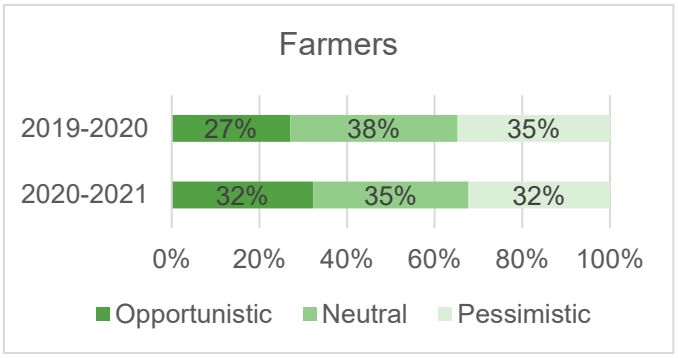
a) level of concern about the pandemic

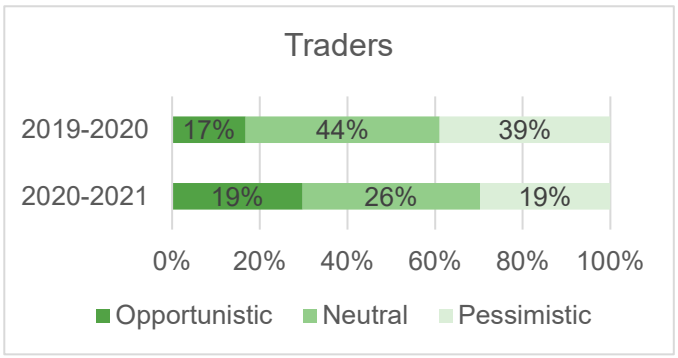


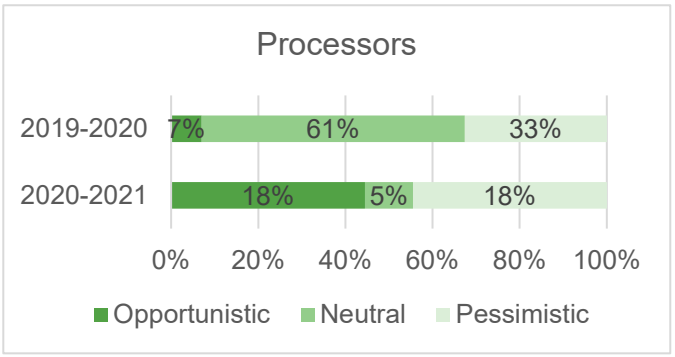




b) level of optimism about the pandemic







Summary and conclusion

This study aimed at assessing the impacts of the COVID-19 pandemic on fish value chains in India, between 2019 and 2020 and between 2020 and 2021. The specific objectives were to assess the impacts of COVID-19 pandemic on: 1) access by fish value chain actors to inputs for fish production, processing and marketing; 2) fish production and sales; 3) access to markets by value chain actors including impacts on sales, prices and competition; and 4) the welfare of fish value chain actors. The results according to each objective are summarized in what follows.

Results for objective 1: The COVID-19 pandemic did not have a significant effect on access by fish value chain actors to inputs such as labor, credit, fish feeds and other farming inputs, processing and marketing inputs, including trade agreements with input suppliers.

The type of labor mainly employed by value chain actors was paid casual (or part-time) male workers in 2019. There were gender differences in employment in 2019, as only a small proportion of employed paid labor were women. However, according to the perceptions of value chain actors, access to paid labor remained about the same in 2020, suggesting that access to labor was not much affected. Similarly, most respondents in the second round believed that hiring was 'about the same' between 2020 and 2021. The respondents continued to experience worries about becoming sick and movement restrictions as the main aspects of the pandemic that influenced the use of labor.

