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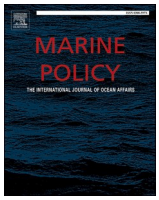

Full length article

Impacts of COVID-19 pandemic on the fisheries sector of Sri Lanka

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ABSTRACT

We empirically ascertained the impact of COVID-19 pandemic on fisheries sector of Sri Lanka, focusing on the year 2020 which helps identify changes in production and income of the sector. Daily wage and monthly income of stakeholders in the pre-pandemic period are well above the national minimum daily wage and monthly income of the workers in Sri Lanka. Defensive measures taken to curb rapid spread of COVID-19 have given a shock to all stakeholders of the sector. Health and safety measures imposed to avert the spreading of pandemic have compelled the stakeholders to incur extra costs. Study indicates significant impact of the pandemic on production and income of the stakeholders in the fisheries value chain. Comparison of total fish production during 2015–2020 confirms the impacts on the sector and, changes in fish production and income in 2020 completely coincide with COVID-19-time line. Severity of impacts is stakeholder and area specific. Fisheries districts in western province are highly impacted over the other districts. DPSIR framework captures the status of social system and unfolds existing problems in the sector, enabling decision-makers to take policy decisions for future actions. Government of Sri Lanka has taken several steps to revive the sector, and stakeholders have shown an adaptive capacity to cope with impacts of the pandemic. Present crisis in the sector is far from over and, short-term impacts are likely to be followed by long-term crises, thus measures should be taken to revive the sector in new normal conditions and the post-pandemic era.

1. Introduction

COronaVIrus Disease (COVID-19) pandemic [1] that began in Wuhan, China in December 2019 has reached over 74 million confirmed cases over the globe by 11 June 2021 [2] and has been declared a global pandemic by WHO on 11 March 2020 [3,4]. Ongoing efforts to curb the spread of the pandemic have dramatically disrupted the well-being and livelihoods of billions of people globally [5]. By today, COVID-19 pandemic has spread all around the world except for a few countries with minor effects [6], being a shockwave to various sectors, including fisheries. Sri Lanka is one of the most vulnerable middle-income countries that suffer badly from this global pandemic since its first local case of COVID-19 was recorded in March 2020 [7]. COVID-19 has seriously affected the health of Sri Lankans while putting their livelihoods at great risk [8]. As of 14 September 2021, the government reported 488,482 confirmed cases with 11431 deaths [2]. The government of Sri Lanka instituted several measures to mitigate the dissemination of COVID-19, including testing and treating of patients, nationwide dusk to dawn curfews, lock-downs, closure of high-risk areas, restrictions on movements & international travel [9]. The cumulative effects of the measures taken to suppress the pandemic have caused an immediate and significant impact on the cost of living and the Gross Domestic Product (GDP) of Sri Lanka [10].

Many fisheries over the globe have faced complete or partial shutdowns at the onset of social distancing that precluded fishers from fishing or trading in close quarters in fish markets [11]. Knock-on economic effects due to market disruptions have directly affected fisher livelihoods through twin disasters; reduced demand and collapse of price [11]. The fisheries sector which plays a significant role in the socioeconomic blooming of many countries has undertaken a productivity crisis with rising of COVID-19 pandemic [12]. For instance, stakeholders of the Indian fisheries sector including fish vendors, processors,

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exporters, fishers and traders etc. have been negatively affected by the sudden lockdown [13]. It is widely accepted that if one of these stakeholders is disrupted, the economy of the country is affected causing rippling effects of disruptions [14]. The fisheries sector of Sri Lanka which plays a vital role in providing 55 % of total animal protein intake per capita [15], and making platforms to offer direct and indirect employment and livelihood for nearly 2.4 million people [16,17] has been highly vulnerable to this global pandemic. Before COVID-19, the marine fisheries sector contributed to 83 % of the total fish production of Sri Lanka, and misconceptions among people have made the path decrease in demand, consumption, and price of fish to a significant level. Curtailment of fishing trips and duration, disturbance to fish value chains and decreased consumer preference has triggered the crashing of the fisheries sector. The Government of Sri Lanka has pulled out all measures through funding packages to support the fisheries sector. Nevertheless, a comprehensive study to unfold the impact of COVID-19 pandemic on the fisheries sector of Sri Lanka has yet to be conducted to elucidate the real impact on the sector that plays a vital role in the Sri Lankan economy contributing around 1.2 % to the GDP [18].

The present study ascertains the impacts of COVID-19 pandemic on the fisheries sector of Sri Lanka, explores response options in place to revive the industry, and further provides recommendations for building a more sustainable post-pandemic fisheries industry. Thus, the present study is designed to comprehensively investigate the impact of COVID-19 pandemic on the marine fisheries sector of Sri Lanka. In this context, primary data were collected from stakeholders of the value chain through administrating a pre-tested questionnaire. Secondary data were obtained from the Ministry of Fisheries and Aquatic Resources (MoFAR), Sri Lanka, and referring to published articles. Analyzed data have been aptly presented to highlight the impact of COVID-19 pandemic on the fisheries sector of Sri Lanka. A DPSIR (Driver-Pressure-State-Impact-Response) framework, employed to capture the status of the social system of the fisheries sector elucidates the necessity of improving the coping capacity of the stakeholders in dealing with the impact of COVID-19 pandemic.

2. Materials and methods

2.1. COVID-19-time scale

The first case in the country, a 44-year-old Chinese tourist from Hubei, China was reported on 27 January 2020 [9], and nearly 40 days later the first Sri Lankan, tourist tour guide tested positive on 11 March 2020 [7]. The Government of Sri Lanka imposed nationwide dusk and down curfews and restrictions on movements on 20 March 2020 which were lifted on 11 May 2020 for the whole country except the Colombo area which was released later on 26 May 2020. Nearly five months later, the second wave of the initial cluster was reported on 04 October 2020 in an apparel industry factory in Minuwangoda, Gampaha. Subsequently, linked clusters were identified on 20 October 2020 in the Peliyagoda central fish market and Colombo Municipal Council area that surfaced serious threats to the health of the people [8]. In this context, The Government of Sri Lanka implicated zonal lockdown, closure of high-risk areas, and restrictions on movement & international travel [9]. The third wave of the pandemic emerged in April 2021 and, the country is still struggling with the pandemic. Restriction on movements and strict health guidelines imposed to avert spreading the pandemic detrimentally affected the fisheries sector, disrupting the activities of the key actors of the value chain. Thus, the year 2020 which consisted of non-impacted and impacted months with varying intensities helps compare the implications of COVID-19 on the fisheries sector of Sri Lanka.

2.2. Data collection strategy

The present study empirically ascertained the implications of COVID-19 pandemic on the marine capture fisheries sector of Sri Lanka, hereinafter termed as fisheries sector, targeting all the actors in the value chain except exporters. Sri Lanka consisted of 15 fisheries administrative districts, and the study was carried out at 47 sampling sites, from December 2020 to March 2021, covering 11 fisheries administrative districts that represented 68 % of the total active fishers in Sri Lanka (Table 1). Primary data were collected from the respondents (n = 326) belonging to five key actors of the value chain namely fishers, fish processors, intermediaries, input suppliers and consumers, all of which except consumers included at least two types of stakeholders (Table 2). Respondents from each actor/stakeholder at each sampling site were selected using snowballing sampling method [19].

