Aquaculture 531 (2021) 735922

Contents lists available at ScienceDirect

Aquaculture

journal homepage: www.elsevier.com/locate/aquaculture

Prospective impact of Corona virus disease (COVID-19) related lockdown on shrimp aquaculture sector in India – a sectoral assessment

M. Kumaran*, R. Geetha, Jose Antony, K.P. Kumaraguru Vasagam, P.R. Anand, T. Ravisankar, J. Raymond Jani Angel, Debasis De, M. Muralidhar, P.K. Patil, K.K. Vijayan

ICAR-Central Institute of Brackishwater Aquaculture, 75, Santhome High Road, Chennai 600 028, India

ARTICLE INFO

Keywords:
COVID-19
Shrimp aquaculture
Impact assessment
Socio-economics
Supply chain disruption
Mitigation measures

ABSTRACT

The lockdown on account of the Coronavirus disease 2019 (COVID-19) adversely impacted the food production sector including aquaculture, globally. Unfortunately, it coincided with the major shrimp farming season in India which contributes 60% of the national annual shrimp production hence the impact was substantial. An on-line survey was carried out among the stakeholders of the shrimp farming sector to evaluate the prospective impact of COVID-19 related lockdown across the shrimp supply chain. The study estimated an economic loss of 1.50 billion USD to the shrimp aquaculture sector during the current year. It is expected that shrimp production and its export performance may be declining by 40% in the current season. The Garret ranking and Rank Based Quotient analyses projected severe constraints in shrimp seed production and supply, disruptions in the supply chain, logistics, farming, processing, marketing and loss of employment and income for the workers due to the pandemic. To mitigate the impact, the Government of India declared fisheries and aquaculture as an essential activity, facilitated the movement of inputs and services. Further, a major Fisheries Development Scheme (PMMSY) with a financial outlay of 267 million USD has been announced to usher in a blue revolution by strengthening the value chain, doubling the fisher/farmer income, employment generation, economic and social security for fishers/fish farmers adhering to the sustainability principles. Short and medium-term technical and policy measures are suggested to tide over the impact of COVID-19 related lockdown and related restrictions.

1. Introduction

The outbreak of coronavirus disease 2019 (COVID-19) first reported from Wuhan, China (Wang et al., 2020) in December 2019 has been declared as a Public Health Emergency of International Concern (PHEIC) and the virus has spread to almost all the countries (Johns Hopkins Coronavirus Resource Center (JHU), 2020). It has infected approximately 22.86 million people worldwide and about 0.78 million people lost their lives as on 20th August 2020 (https://www.worldometers.info/coronavirus/). In India, around 2.77 million people were diagnosed positive for COVID-19 and 53,000 people lost their lives by the end of August 2020 (https://www.mohfw.gov.in/). India had imposed a countrywide lockdown from 25 March to 20 August 2020 in different phases restricting the movement of people, closing down transport networks and all the economic activities except a few essential and medical services. Due to the highly contagious nature of the virus which till date does not have a specific treatment or vaccine, many countries have enforced complete lockdown/shutdown in their respective territories to contain the spread of the virus. COVID-19-induced restrictions exert a symmetric, but asynchronous shock on the global and national food systems from primary supply to processing, exports to trade as well as national and international logistics systems (Schmidhuber et al., 2020; Torero, 2020). A paradox of unemployment due to close down of activities in manufacturing and service sectors in one side as well as labour shortage in primary food production systems due to social and movement restrictions might cause severe economic consequences that can result in global economic recession as bad as the great depression (International Monetary Fund (IMF), 2020). Moreover, export restrictions across the countries might limit global farm-food trade and market access (Laborde, 2020; IFPRI, 2020) and the reduced freight capacity on commercial flights for agricultural goods led to global supply chain disruptions (FAO, 2020a; Ivanov, 2020). Further, the declaration of lockdown without preparedness impacted all the operations across the food system value chain (FAO, 2020b; Stephens et al., 2020).