Initially, the COVID-19 pandemic had differential effects on access to credit, as there was a fall in access to loans reported by farmers compared to traders and processors. However, differences in access to credit were not statistically significant across the value chain. Fish farmers reported less access to formal credit from banks in 2020, and many switched from formal to informal sources of credit. Processors on the other hand mainly relied on informal sources (mainly friends and family) in both 2019 and 2020. In the second round, most respondents of all actor types mainly sourced credit from banks and friends and relatives, without any significant changes between 2020 and 2021. Compared to the first round, more farmers and less traders and processors accessed credit; however, this may be due to different sample populations rather than the impacts of the pandemic.

Concerning fish feeds, farmers reduced their use of floating pellets and sinking pellets, and increased their use of rice bran and oil cake, in 2020 compared to 2019, however the differences were not statistically significant. In the second round, farmers reduced their use of rice bran and oil cake in 2021 compared to 2020, but maintained their use of floating an sinking pellets. According to farmers' perceptions, movement restrictions which prevented purchase of fish feeds was the primary reason for change in use of the different feed types, followed by increased prices, input vendors being closed and less available for sale. Movement restrictions continued to prevent purchasing in the second round. In contrast to the first round, most farmers in the second round also reported increase of feed as a barrier. Procurement of fish farming inputs by farmers was primarily from agricultural input vendors, processors or buyers and other farmers in the first round. In the second round, the majority of farmers purchased inputs primarily from agricultural input vendors. The number of input vendors remained about the same in 2020 (compared to 2019), according to farmers, with most of them reporting no change in fish farming inputs as related to the COVID-19 pandemic. In the second round, farmers reported that the number of input vendors was about the same or higher in 2021 than in 2020, and believed changes were related to the COVID-19 pandemic.

Processing and marketing inputs for fish traders and processors were mainly sourced from processors, farmers, fisher folk, wholesalers, assemblers/other small traders in the first round. This shifted in the second round, where traders purchased inputs mostly from farmer and processors purchased inputs mostly from cooperatives. According to their perceptions in the first round, the number of potential suppliers for most traders was somewhat lower, while those of processors remained about the same, when comparing 2020 to 2019. Most traders attributed the change completely to the COVID-19 pandemic situation. In the second round, most traders and procesors felt the number of input suppliers were about the same, and this lack of change was attributed to the COVID-19 pandemic.

In terms of contracts, a small proportion of traders and processors reported any formal or informal agreements with their suppliers in both rounds, and this did not change much over either period. Moreover, only a small proportion of traders and processors offered any marketing services (such as technical assistance, credit in kind or in cash) to their suppliers.

Results for objective 2: The COVID-19 pandemic had a negative effect on fish production and trade. While farmers continued to experience decreased production in 2021, there was some evidence of increased market activity for traders and producers.

There were no statistically significant changes in the types of fish produced, traded, or processed in either round for all fish types, except for farmers whose shrimp production dropped significantly between 2019 and 2020. In the second round, sardine and shrimp production increased, though not significantly. In the first round, the overall average volume of fish produced/traded/processed by all value chain actors declined significantly by 5.2 metric tons between 2019 and 2020. More specifically, the volume of fish produced by farmers dropped significantly by 7.4 metric tons, whereas the volume of fish sold by traders dropped significantly by 3.5 metric tons. In contrast, there was no significant change in the volume of fish processed by processors. This is perhaps because processors are able to source their fish to process, both from fish farmers and fisher folk, hence their fish supply was not much affected by the COVID-19 pandemic situation.

In the first round, farmers attributed the fall in fish production mainly to weather, change in area under cultivation, quality of fish seed (fingerlings), difficult access to markets, changes in availability of labor and other reasons. Traders and processors attributed the fall in volume of fish sales to movement restrictions due to COVID-19 pandemic, change in demand for fish, change in cost of transportation, change in fish supply, change in demand for fish, change in cost of operations and other reasons.