Primary data were collected by administrating a pre-tested questionnaire that consisted of direct and open-ended questions. The questionnaire was structured to distill different dimensions of the impact of COVID-19 on the fisheries sector, focusing on demographic status, production & income (daily, monthly), labour utilization, the extra cost incurred in following health guidelines, livelihood strategies and, income of fisher spouse, livelihood assets, support extended by the Government of Sri Lanka and other entities, and adaptive capacity of respondents. Interviews, conducted in pairs strictly following COVID-19 safety protocols [20] were carried out in the native language of the respondents (Sinhala and Tamil). In addition, the veracity of the collected data was confirmed through key informant interviews conducted with Fisheries inspectors and District Fisheries Officers, and focus group discussions carried out at fishery harbours/ fish landing sites and respective Fisheries Inspector offices. Secondary data on total fish production of the fisheries sector during 2016–2020 were obtained from the MoFAR, Sri Lanka [16].

2.3. Data analysis

Qualitative and quantitative data collected from each stakeholder were analyzed separately for the sampling sites, fisheries administrative districts, and the country as a whole, all of which were aptly presented. Production and income of each actor/stakeholder were computed as the monthly and quarterly average values. Fish production in 2020 was analyzed on monthly basis to compare with the COVID-19-time scale. Monthly income, expenditure, and the number of working hours or days of key actors/stakeholders were computed as average values. Extra costs incurred by each actor/stakeholder were computed as a percentage of the monthly income. Primary and secondary data were exported and analyzed in the IBM SPSS 25 edition. Secondary data collected from the MoFAR were analyzed as monthly and quarterly average fish production. Kruskal-Wallis post-hoc pairwise comparison was employed to compare quarter-wise differences in production and income of different actors/stakeholders. One-Way ANOVA was performed to compare the changes in production yearly and quarterly from 2016 to 2020. Currency conversions were made basing on the rates on March 2021 as 1 USD = 199.52 LKR.

Table 1
Representation of respondents from fisheries administrative districts of Sri Lanka.

Fisheries district	Number of respondents	Percentage (%)
Negombo	43	13.2
Trincomalee	11	3.4
Puttalam	23	7.1
Chilaw	28	8.6
Matara	55	16.9
Tangalle	44	13.5
Jaffna	41	12.6
Mullaitivu	19	5.8
Mannar	16	4.9
Colombo	21	6.4
Kalutara	25	7.7

Table 2
Stakeholders of the fisheries sector belong to different actors and, the composition of the respondents.

Actors	Stakeholders	Composition (%)
Fishers	Non-mechanized traditional boats (NTRB) - Theppam	6.0
	Non-mechanized traditional boats (NTRB) - Wallam	5.0
	Out-Board Engine Fiberglass Boats (OFRP)	24.0
	Inboard Multiday boats (IMUL)	18.0
	Beach seine (BS)	8.0
Fish processors	Dried fish processors	3.68
	Maldives fish processors	1.84
	Fish processors	1.23
Intermediaries	Wholesalers	9.0
	Retailers	7.0
Input suppliers	Ice suppliers	2.0
	Fuel suppliers	2.0
	Net and engine repairer	2.0
Consumers	Consumers	10.0

Impacts of COVID-19 pandemic on actors/stakeholders, distilled from the respondents were summarized and organized into 10 impact categories as the impact on; (a) health and safety, (b) production, (c) marketing, (d) income, (e) access to fishing/related activities, (f) labour scarcity, (g) operational expenditure, (h) value-added product, (i) alternative livelihoods, and (j) consumer preference. These impact categories were used to assess the implication of COVID-19 on actors/stakeholders and finally for each fisheries administrative district.

Impacts of COVID-19 pandemic on each stakeholder were computed using the responses under 10 impact categories as percentages, separately. Percentage response considered as the severity of the impact on each impact category was arranged into ranges and, each range was assigned a score (from 0 to 5), following the Likert scale that consisted of six evaluation categories. Evaluation categories in the Likert scale were named to denote the impact levels. In this context, the severity of impact derived from the respondents for an impact category between 76 % and 100 % was assigned the score of 5 ('severe' impact), while no impact on respondents for an impact category (0 %) was assigned the score 0 ('no' impact). Having the percentage response between 26 % and 50 % for an impact category was assigned the score of 3 ('moderate' impact). Likewise, based on the percentage responses of respondents, scores 1, 2, and 4 were assigned 'very low', 'low' and 'high' impact levels for respective impact categories. The severity of impacts, calculated as percentage response for each impact category, the respective score assigned, and categories of the Likert scale to denote impact level are given in Table 3.

The overall impact of COVID-19 on the respective district was computed on the ICOV-19AF scale (Impact of covid-19 on fishery) by pooling responses of all respondents disregarding the type of actors/stakeholders. Here also, scores assigned (0−5) for 10 impact categories were similarly employed to elucidate the impact level through the ICOV-19AF scale which was determined using the mode value of the scores assigned to 10 impact categories in concern. In this context, the same Likert scale, having six categories (Table 3) was used to elucidate the overall impact level from 'no' impact to 'severe' impact. Thus, having mode value 5 was identified as the 'severe' impact, and also having mode value 1 was identified as a 'very low' impact. Having mode values, 2, 3, and 4 were identified as "Low", 'Medium" and 'High" impacts, respectively for the fisheries sector of each fisheries administrative district.

Table 3
Likert scale categorizing impact levels, score assigned concerning the severity of the impact.

Severity of Impact (%)	Assigned Score	Impact Level
0	0	No
1–10	1	Very Low
11–25	2	Low
26–50	3	Moderate
51–75	4	High
76–100	5	Severe

Stakeholders' responses to the measures taken by them to mitigate the impacts of COVID-19 and the adaptive capacity of the actors/stakeholders were appropriately summarized. To assess the overall status and help identify the priorities and most efficient response measures, DPSIR (Driver-Pressure-State-Impact-Response) framework was constructed to address the changes happening in the social system of the sector, describing how COVID-19 pandemic exerts pressure on the fisheries sector during the peri-pandemic period. In this context, COVID-19 pandemic was taken as the Driver and, the Response was triggered by Impacts in the constructed framework. The State of the fisheries sector was altered by the Driver considered in the framework.

3. Results

Present results elaborated survey responses of key actors of the fisheries sector that included fishers, fish processors, intermediaries, input suppliers, and consumers, all of which but the latter included at least two stakeholders. The majority of the respondents were fishers (61 %), fishing with Fibre Reinforced Plastic Boats with Outboard Motor (OFRP) boats, Inboard Multi-day (IMUL) boats, beach seine (BS), and Non-mechanized Traditional Boats (NTRB), while the minority were input suppliers (6 %). Of the respondents, 91.7 % were males and the rest (8.3 %) were females, and the age of the respondents ranged between 22 and 71 years.

The net income of all the stakeholders except intermediaries was 1500–4250 LKR (≈ 8–21 USD) per day. The number of working hours per day and working days per month varied amongst stakeholders, thus their income and expenditure varied accordingly. Intermediaries held the highest monthly household income and expenses, while the lowest income and expenditure were recorded from NTRB fishers (Table 4). COVID-19 pandemic directly affected the fisheries sector, resulting in a reduction of production due to restricted/ no access to fisheries/ related activities that led to reducing the number of working hours/day and days/month, and the availability of labour force.