Shrimp aquaculture is a vibrant agri-business sector in India with a production of 0.7 Million Tonnes (MT), most of which (90%) is exported to the United States of America (USA), South East Asia,

* Corresponding author.
E-mail addresses: mkumaran@ciba.res.in (M. Kumaran), ravisankar@ciba.res.in (T. Ravisankar), muralichintu@ciba.res.in (M. Muralidhar).

https://doi.org/10.1016/j.aquaculture.2020.735922
Received 10 May 2020; Received in revised form 21 August 2020; Accepted 5 September 2020
Available online 11 September 2020

European Union (EU), China and Japan earning a substantial amount of foreign exchange to the tune of 5 billion USD (MPEDA, 2019). Nearly 70,000 t of shrimps were consumed domestically. India is also the third largest producer of farmed shrimp globally with extensive farming regions distributed in the east and west coasts of the country. About 1.2 million people are employed directly or indirectly in the shrimp supply chain which encompasses seed production and supply, farming, production and supply of feeds and other inputs, harvest, post-harvest handling and marketing (Geetha et al., 2019). Shrimp farming is practiced in about 0.15 million ha spreading across nine coastal states with an average productivity of 6 t/ ha mostly by small and medium scale farms (MPEDA, 2019). However, major critical inputs such as seed, feed, pond supplements and shrimp health care products are produced mostly in two southern states: Andhra Pradesh and Tamil Nadu and transported to all the other states. The processing factories are spread across the maritime states. Therefore, interstate and intrastate movement of inputs and farmed shrimp are of utmost importance for the sector. Since 2010, Pacific white shrimp (*Penaeus vannamei*) has been the main species farmed and hatcheries rely on Specific Pathogen Free (SPF) brood stocks imported from the USA, Madagascar and Mexico for seed production. The SPF shrimp brood stock imported from overseas suppliers are quarantined in a government-owned Aquaculture Quarantine Facility (AQF) (http://www.rgca.org.in/aqf.php) located at Chennai, Tamil Nadu to ascertain them that they are free of OIE listed pathogens before entering the hatcheries.

The short and long-term effects of COVID-19 risks marginalise coastal communities who are already vulnerable to many social and environmental changes (Bennett et al., 2020). FAO (2020b) in its initial assessment on COVID-19 indicated that shrimp farming gets disrupted as supply chains are broken, labour shortage emerges and market access gets affected. Therefore, it is important to investigate the immediate and long-term consequences of this pandemic for the global network of agricultural and food systems (Bennett et al., 2020; Stephens et al., 2020). Under these circumstances, the present study was undertaken to account the impact of COVID-19 related lockdown restrictions and their cascading effect on the shrimp value chain, from the perspective of stakeholders. This study intends to bring out suggestions for interventions that could contribute to developing mitigation measures and policy responses for the resilience of the shrimp farming sector in India.

2. Materials and methods

Since the country was in complete lockdown, an online survey was carried out as it is one of the efficient data collection methods to obtain data in a short time frame as done in previous studies (Geldsetzer, 2020; Anne et al., 2018; Katharina et al., 2016). A digital questionnaire was