In the second round, the volume of fish produced by farmers decreased from 98 to 72 metric tons between 2020 and 2021, although this was not significant. Farmers reported that this reason was mostly due to reasons not directly related to the pandemic, such as weather and poor-quality seed. In contrast to farmed fish, the volume of traded fish increased significantly from 59 to 86 metric tons between 2020 and 2021. The volume of processed fish also increased, from 22 to 53 metric tons, although this was not significant. Regardless, the increased volume of traded and processed fish indicates possible rebound or improvement between 2020 and 2021.

Results for objective 3: The COVID-19 pandemic had a significant negative effect on access to markets by value chain actors, with negative effects on sales, prices and competition.

The share of farmers who sold any fish dropped significantly from 90% in 2019 to 51% in

2020. Consequently, fish sales dropped significantly by 39% in 2020, indicating a significant negative impact of the COVID-19 pandemic on fish sales. The value chain actors had varying perceptions on how fish sales and selling prices changed in 2020 compared to 2019, the perceptions on negative impact in terms of depressed fish prices was most felt by farmers and then traders, whereas processors were not much affected. When asked, farmers attributed the drop in fish sales mainly to movement restrictions due to the COVID-19 pandemic. Round two showed similar trends, where the share of farmers who sold fish decreased by 37% between 2020 and 2021. The value chain actors were slightly more positive about how fish sales and selling prices changed in 2021 compared to 2020, with most reporting that prices were the same or higher in 2021 than in 2020. This may indicate a level of resiliency to the conditions of the pandemic one year in. Reasons for the changes in sales and prices were around reduced demand, which may be an ongoing effect of the pandemic.

Value chain actors reported that the main type of buyer of their fish in 2019 were traders or wholesalers, and this arrangement did not change much in 2020, for traders and processors. However, for farmers, fish purchases by traders or wholesalers reduced significantly between 2019 and 2020, whereas fish purchases by retailers increased significantly. Purchases by processors, and consumers were not significantly impacted. Moreover, the share of farmers who did not make any fish sales, and therefore could not report any buyers increased significantly in 2020 compared to 2019, indicating a significant negative impact of COVID-19 on fish marketing with some farmers unable to make sales. In the second round, farmers reported selling mainly to wholesaler and traders, but, in contrast to the first round, traders and processors reported selling mainly to consumers. No significant changes ocrrued between 2020 and 2021. All value chain actors expected profits to increase or remain the same in 2021 compared to 2020, further indicating some level of resilience.

A very small share of value chain actors reported that they had formal or informal agreements with their buyers in both rounds, and there was no statistically significant change in 2020 or 2021. Processors, however, had relatively more agreements with their buyers, compared to traders and farmers in the first round. In the second round, the percentage of actors with formal or informal agreements was even less than in the first round. Compared with the first round, more processors reported that their buyers provided commission or better price and that the buyer provided credit or advance payment in the second round. Value-chain actors may have been enabling sales and business to continue using adaptations to payment schemes, indicating a level of resilience and innovation to the conditions of the pandemic.

Regarding competition, the Gini indices showed inequality in the distribution of fish trade among the value chain actors in all three years. Generally, inequality was highest among traders, followed by processors and then farmers in all three years. Inequality decreased slightly among farmers and processors in 2020 compared to 2019, but increased slightly among traders in the same period. Inequality continued to decrease for farmers in 2021, but remained the same for traders and increased for processors. Hence, unequal competition particularly among traders and processors might have been aggravated by the COVID-19 pandemic situation. The measures of concentration (CR4 and CR8) show similar evidence of varying levels of competition among the value chain actors. The CR4 and CR8 ratios indicated that the fish market was fairly competitive among farmers in all three years. In contrast, the CR4 and CR8 ratios indicated that the fish market among traders and particularly among processors was non-competitive (oligopolistic) and worsened for processors in 2021 compared to 2020.

Results for objective 4: The COVID-19 pandemic had a significant negative effect on the welfare of fish value chain actors.