Total marine capture fisheries production over the past 5 years indicated a clear decline in 2020. Total marine capture fisheries production in Sri Lanka was within the range of 415,490–456,990 metric tonnes (MT) during 2016–2019, and the respective figure in 2020 was only 326,930 MT, indicating a 21.3 % decrement from 415,490 MT in 2019 (Fig. 1). Average fish production per month from 2016 to 2019 was

Table 4
Engagement in fishing/ related activities and financial status of the stakeholders in the fisheries sector of Sri Lanka (income and expenditure are in LKR, and the respective values in USD are in parenthesis).

Actor/ Stakeholder	Number of working hours/ day	Number of working days/ months	Monthly household income	Monthly household expenditure
NTRB fishers	7 ± 0.43	22 ± 0.92	39823 (≈200)	39470 (≈198)
OFRP fishers	8 ± 0.33	20 ± 0.71	53357 (≈267)	42184 (≈211)
IMUL fishers	13 ± 0.57	24 ± 0.69	66263 (≈332)	65350 (≈328)
BS fishers	7 ± 0.69	25 ± 1.66	69190 (≈347)	68571 (≈344)
Processors	9 ± 0.91	24 ± 1.51	77071 (≈386)	76500 (≈383)
Intermediaries	8 ± 0.82	26 ± 0.84	133450 (≈669)	113500 (≈569)
Input suppliers	8 ± 1.34	26 ± 0.95	75000 (≈376)	72800 (≈365)

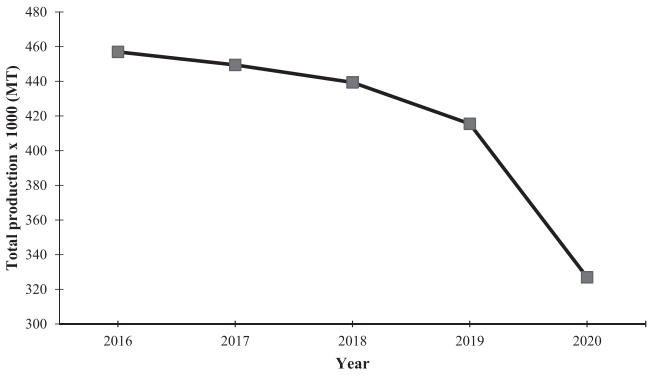

Fig. 1. Trend in total marine capture fisheries production in Sri Lanka from 2016 to 2020.

38,083 ± 3225, 37,453 ± 3084, 36,614 ± 2916, and 34,624 ± 2579 MT, respectively, all of which were significantly higher ($p < 0.05$) than that of the year 2020 (27,244 ± 5613 MT). Quarterly analysis of the production during 2016–2020 further confirmed the significant decline ($p < 0.05$) in production during 2020 (Fig. 2). Detailed analysis indicated that there was no significant difference in production ($p = 0.171$) of the first quarter (Q1) in the years from 2016 to 2020. Total marine fish productions in the second (Q2), third (Q3) and fourth quarter (Q4) of the year 2020 were significantly lower ($p < 0.05$) than that of the years from 2016 to 2019 (Table 5).

The resultant decline in total fish production in 2020 surfaced since the first Sri Lankan was found infected (Fig. 3). Restrictions on movements imposed by the government compelled fishers to stay at home. And it indirectly affected labour availability necessary for the sector which led to operating fishing/ related activities with the minimum labour force, especially in IMUL, BS fisheries, and dried fish production all of which required divisions of labour and a high labour force. Variation in fish production affected stakeholders with different magnitudes and, income variation among stakeholders was in par with the decline in production. Kruskal-Wallis post hoc pairwise comparisons performed to identify the quarterly variation in production and income of each actor/ stakeholder in 2020 are in Table 6.

Differences in production (kg) and income (LKR) per actor/stakeholder during 2020 elucidated the impacts of COVID-19 pandemic on the fisheries sector in Sri Lanka. The average income of stakeholders in each quarter was directly proportional to the quarterly average production of all stakeholders but NTRB fishers, BS fishers, and fish processors. Of the fishers, quarterly production amongst fishers fishing using NTRB and OFRP boats in 2020 was significantly different ($p < 0.05$), and their fish production in Q2 and Q4 were comparatively lower. The highest and lowest production of NTRB fishers were recorded

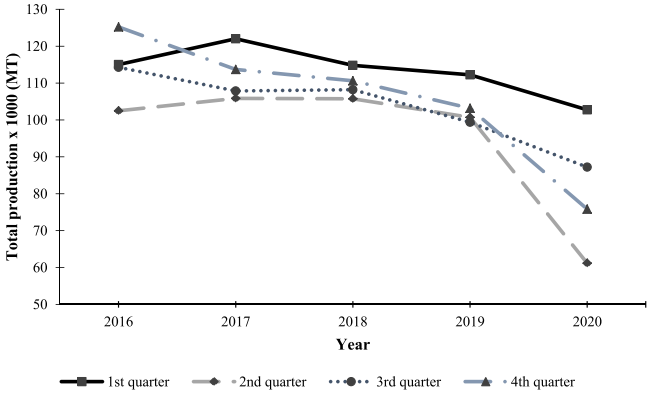

Fig. 2. Quarterly total marine capture fisheries production in Sri Lanka during 2016–2020.

Table 5
Quarter-wise average monthly production of the marine capture fisheries sector in Sri Lanka during 2016–2020.

Quarter	Production (MT)				
	2016	2017	2018	2019	2020
Q1	38337 ± 2150[a]	40677 ± 1993[a]	38266 ± 1972[a]	37410 ± 3929[a]	34247 ± 3549[a]
Q2	34157 ± 1860[a]	35287 ± 3795[a]	35247 ± 4242[a]	33570 ± 1640[a]	20387 ± 1469[b]
Q3	38097 ± 2230[a]	35953 ± 1895[a]	36073 ± 3518[a]	33130 ± 659[ab]	29073 ± 994[b]
Q4	41740 ± 932[a]	37897 ± 2014[ab]	36870 ± 2248[b]	34387 ± 1138[b]	25270 ± 1599[c]

*Means (± SD) with different superscripts letters in each year (a, b, c) were significantly different ($p < 0.05$).

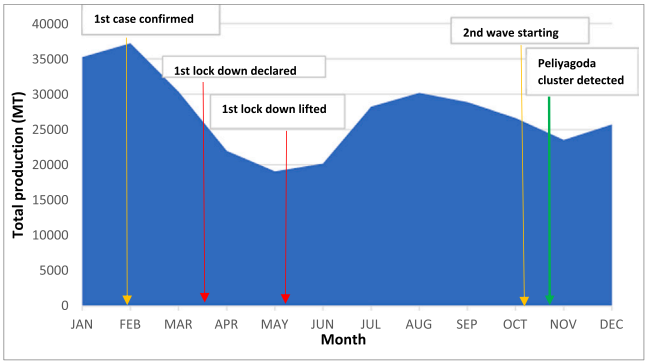

Fig. 3. Variation in total marine capture fisheries production in Sri Lanka during 2020 along with the COVID-19 time scale.