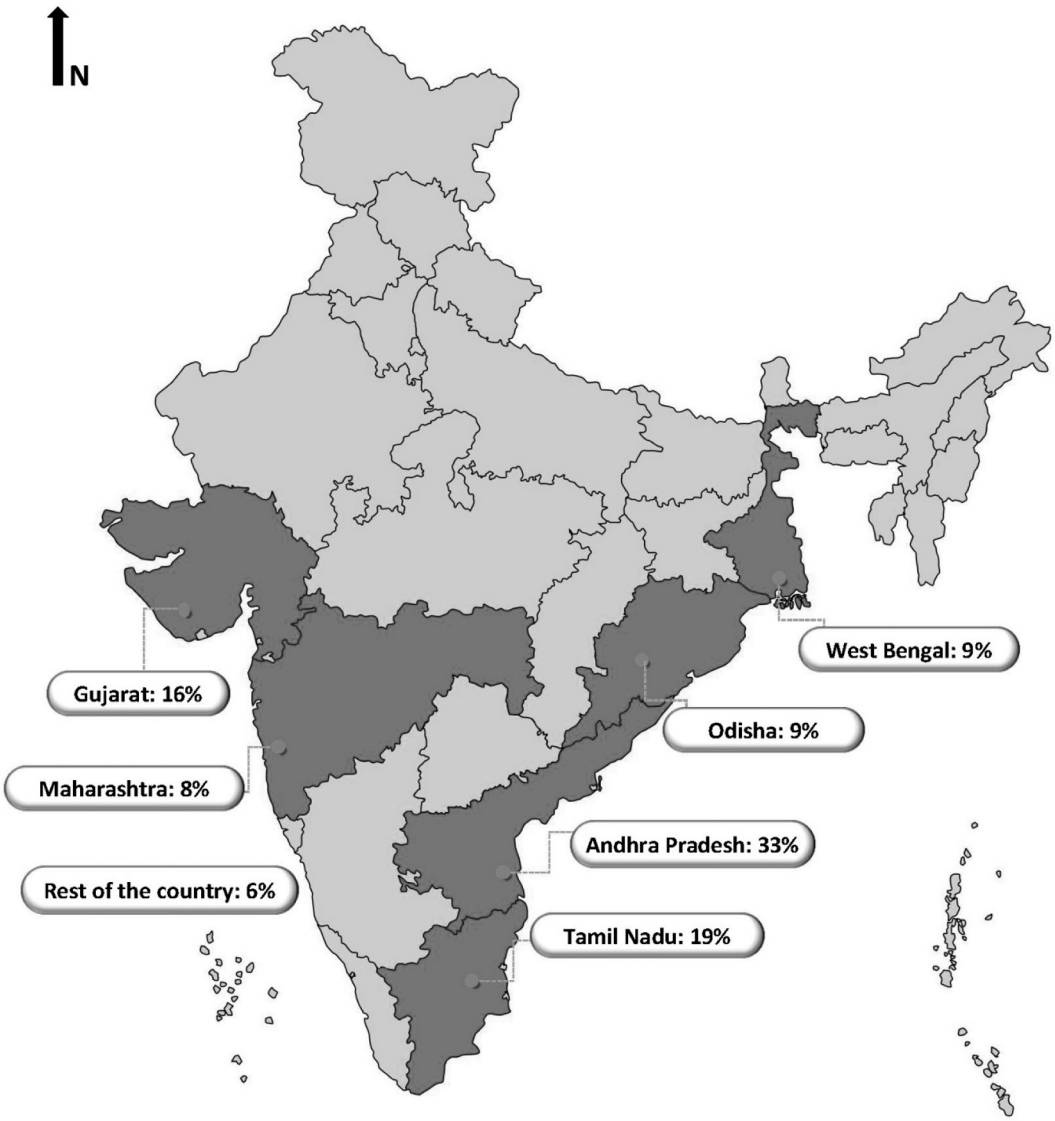

Fig. 1. State wise representation of stakeholder participation in the survey (n = 504).