Value chain actors were asked a number of questions in order to capture their perceptions on how the COVID-19 pandemic affected their household welfare, in terms of food security and income, and how households were able to cope. According to their perceptions on food availability and nutrition, farmers were more negatively affected, followed by traders and then processors in the first round. Food availability for farmers improved between 2020 and 2021, but worsened for traders and processors. In terms of food consumption, processors and traders were more negatively affected compared to farmers. In terms of food access, traders followed by processors were more negatively affected, compared with farmers. In the second round, processors were much more negatively affected than traders and farmers. Hence, the COVID-19 pandemic had a differential and negative effect on household food security. Farmers were less negatively affected in terms of food access and consumption (compared to traders and processors), perhaps because they could consume their own production as a coping strategy, indicating the importance of subsistence farming for household resiliency.

In 2020, the majority of farmers perceived that their household income was much lower compared to 2019, whereas the majority of traders perceived that their household income was somewhat lower. In contrast, the majority of processors perceived that their household income had remained about the same in 2020. In the second round, some farmers perceived their income to be somewhat higher, while others perceived it to be the same or somewhat lower. Traders and procesors perceived their income to be somewhat higher, or the same, probably a reflection of the increased volumes traded and produced in 2021. The majority of the value chain actors attributed the change in household income to the COVID-19 pandemic situation in both rounds.

In both rounds, most farmers and traders reported that the aspects of the COVID-19 pandemic that changed their household income included: inability to work because of concern about getting sick, inability to work because business was closed by authorities, movement restrictions affected ability to earn income, the pandemic reduced consumer demand for fish commodity of farmers. In the second round, traders' and processors' ability to work was more impacted by concerns of getting sick, possibly due to more social work environments and a need to interact with many people in order to work. Movement restrictions continued to be a barrier to work in 2021, indicating the continued impacts of the ongoing pandemic.

The majority of value chain actors reported that they had not received any form of aid—although a small proportion reported that they received aid, mainly from government. Even fewer actors reported receiving aid in the second round. Of those who received aid, it was mostly in-kind provisions and cash transfers in both rounds.

Value chain actors were asked to rate their own feelings about the pandemic on a Likert scale ranging from 1 to 5. In the first round, the majority of value chain actors rated their level of concern related to the pandemic as level 4, meaning that they were somewhat very concerned about the pandemic. When rating their level of optimism related to the pandemic, the average score was 3, indicating that they were moderately optimistic about the pandemic. In general, processors were both more optimistic and more concerned about the pandemic, followed by traders and then farmers. In the second round, processors were generally the least concerned about the pandemic, whereas farmers

were generally the most concered about the pandemic. All respondents were generally pessimistic about the pandemic, possibly disheartened from continued pandemic conditions into 2021.

Recommendations

It is clear that the COVID-19 pandemic had a generally negative effect on the fish value chain in India. Hence, policy makers need to develop strategies to mitigate the disruptions and negative outcomes on fish value chain actors and their households. The following can be recommended based on the findings of the study:

- There is need to invest in more data collection and research, in order to get a better understanding of the ongoing short-term and long-term impacts of COVID-19 on fish and other value chains, the adaptation processes in different regions, and what policy response mechanisms to adopt.

- There is need to promote and develop more programs to boost the fish food value chain as it is an important source of livelihood, employment, income and nutrition security.

- The fish value chain was dominated by male actors. Moreover, there were gender differences in paid employment in the fish value chain, with only a small proportion of employed paid labor being females in 2019. Further research and gender-responsive support programmes are recommended, as gender equality is one of the sustainable development goals, and women tend to be the most vulnerable in society. Hence increasing their income generating opportunities through inclusive policies and programs could be important in mitigating the negative impacts of COVID-19 on household welfare.

- There was a significant negative impact of the COVID-19 pandemic on fish production and trade, on fish sales and marketing, including competition. Hence there is need for scaling up financial aid and subsidized credit by government and private groups to support value chain actors who have lost out due to the COVID-19 pandemic, particularly farmers and small-scale actors who may be less resilience than larger actors. This could be important in mitigating the negative impacts on the welfare of value chain actors.

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