in Q1 (1514 ± 574) and Q2 (481 ± 117), respectively. The income of NTRB fishers was the highest in Q1 (162,522 LKR; ≈815 USD) and the lowest in Q2 (65,245 LKR; ≈327 USD). The lowest production in OFRP fishers (1022 ± 183) was in Q2 and the highest production (1817 ± 257) was in Q1. In line with the production, the income of the OFRP fishers was highest in Q1 (295156 LKR; ≈1479 USD) and the lowest (102,407 LKR; ≈513 USD) in Q2. Fish production in IMUL and BS fishers showed a similar trend, even though quarterly productions were not statistically significant ($p > 0.05$). Average production of IMUL fishers in Q1, Q2, Q3 and Q4 were 10,136 ± 2589, 7881 ± 1757, 9370 ± 2084 and 8393 ± 1387 kg, respectively. The highest income of the IMUL fishers was recorded in Q1 (944,677 LKR; ≈4735 USD) while their lowest value was recorded in Q2 (595,790 LKR; ≈2986 USD). BS fishers gained the highest (4950 ± 1060) and the lowest (3236 ± 785) production in Q1 and Q2 respectively. The highest (379,841 LKR; ≈1904 USD) and the lowest (162,464 LKR; ≈814 USD) income of BS fishers were recorded in Q1 and Q3, respectively. The highest (16,183 ± 13,436) and lowest (1318 ± 508) production of fish processors were recorded in Q1 and Q2 respectively, and their highest and lowest income was also recorded in Q1 and Q2 respectively. Quarterly production purchased by the intermediaries as well as the consumer preferences in each quarter were significantly different ($p < 0.05$). Moreover, average production purchased by intermediaries in Q1, Q2, Q3 and Q4 were 16,058 ± 4972, 8612 ± 3088, 8715 ± 2.441 and 7581 ± 3462 kg, respectively. Quarterly variations in average production and income of key actors/stakeholders are depicted in Fig. 4. Of the input suppliers, ice production (kg) in Q1, Q2, Q3, and Q4 were 419708 ± 395123, 296080 ± 276055, 414690 ± 396368, and 360308 ± 311022 kg, respectively. Quarterly average production and income of the processors, intermediaries and input suppliers are in Table 7.

Health and safety-related measures taken by almost all stakeholders in the sector positively affected to increase in their total recurrent

Table 6
Kruskal-Wallis post hoc pairwise comparison of quarterly production and income amongst all actors/stakeholders of marine capture fisheries sector in Sri Lanka during 2020.

Actor/ Stakeholder	Variable (α)	Pairwise comparison (β)							
		Production				Income			
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
NTRB fishers		Test significant (H(3)= 9.890, p = 0.020)				Test significant (H(3)= 17.153, p = 0.001)			
	Q1	–				–			
	Q2	0.010	–	ns	ns	0.001	–	ns	ns
	Q3	ns		–		0.007		–	ns
	Q4	ns		ns	–	0.022			–
OFRP fishers		Test significant (H(3)= 13.634, p = 0.003)				Test significant (H(3)= 25.277, p = 0.000)			
	Q1	–				–			
	Q2	0.002	–	ns	ns	0.00	–	ns	ns
	Q3	ns		–		0.005		–	
	Q4	ns		ns	–	0.004		ns	–
IMUL fishers		Test not significant (H(3)= 1.922, p = 0.589)				Test not significant (H(3)= 7.759, p = 0.051)			
BS fishers		Test not significant (H(3)= 2.212, p = 0.530)				Test not significant (H(3)= 5.394, p = 0.145)			
Processors		Test not significant (H(3)= 4.063, p = 0.255)				Test not significant (H(3)= 2.907, p = 0.406)			
Intermediaries		Test significant (H(3)= 8.076, p = 0.044)				Test significant (H(3)= 10.359, p = 0.016)			
	Q1	–				–			
	Q2	0.035	–	ns	ns	0.038	–	ns	ns
	Q3	ns		–		ns		–	
	Q4	ns		ns	–	ns		ns	–
Input suppliers		Test not significant (H(3)= 0.650 p = 0.885)				Test not significant (H(3)= 1.695, p = 0.638)			
Consumers		Test significant (H(3)= 9.601 p = 0.022)* *							
	Q1	–							
	Q2	0.013	–	ns	ns				
	Q3	ns		–	ns				
	Q4	ns			–				

ns= not significant at 0.05 * * consumption was considered for consumers.
α and β are the samples 1 and 2, respectively. p values are mentioned for the significant comparisons. Significance values were adjusted by Bonferroni correction for multiple tests.

expenses. Five percent of the total respondents or their close family members were infected with COVID-19. Almost all respondents (99 %) followed health and safety guidelines while performing their activities, whereas the rest (1 %) neglected the imposed health and safety guidelines. In complying with health and safety measures, each stakeholder incurred an extra cost depicted in Fig. 5.

In par with the decline in production and income, changes in fish price and sales were the most common negative impacts experienced by the actors/stakeholders. In addition, stakeholders experienced some other impacts, and their level of impact was stakeholder specific. Some of the impacts severely affected some stakeholders while the others created very low or no impact on the same or other stakeholders. Marketing and income-related issues similarly affected each stakeholder. However, impacts on the stakeholders of dried fish & Maldive fish industry during peri-pandemic were comparatively low over the other stakeholders. Major issues/ impacts categories and level of the severity and impacts of COVID-19 on stakeholders of the fisheries sector are in Table 8.

ICOV-19AF scale, calculated for each fishery district indicated that the severity of the overall impact on the fisheries sector was not identical, and it varied from minor to high. All the fisheries districts were impacted by the pandemic. Colombo, Chilaw, and Kaluthara districts were highly impacted, while Mannar, Mullaitivu, and Jaffna districts were shown to have very low impacts. Also, the Negombo fisheries district had a moderate to high impact. Puttalam and Matara districts were affected moderately, whereas Tangalle and Trincomalee fisheries districts showed a low level of impact (Fig. 6).

The Government of Sri Lanka had taken several steps to mitigate the negative impacts of the pandemic on the fisheries sector through fisheries-related institutions and formal and informal community-based organizations. In this context, Ceylon Fisheries Cooperation (CFC), affiliated with the MoFAR had alone purchased 15 % of fish harvest during the peri-pandemic period. Moreover, 47 % of stakeholders were provided with financial subsidies by the Government of Sri Lanka to recover the loss of income while 4 % of stakeholders were given financial subsidies from community-based organizations and Non-governmental organizations (NGOs). Albeit, 34 % of respondents were not benefited from any of the support. However, only 9 % of the stakeholders were satisfied with the received subsidies/ support, and 91 % of the respondents expected government intervention in hampering the negative impacts of COVID-19, including subsidies, stabilizing the price, and relief for repayment of loan installments (Table 9).

COVID-19 hampered the economic activities of the key actors, and also the activities and income of their spouses. 27 % of fisher wives engaged in the fisheries sector directly or indirectly. Of them, 31.8 % of fisher wives engaged in dried fish production while 27.2 % of them engaged in cleaning nets and fish sorting. Moreover, 25 % of them actively engaged in selling fish at retail markets. The rest of them engaged in net repairing (11.4 %) and running small shops at the fish landing sites (4.5 %).

Stakeholders of the fisheries sector adopted several measures to avert the negative impact of COVID-19. Some of them affected positively whilst others affected negatively in the fisheries sector. 15.3 % of the stakeholders changed fishery or fishery-related activity to other alternative livelihood strategies. 14.7 % of the wholesalers/ retailers changed in selling strategy to doorstep delivery. In this context, stakeholders used mobile and online communication methods. To compensate for the labour scarcity, 5.8 % of respondents implemented a rotatory system in employing crewmembers, and 3.4 % of the respondents continued fishing with a minimum number of crewmembers. Production of value-added products (2.5 %), use of preservatives (12 %), etc were initiated as measures to reduce postharvest losses of unsold fish increased due to the reduction of consumer demand. Moreover, changes in fishing behaviour (4.3 %), number of fishing gears used (2.1 %), number of days engaged in the fishery (6.1 %), as well as changes in fish landing sites (2.8 %) were some other adoptive measures used to avert the change in demand for fish.