prepared in the English language containing both closed-ended and open-ended type questions. The questionnaire comprised two parts: The first portion comprised of questions on contact details of respondents and their stakeholder type. Whereas the second part contained three different sets of questions respectively pertaining to (i) farmers and extension personnel (input dealers, technicians and consultants); (ii) seed and feed producers; (iii) shrimp processors and exporters. The logic was set in such a manner that upon selection of the particular stakeholder type, the questions pertaining to that particular segment alone gets displayed for eliciting their response. Some questions were common in all the three sets to obtain the perceptions of the stakeholders regarding the impact of the pandemic on the sector as a whole. The questionnaire was prepared using the on-line survey platform survey monkey (www.surveymonkey.com). The survey was open to all the stakeholders in the shrimp aquaculture sector who had access to digital platforms and the opportunity to participate and record their perceptions. It was posted across the digital platforms (CIBA Shrimpapp, ICAR-CIBA website, WhatsApp groups, Facebook groups and linkedin networks of shrimp aquaculture stakeholders in India) on 12th April 2020. The questionnaire is appended as a supplementary material. Within a fortnight, 504 stakeholders representing farmers (46.08%), input dealers, technicians and consultants (40.38%), seed and feed producers (9.48%) and processors (4.06%) across the country (Fig. 1) responded to the survey and recorded their opinion. Few (3–4 numbers) key informants in each segment of shrimp aquaculture sector acquaint with the authors were contacted telephonically to validate the data collected through the online survey. Their inputs were incorporated in the discussions under relevant portions. The data were statistically analyzed by using Garrett ranking and Rank Based Quotient analyses. Microsoft Office spreadsheet was used to estimate the prospective economic impact on shrimp aquaculture. The analyzed data are appropriately presented as tables and graphs.

2.1. Garrett ranking analysis

Garrett's ranking technique was employed to find out the critical constraints faced by the shrimp hatcheries and processors. It was calculated as percentage score and the scale value was obtained by applying Scale Conversion Table given by Garret and Woodworth (1969). The percentage score is calculated using the following formula:

$$\text{Percentage score} = -\frac{100\ (R_{ij}-0.5)}{N_j}$$

where,

Rij = Rank given for i^{th} item by j^{th} individual.

Nj = Number of items ranked by j^{th} individual.

For each constraint, the scores of individual respondents were added and divided by the total number of respondents. These mean scores for all the constraints were ranked in order to identify the critical constraints.

2.2. Rank based quotient analysis

The constraints experienced by shrimp farmers and the overall critical impact of COVID-19 lockdown on the sector as a whole were analyzed using the Rank Based Quotient (RBQ) analysis to explain the order of severity. The important constraints reported were ranked as per their severity and the RBQ for each constraint was calculated using the formula proposed by Sabarathnam and Vennila (1996) which is widely adopted in agriculture and allied sectors (Katole et al., 2015; Bandara et al., 2016; Rimiki et al., 2017).

$$RBQ = \frac{\Sigma\ (F_i)\ (n + 1 - i)}{Nn} \times 100$$

where in

F_i = Number of respondents reporting a particular problem under i^{th} rank.

N = Number of respondents.

i = Number of ranks.

n = Number of constraints identified.

3. Results and discussion

The results are presented and discussed in four sections: (i) shrimp seed production and supply, (ii) shrimp farming, (iii) processing and marketing and (iv) overall impact and economic loss to the sector as a whole.

3.1. Seed production and supply

The impact of COVID-19 lock down on shrimp hatcheries is given in the form of Garret ranking mean score in Fig. 2. Manpower shortage (65.33) and non-availability of skilled technicians (48.11) at shrimp hatcheries due to restrictions in the movement were ranked as severe constraints followed by insufficient SPF brood stock availability (46.78) and lack of transport facilities to distribute the seed across the farming regions which together adversely affected the hatcheries. Similar views were reported in other media (https://www.undercurrentnews.com/2020/04/02/indian-hatcheries-hit-by-virus-lockdown/). It was reported that quarantine measures were severely affecting the labour availability for critical farming operations and the timing of labour needs is often inflexible for seasonally produced foods (Stephens et al., 2020).

There were two scenarios extracted based on the data collected and validated with key informants. In the first scenario, wherein, the seed produced by the shrimp hatcheries prior to the lockdown which should have been ideally sold to farmers during the first week post- lockdown could not be sold due to total disruption in transportation, uncertainty and non-availability of workforce. Since holding ready to sale shrimp post larvae (PL) for longer periods was uneconomical for the hatchery and with anticipated no improvement in demand, transportation and future prospects, most of the shrimp hatcheries discarded the available seed stock. Most importantly, a section of farmers being aware of the pandemic situation in other countries during the beginning of the year itself and anticipating a fall in prices due to weakening export demand in these countries, were not keen on stocking shrimp even prior to lockdown. Further, the farmers in the northern states (Odisha, Gujarat and West Bengal) and 30% of farmers in Andhra Pradesh and Tamil Nadu states where stocking of shrimp seed was scheduled for the end of March to mid-April did not do so. This was owing to the uncertainties in the availability of other inputs, manpower and expected slump in

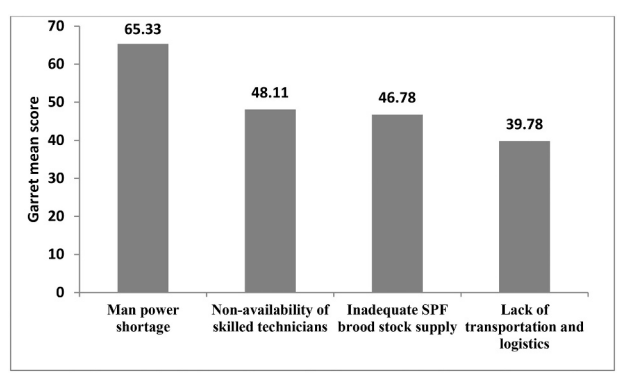

Fig. 2. Impact of COVID-19 Lock down on shrimp seed availability and input producers (n = 50).

shrimp prices due to forecast of poor demand in the international markets by trading houses.

In the second scenario, farmers who had a standing stock during the lockdown resorted to 'panic harvesting' of small-sized shrimps and sold them for lower prices to avoid the massive financial losses. This interruption in the staggered harvesting and restocking might lead to a spike in seed demand immediately after the relaxation of the lockdown. However, due to disruption in international air cargo movement, the import of SPF brood stock was temporarily suspended, and the hatcheries did not have adequate brood stock to meet the increasing demand for seed. During the initial days of this crisis in India, most of the airlines had stopped their operations and even the commercial cargo flights had vastly decreased their freight capacity for agricultural goods, which had caused disruptions in the global supply chain. Ivanov (2020) reported that the agri-food sector is highly connected internationally. Hence the reduction in international cargos can severely disrupt the shrimp value chain across the world. Therefore, the reduced local demand and lack of SPF brood stocks for sustaining seed production severely impacted the shrimp hatcheries. Further, the exodus of the migrant labour employed as technical hands in the large-scale hatcheries, coupled with the inability to source new labour due to movement restrictions, severely affected the performance of the hatcheries resulted drop in seed production (Fig. 2).

3.2. Shrimp farming

Shrimp farming has two major seasons in India viz., summer crop (March–April to June–July) and the winter crop (July–August to November–December). The summer crop happens to be the major contributor (60%) to the Indian shrimp production and unfortunately the lockdown coincided with the main cropping season. The farming scenario during lockdown revealed a mixed picture. About 27% of farmers who had prepared their ponds for stocking did not do so because of the difficulty in obtaining quality seed, uncertainty over continuous supply of other inputs and the unpredictable market conditions. About 25% of the farms were in Phase-I with less than 30 days of culture (DoC), 34% were in phase-II with 30 to 80 DoC, and about 14% were in the category above 80 DoC (Phase-III). The DoC reflected the financial impact on the farmer, wherein farmers in phase I and II may not, realize their investment, while those in phase III, could make break even or get small profits albeit with production risks and increased expenditure as highlighted by the FAO (2020a).