COVID-19 was identified as the Driver that affected the social system of the fisheries sector. All the social responses against the Driver (COVID-19) were triggered by impacts on society. Changes in the

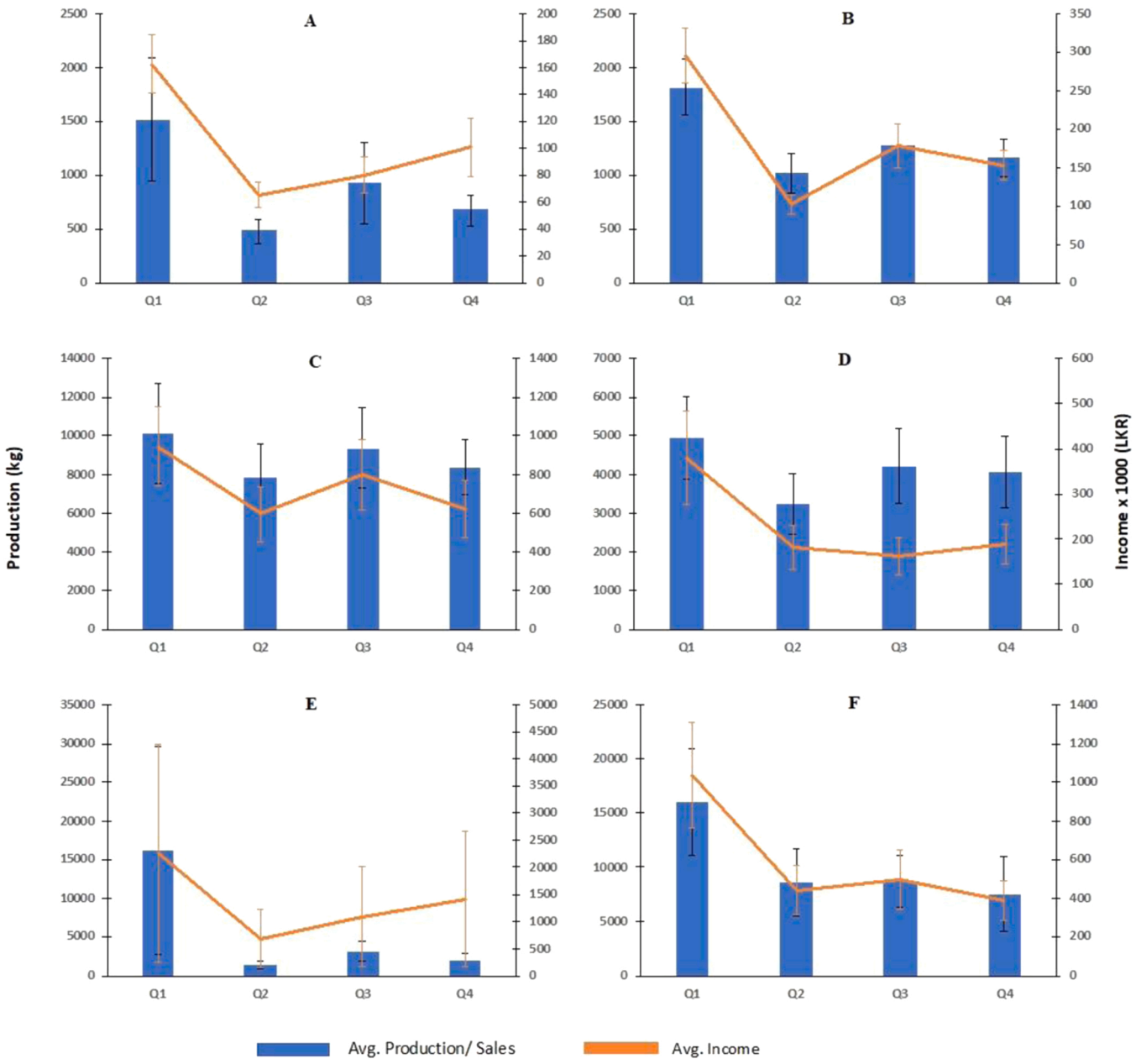

Fig. 4. Quarter-wise average monthly production and income of actors/stakeholders of the fisheries sector in Sri Lanka during 2020 (A: NTRB fishers, B: OFRP fishers, C: IMUL fishers, D: BS fishers, E: Processors, F: Intermediaries).

Table 7
Quarter-wise monthly production and income of stakeholders categorized into processors, intermediaries and input suppliers of the fisheries sector in Sri Lanka during 2020 (income is in LKR and the respective values in USD are in parenthesis).

Actor	Stakeholder	Production (kg)				Income			
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Processors	Dried fish producers	1288	693	836	670	178508 (≈895)	103777(≈520)	124831 (≈626)	126577 (≈634)
	Maldive fish producers	701	588	1159	606	370536 (≈1857)	223339 (≈1119)	259821 (≈1302)	221714 (≈1111)
	Fish processors	91688	4625	13975	8850	12375000 (≈62024)	624500 (≈3130)	3742500 (≈18758)	3186250 (≈15970)
Intermediaries	Retailers	994	526	519	804	247262 (≈1239)	137972 (≈692)	121962 (≈611)	221990 (≈1113)
	Whole sellers	37285	20007	20263	17130	1848287 (≈9264)	838534 (≈4203)	953973 (≈4781)	480939 (≈2410)
Input suppliers	Ice suppliers	419708	296080	414690	360308	741020 (≈3714)	420900 (≈2110)	961650 (≈4820)	553700 (≈2775)
	Fuel suppliers	–	–	–	–	4665000 (≈23381)	2167500 (≈10864)	2872500 (≈14397)	2296000 (≈11508)
	Net and gear repairers	–	–	–	–	163333 (≈819)	38333 (≈192)	137000 (≈687)	38333 (≈192)

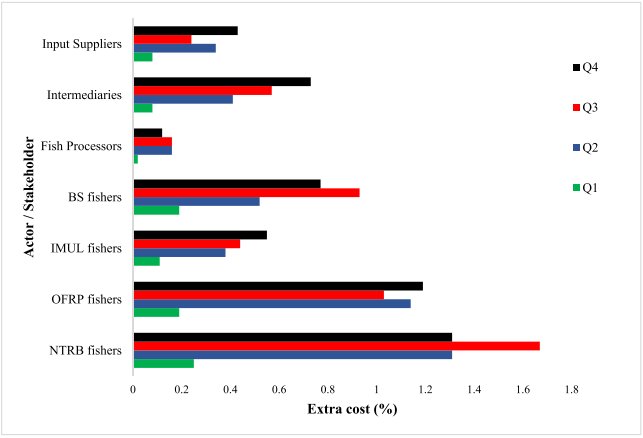

Fig. 5. Extra cost incurred by key actors/stakeholders of the fisheries sector to avert COVID-19 health risk in Sri Lanka.

behavior of stakeholders exerted pressure on the social system and state attributes exposed the status of the social system of the fisheries sector. The DPSIR framework constructed for the changes in the social system of the fisheries sector during the peri-pandemic 2020 is depicted in Fig. 7.