The constraints experienced by the shrimp farmers during the lockdown are detailed in Table 1. Access to processors for marketing and transportation of harvested shrimp were flagged as severe constraints with RBQ scores of 86.31 and 82.86, respectively. Similarly, access to diagnostic labs (80.71) and post-harvest handling materials (78.45) were the other major constraints. Anticipating a further drop in prices and worsening market conditions, around 50% of the farmers who had a standing crop with small and medium-sized shrimps decided for harvest and make a "distress sale" (forced to sell for lower price).

Table 1
Impact of COVID-19 Lock down on shrimp farming/farmers (n = 433).

Sl. No	Impact on farming/farmers on account of access to	RBQ score	Rank
1.	Seed	74.40	7
2.	Feed and shrimp healthcare products	69.64	9
3.	Water quality monitoring kits and supplements	73.10	8
4.	Diagnostic labs	80.71	3
5.	Farming equipments and spare parts	77.26	5
6.	Skilled personnel	76.31	6
7.	Technical guidance	66.79	10
8.	Processor/market	86.31	1
9.	Post-harvest paraphernalia	78.45	4
10.	Transport	82.86	2

But they even couldn't do that due to inadequate access to insulated trucks, skilled workforce, ice and seafood processors at the right time, which all were reported to be the major constraints faced by farmers. Bennett et al. (2020) reported such a similar scenario that farmers experienced as 'twin disaster', which was characterized by reduced demand and attendant collapse of prices during the pandemic.

Screening of water and soil samples at weekly intervals is a vital prerequisite to manage the optimum water quality parameters and this has a direct bearing on the health of the farmed shrimp. Access to the diagnostic laboratories for such regular screening was a severe constraint due to movement restriction. In case of feed production and supply, barring the minor glitches during the first week of the lockdown the feed mills resumed their production. However, the issues related to labour and logistics hindered the timely supply of feed. Feed production was driven by the demand from farming operations. Therefore, a significant reduction in the farming area led to the scaling down of feed production.

Though the Government relaxed the restriction on the movement of aquaculture inputs and services for farming activities by classifying it under "essential activity", the access to machinery and their parts required for farming operations were severely affected. Shrimp farms in Gujarat, Maharashtra and Andhra Pradesh states were mostly manned by migrant labourers from eastern parts of India hence the reverse migration of these labourers to their home states created a labour vacuum affecting the farming operations. Schmidhuber et al. (2020) reported that labour availability for agricultural supply chains has become a near ubiquitous problem, such deficits are caused by domestic labour supply disruptions, as well as by shortages of seasonal and migrant workers. Taking a cue from the evolving market conditions, when farmers from these states eventually planned for stocking, availability of migrant labourers were a major constraint due to the nationwide lockdown.

3.3. Processing and marketing

The challenges faced by the shrimp processors are given in the Fig. 3. Shortage of manpower was reported as the major constraint by 75% of the processors. The majority of the skilled workers employed in processing plants are migrant workers who went back to their native places during the initial days of the lockdown and did not return to work. Social distancing and movement restrictions by the community are severely affecting labour availability for key time critical operations (Stephens et al., 2020) and shortages of seasonal and migrant workers (FAO, 2020b; Schmidhuber et al., 2020). Harvesting and post-harvest handling of shrimps was usually done by skilled fishers, and their absence led to poor handling of shrimps at farms and a drop in the quality of shrimps harvested. Similar situations have been reported from the agriculture and animal husbandry sector, where agricultural production, meat and dairy products have been adversely affected by the pandemic induced labour shortages (FAO, 2020b). To provide policy

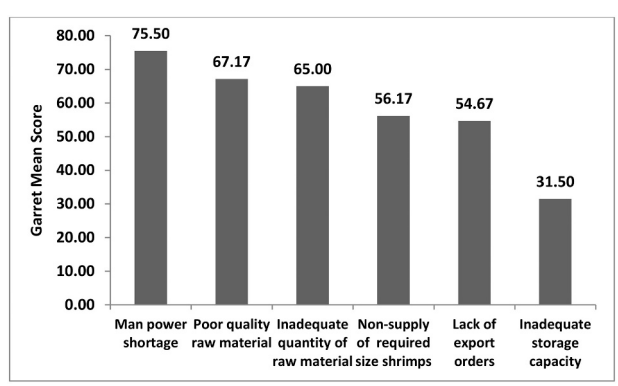

Fig. 3. Impact of COVID-19 lockdown on shrimp processing (n = 21).

Table 2
Shrimp procurement price fixed by the Andhra Pradesh State Govt. during lockdown.

Size of the harvested shrimp in g	Minimum procurement price in INR
Above 30	430 (5.7 USD)
25–29	310 (4.1 USD)
20–24	260 (3.5 USD)
1719	240 (3.2 USD)
14–16	220 (2.9 USD)
12–13	200 (2.6 USD)
11	190 (2.5USD)
10	180 (2.4 USD)

(Approximately 1 USD is equal to 75 Indian Rupees.)

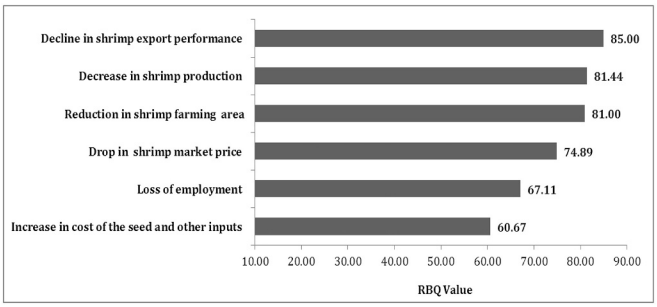

Fig. 4. Perceived overall impact of COVID-19 Lock Down (> 30%) (n = 504).

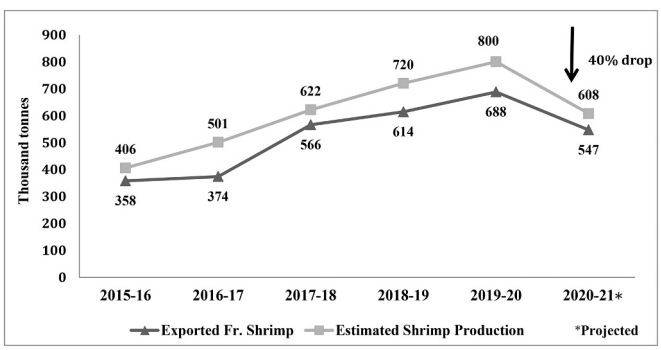

Fig. 5. Projected decline in the Indian shrimp production and export due to COVID-19.

support to the farmers, the state Government of Andhra Pradesh negotiated with the Seafood Exporters Association of India and assured a minimum procurement price for different sizes of the harvested shrimps (Table 2) (*Undercurrent News Dt.* 1/5/2020, 2020). However, 67% of the respondents reported that the processors refused to pay the price fixed by the Government, citing the poor quality of harvested shrimp.

Inadequate quantity of raw material (harvested shrimp) to run the processing facility, non-availability of desired size quality shrimp, lack of export orders and insufficient storage facility with small scale buyers were the constraints reported by 65, 56, 54 and 31% respectively of the processor respondents. Moreover, processors were battling a period of low demand due to weakening economic situations in the importing countries, resulting in accumulation of unsold inventory filling the cold storage limits, thus hampering further procurement. Closure of local markets due to lock down and absence of cold storage space with local buyers further strained the marketing and distribution system. The sudden nature and severity of the lockdown left little scope for identifying suitable domestic substitutes in the short term but may spur less reliance on global agri-food value chains in the future (FAO, 2020b; Stephens et al., 2020; Schmidhuber et al., 2020).