4. Discussion

Present findings empirically confirmed that COVID-19 pandemic has negatively affected the fisheries sector of Sri Lanka. Policy measures taken by the Government of Sri Lanka to curb the pandemic have significantly disrupted the activities of the key actors in the fisheries value chain. COVID-19 has created a systemic shock to the fisheries sector of Sri Lanka, putting stakeholders in uncertainty about their income which falls them into poverty, if they do not develop a coping strategy. Present findings are in par with Labourde and others [21] in which the authors predicted that 90–150 million people are fallen into extreme poverty, especially in Asia and Africa. The present study is significant and the outcome would be an important document for policymakers as the fisheries sector of Sri Lanka supports millions of people through direct and indirect employment and livelihoods [16]. Also, the study unfolds the socio-economic impacts of COVID-19 on key actors of the fisheries value chain, dwelling in the 11 fisheries districts of Sri Lanka.

The vast majority of the stakeholders are from the harvesting sector in which males dominate in developing countries [22] whereas females engaged in pre and post-harvesting sectors [23] are the minority in the sample (8.3 %). In the pre-pandemic situation, the daily wage and monthly income of the stakeholders are well above the national minimum daily wage and monthly income of the workers of Sri Lanka which are 500 LKR (≈3 USD) and 12,000 LKR (≈60 USD), respectively [24,25]. This is evident that the minimum household income of the stakeholders in the fisheries sector is much higher than that of the workers in the other sectors in Sri Lanka. Relatively higher income of the stakeholders in the sector motivates them to account for high monthly household expenditure. However, this scenario has been changed during the peri-pandemic period. Mitigation measures taken to curtail the outbreak of the pandemic have ceased activities of the stakeholders, thereby affecting on food security of the people who rely on seafood for animal protein and essential micronutrients [26]. Marine capture fisheries production in recent pre-pandemic years (2016–2019) is relatively stable [16] but it decreases in 2020 by about one-fifth (20 %) due to the pandemic. In addition, statistics of the peri-pandemic 2020 help identify the changes in production and income of the stakeholders in the sector. The first wave of COVID-19 pandemic began at the end of the first quarter of 2020 (Q1), amid March, and the rest of the quarters (Q2-Q4) have been influenced by the pandemic with a varying magnitude of severity. Marine capture fisheries production in the year 2020 is well accompanied by COVID-19-time line, and the production in Q1 of 2020 which experiences the minimum influence from the pandemic is in line with Q1 of the recent pre-pandemic years (2016–2019). Present findings indicate the significant negative impact of COVID-19 on the production of all key actors of the fisheries value chain. And the findings are well supported by the total marine capture fisheries production of the country during 2015–2020. With the first wave of the pandemic, the supply chain of the fisheries sector has been disrupted and negatively influenced. In line with [27], curfew and curtailment of movements have caused impediments to long-distance marketing and distribution of fish in Sri Lanka. Intermediaries have not been able to deliver fish and fishery products to major fish markets in cities, suburbs, and the countryside due to imposed travel restrictions, limitations on operating hours of wholesale and retail markets, and shortage in labour supply. As a result, intermediaries have ceased buying fish or bartered for lower prices which leads to partially or closed fishing operations. Social distancing has precluded fishers from fishing activities, due to fleet size

Table 8
Severity and impact levels of COVID-19 on stakeholders of the fisheries sector in Sri Lanka during 2020.

Impact category	The severity of impact (%) & Impact level							
	NTRB fishers	OFRP fishers	IMUL fishers	BS fishers	Fish processors	Intermediaries	Input suppliers	Consumers
a. Health & safety	80 (Severe)	80 (Severe)	91 (Severe)	92 (Severe)	85 (Severe)	90 (Severe)	82 (Severe)	80 (Severe)
a. Production	10 (Very low)	18 (Low)	36 (Moderate)	29 (Moderate)	41 (Moderate)	21 (Low)	43 (Moderate)	–
a. Marketing	54 (High)	50 (Moderate)	61 (High)	67 (High)	38 (Moderate)	74 (High)	45 (Moderate)	–
a. Income	57 (High)	45 (Moderate)	43 (Moderate)	64 (High)	40 (Moderate)	57 (High)	68 (High)	–
a. Access to fishing/related activities	31 (Moderate)	39 (Moderate)	51 (High)	32 (Moderate)	10 (Very low)	29 (Moderate)	39 (Moderate)	–
a. Labour scarcity	10 (Very low)	10 (Very low)	46 (Moderate)	65 (High)	54 (High)	40 (Moderate)	35 (Moderate)	–
a. Operational expenditures	20 (Low)	23 (Low)	39 (Moderate)	18 (Low)	42 (Moderate)	40 (Moderate)	34 (Moderate)	–
a. Value-added products	0 (No)	15 (Low)	58 (High)	20 (Low)	64 (High)	40 (Moderate)	–	–
i. Alternative livelihoods	70 (High)	55 (High)	15 (Low)	54 (High)	21 (Low)	38 (Moderate)	42 (Moderate)	–
a. Consumer preference	–	–	–	–	–	–	–	45 (Moderate)

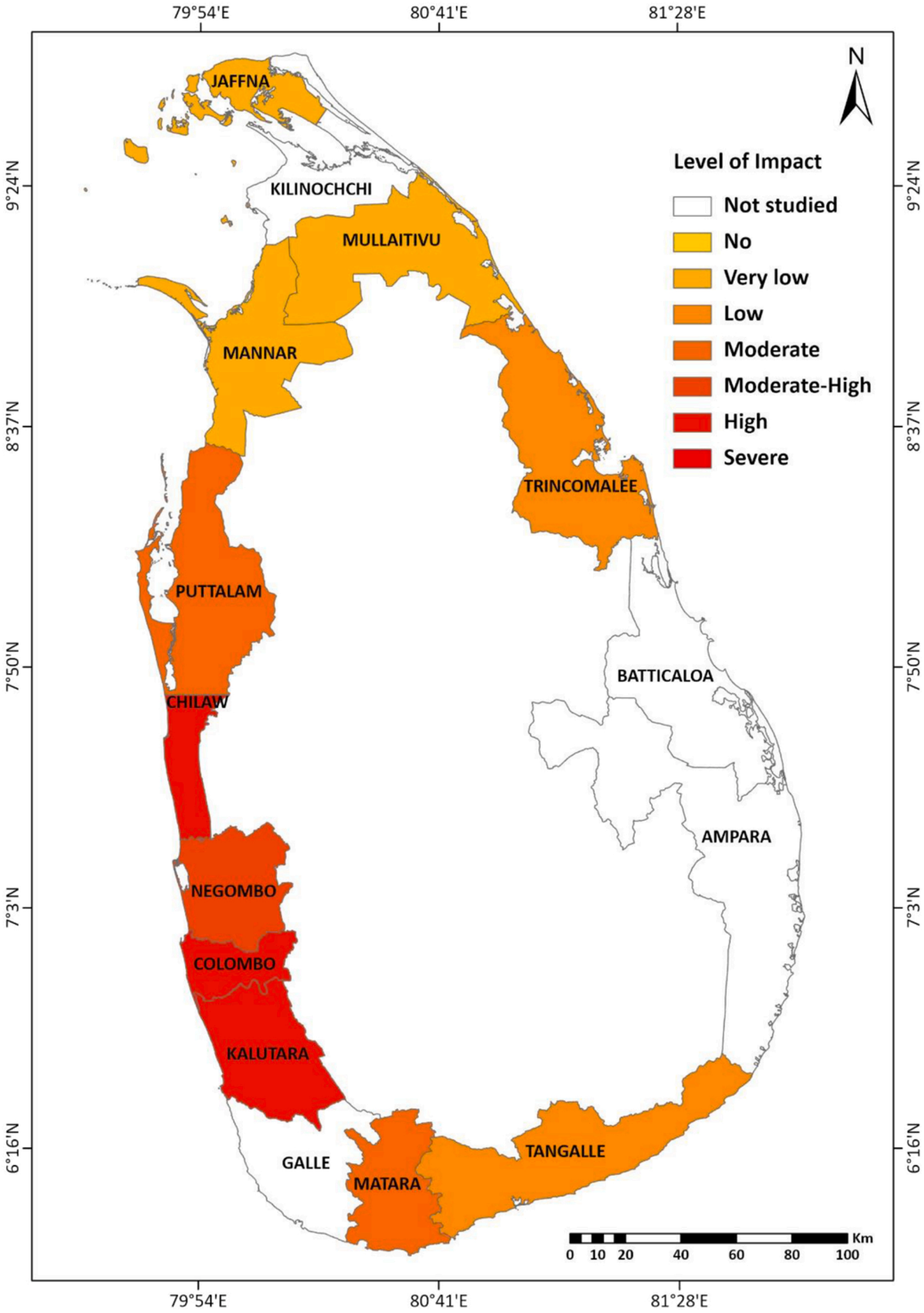

Fig. 6. Severity of impact of COVID-19 pandemic on fisheries sector at each fisheries administrative district of Sri Lanka.

Table 9
Support anticipated by stakeholders of the fisheries sector in Sri Lanka to avert negative impacts of COVID-19.

Support category	Response	
	Frequency	Percentage
Subsidies	134	41.1
Price stabilization	62	19.0
Relief for repayments of loan instalments	33	10.1
Health insurance	18	5.5
Strengthen CFC to purchase fish	17	5.2
Storage facilities	12	3.7
Reduction of input prices	10	3.1
Infrastructure development	8	2.5
Provision of sanitary facilities	8	2.5
Measures to eradicate the COVID-19 pandemic	4	1.2

or trading in close quarters in fish markets or piers [11], and fleet operations are disrupted by the insufficient number of skilled workers. These circumstances created a path to reduce family income and piled up unsold quantities of fish catch due to the resultant reduction in fish production and demand for fish.

Quarterly analysis of total production in 2020 evident that direct impacts of COVID-19 on the fisheries value chain have negatively affected the well-being of the stakeholders in the fisheries sector. The second wave of COVID-19 began at the beginning of Q4 with the epicentre of the Central fish market of Sri Lanka (Peliyagoda) where intermediaries assemble for the marketing and distribution of fish over the country. Due to the nature of fish marketing approaches, in agreement with [14], stakeholders have potentially become 'hotspots' for rapid COVID-19 infection. This incident alters consumer attitude towards fish consumption due to the common notion that fish can carry and transmit the virus to humans while handling and cleaning. Stakeholders have faced risks of COVID-19 spread and infection, and mitigating measures have further limited the activities of the key actors in the value chain, such as fishing, selling and buying of fish, ice production, and meddling gill nets. Labourers face social, economic, and mobility issues due to the curtailment of movements. Boat owners have encountered problems in finding labourers to continue fishing operations and activities. These factors have inevitably disrupted the fisheries value chain and changed in fish production in peri-pandemic 2020, causing trajectory effects on the socio-economic well-being of the people which may last for many years.

In-depth analysis is evident that COVID-19 pandemic has affected different stakeholders with varying magnitudes. Fishers, notably small-scale fishers and intermediaries, solely depending on fishers have been impacted significantly more than the other fishers (IMUL and BS fishers), and input suppliers. The corresponding decline in income of the stakeholders completely coincides with the production and COVID-19-time line. Small-scale fishers (NTRB, OFRP) experience a significant reduction in production while BS fishery which is community oriented and labour-intensive [28,29] experience a reduction in income mainly due to labour scarcity and lower market demand. This implies that small-scale coastal fishers are highly vulnerable to the pandemic [6] than offshore multiday fishers. The income and production of fish processors follow the same trend due to the collapse in production and consumer preferences. As a whole, the income and production of stakeholders have slashed in Q2 and Q4 of 2020. The primary reasons behind these collapses are the implementation of a two-month lockdown period that lies in Q2 and the beginning of the second wave in Q4 at the Central Fish Market, Peliyagoda. Reduction in fish demand and sales lead remarkable increase in the production of dried and Maldive fish, but the selling price of dried and Maldive fish has dropped owing to excess production, reducing the income of dried and Maldive fish processors.

Health status and safety control measures which are very common among almost all stakeholders have impacted significantly on all actors of the value chain. It has been mandatory to strictly follow the health guidelines and measures which incur an extra cost that in turn increases the total expenditure of the value chain actors. In addition, several other factors which are stakeholder-specific have affected stakeholders of the sector. Labour scarcity severely affects BS fishery, offshore fishery, and the other key actors, such as fish processors, intermediaries, and input suppliers. The second wave has declined consumer preference significantly. The severities of impacts, assessed by grouping responses into

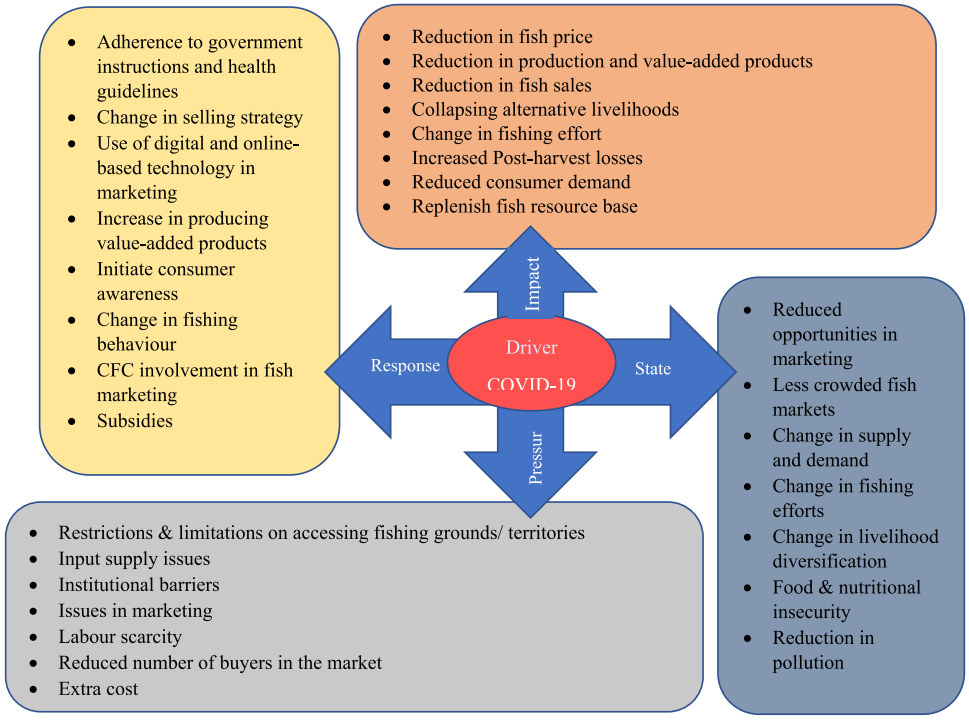

Fig. 7. DPSIR assessment framework constructed for the social system of stakeholders in the fisheries sector of Sri Lanka during 2020.

impact categories confirm the impact of COVID-19 pandemic on each stakeholder. The severity level of each impact category on stakeholders varies from one to another and, almost all stakeholders are affected by multiple impacts with different intensities from severe to low levels. Present analysis implies that COVID-19 has severely disrupted the well-being of all stakeholders in the fisheries sector and, it illuminates the underline crises of the sector embedded in the pre-pandemic system [30].

Impact levels assessed through the ICOV-19AF scale show an intact relationship with the population density of each fisheries district. Fisheries districts consisting of high population density have been affected more intensively than those with low population density. ICOV-19AF scale indicates high impacts in Colombo, Kaluthara and Chilaw districts within which a higher number of COVID-19 infected patients has been reported. Districts with a lesser number of COVID-19 cases have shown relatively a very low impact. These findings demonstrate that human health and COVID-19 impacts on the fisheries sector are interconnected, and the severity of impacts coincides with the number of infections in the area [2] and the population density. The severity of impact amongst fisheries districts indicates that fisheries districts in the western province that contribute a higher production to total fish production of the country have been highly impacted. Fisheries districts in Northern and Eastern provinces have shown very low and low impacts, while those in the southern province show moderate and low impacts. The map developed on the severity of impact visualizes the impact levels and provides signals for developing management policies, as fisheries are a vital source of employment, nutritious food, and income for millions of people and, the fisheries sector in developing countries is often considered marginalized and neglected [31].

The Government of Sri Lanka generally supports the fisheries sector by providing infrastructure facilities. Due to a lack of alternative livelihoods, stakeholders especially fishers and intermediaries whose income has collapsed significantly during the peri-pandemic period have been compelled to depend on government subsidies to compensate impacts of the pandemic. The Government of Sri Lanka has taken several steps to revive the industry through financial subsidies and other facilities including the declaration of fisheries as an essential service. Fisher wives engaged in self-employment for day-to-day subsistence have lost their income which affects the livelihoods and the well-being of the communities. All stakeholders in the fisheries value chain have faced social, economic, psychological, and physical challenges due to income loss, inability to support families, and repayment of loans. Consequently, stakeholders have taken several reactive and proactive measures to continue businesses in operation, showing the adaptive capacity to the changes in the social system. Stakeholders have changed the general practices of selling fish and fishery products directly to consumers through online marketing by placing orders over the phone and promoting other online-based technologies such as WhatsApp and Social media, similar to home delivery systems and online fish selling platforms already observed in Seattle [32], Ghana [33], and the United Arab Emirates [34]. Stakeholders have attempted food sharing, the revival of local food networks, an increase in local sales through direct marketing and deliveries, collective actions to safeguard rights, community-government collaborations, and reduced fishing pressure in some places. The adaptive capacity of stakeholders in coping with the impact of the pandemic even though it needs to be further developed has exposed critical flaws in the pre-pandemic fisheries system.

Despite the negative impacts that surfaced due to the onslaught of COVID-19, some beneficial effects on fisheries commons and habitats in the coastal marine environment have also been revealed. Restrictions on travel & movement and limitations in marketing & distribution of harvest have dropped fishing efforts that boost recovering the ecosystem and resources. Further, it leads to cutting off marine pollution and indirectly reducing anthropogenic disturbances on marine biota. However, the present study focused on the impacts of COVID-19 on the social system of the fisheries sector, rather than the impacts of the pandemic on the environment and resource base. Thus, the DPSIR framework, developed by the European Environmental Agency [35] has been employed to capture the state of the social system of the fisheries sector, as the DPSIR framework enables a good analysis of existing problems in the system [30]. The impact of COVID-19 pandemic that leads to change in the social system is considered a driving force in the framework. Activities of stakeholders exert pressure derived from the driving forces [36] on the system and, identified attributes of pressure are the key issues in the social system of the fisheries sector to be addressed, as future policy decisions should be focused on underlying drivers and the pressure derived from the stakeholder behaviour. State attributes unfold the status of the social system in the face of COVID-19 pandemic and discuss the factors that increase the vulnerability of the system to the pandemic. For a long-lasting solution for the issues in the fisheries sector, in addition to the driver, the state of vulnerability should be properly addressed. The attributes that change the social system of the sector are the impacts on the fisheries systems, and the attributes identified in the study significantly affect the well-being and economic prosperity of the stakeholder communities. Identified impact attributes warrant policy measures that should be formulated to address the impacts of the pandemic. Assessing vulnerability and impact helps initiate remedial actions for bouncing back to pre-pandemic status through responses and policies. Constructed DPSIR framework provides a conceptual analysis between change in the social system and driving forces responsible for that change together with the effects of pressure on the system and impacts on the livelihoods of the stakeholders in the sector. The DPSIR framework elucidates the necessity to improve the coping capacity of stakeholders to deal with the impacts of COVID-19. The key benefit of the framework is that it helps identify the actions or responses that have to be taken by stakeholders individually or collectively and government or other entities to ameliorate/ prevent the changes in the state of the social system or to compensate for the socio-economic impact on human wellbeing. As a whole, study findings through the lenses of the DPSIR framework highlights that priorities should go to the policies that reduce vulnerability.

5. Conclusion

Qualitative and quantitative analysis of the impacts of COVID-19 that overwhelmed the fisheries sector of Sri Lanka has revealed that defensive measures including nationwide lockdown, restrictions on movements and travel, and temporary closure of entities and business activities have given a shock to all stakeholders in the fisheries value chain. The pandemic has affected mainly the fisheries sector by reducing in production quantity and incomes of the stakeholders. Since the second wave of the pandemic of which the epicentre is the Central fish market in the country, consumer perception of consumption of fish & fisheries products have changed dramatically. The cumulative effects of the pandemic have caused devastating consequences to the socio-economic status of the stakeholders in the value chain, especially small-scale fishers and intermediaries. The Government of Sri Lanka has taken several steps to revive the sector, and the stakeholders have developed adaptive measures to cope with the impacts of the pandemic. In this context, the study has surfaced some positive initiatives and outcomes, all of which are far outweighed by the consequences of the pandemic. Therefore, long-term support to address the impact of COVID-19 in future requires developing more resilient stakeholder communities. The DPSIR framework provides a mechanism for planning and organizing information, identifying knowledge gaps, and stakeholder concerns. As the DPSIR framework has been widely lauded as a communication tool among policymakers, it enables feedback to decision-makers in taking policy decisions which are to be made in the future. Present findings help recommend several approaches and interventions for further strengthening the adaptive capacity of stakeholders to be better prepared for similar challenges and threats in future. Briefly, these recommendations include; (1) strengthening the social

safety net of the communities, (2) increasing livelihood diversification to reduce high dependency on fishery and provide alternative sources of income, (3) increasing the socio-economic status of communities through savings, credits and insurance, (4) improving marketing and distribution through new strategies and techniques, (5) reducing marketing uncertainties through improving facilities and promoting value-added products, and (6) introducing value chain upgrading through the concept of value chain development for sustainable fisheries. It is evident that present crises in the sector are far from over, and thus short-term impacts unfolded in the present work are likely to be followed by mid-term and long-term crises, thus appropriate policy measures should be formulated to revitalize the industry into new normal conditions and post-pandemic era.

Conflicts of Interest

The authors declare no conflict of interest.

Data availability

Data will be made available on request.

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