3.4. The overall impact and economic loss to the sector

The overall impact and economic loss were estimated based on the responses of the stakeholders irrespective of their affiliation. The pandemic related disruptions adversely affected the shrimp aquaculture sector to the extent of 30–40% in economic terms (Fig. 4). Most of the respondents (85%) opined that the expected decline in shrimp export performance to the major importing nations whose economies were also severely affected was a major impact. This may be due to the reduction of farming area and production, as expressed by 81% of respondents. Therefore, it is expected that farmed shrimp production and export could decline by 40% compared to the previous year (Fig. 5). About 75% of the respondents predicted that the shrimp market price in the current season would be reduced by more than 35%. The loss of employment for the workers during the season was 30–40%, as reported by 67% of the respondents. The shrimp supply chain is heavily dependent on diversely skilled labour. It offers wide range of jobs opportunities, such as farm management, technical help at hatcheries, farms and processing units, personnel for manufacturing and marketing of inputs, wholesale and retail businesses, workers to operate farm machinery, vehicles, civil works, plumbing, mechanical and electrical equipment.

Labourers from the local villages also could not attend work due to movement restrictions. In-house migrant workers went home due to fear of infection and lack of salary assurance/subsistence from the employers. The aquaculture labourers were un-organized and with the loss of their employment do not have social protections as reported elsewhere (Harper et al., 2020). The sealing of state and district borders and restrictions on day to day movement of people affected their access to work places causing huge loss of employment and income. Similar views were expressed by international organizations and institutions (Bennett et al., 2020; FAO, 2020b; International Monetary Fund (IMF), 2020; Schmidhuber et al., 2020; Stephens et al., 2020). As a whole, this study estimated a probable loss of about 40% to the Indian shrimp sector in each component, the total loss in value terms being 1.50 billion USD (Table 3). However, the impact in each component as well as the overall economic loss would be much higher than that projected, if

Table 3
Covid 19 lockdown: approximate estimate of economic loss to the sector.

Components/subsector	Annual capacity/ resource (A)	Assumed that 60% of (A) is done in this season (B)	Unit cost	@ 40% loss	
				Approximate loss in units	Approximate loss in In million USD
Seed production (post larvae PL-billion seeds)	70	42	40 NP/PL	16.8	89.60
Feed (million tonnes)	1.3	0.78	Rs.80/Kg	0.312	33.30
Farming & Production (million tonnes)	0.8	0.48	Rs.350/Kg	0.192	896.00
Market and Export (million tonnes)	0.62	0.372	Rs.500/Kg	0.148	99.20
Employment including hatchery, farm, inputs, processing etc. (million people/million man days)	1.2	0.48	Rs.500/day	57.6	384.00
Total (in million USD)					1502.10

(Approximately 1 USD is equal to 75 Indian Rupees; 100 NP = 1 Indian rupee).

Table 4
Short and medium term mitigation measures suggested by the study.

Sl. No	Sub-systems	Immediate/short term (current year)	Medium term (in 2–5 years)
1	Seed production	➢ Govt. of India may take efforts to import SPF brood stock from overseas suppliers through special cargo flights. ➢ Strengthening the existing Aquaculture Quarantine Facility to ensure adequate supply of imported brood stocks.	➢ Establishment of Brood stock Multiplication Centres to ensure the in-house supply of shrimp brooders. ➢ Establishment of additional Aquaculture Quarantine Facilities one each in east and west coasts to ensure adequate supply of imported brood stocks. ➢ Promotion of species diversification with indigenous species like Indian White Shrimp and Black Tiger Shrimp for farming with SPF strains.
2	Shrimp farming	➢ Adoption of nursery rearing to enhance survival and better growth. ➢ Shorter duration crops with high stocking densities to produce smaller size shrimps for local markets. ➢ Adoption of phase wise stocking in tune with seed availability and harvest as per the market demand.	➢ Development of novel production systems and better-fit technology packages to ensure sustainable shrimp production. ➢ Implementation of govt.fixed inputs cost and procurement price for farmed shrimps.
3	Processing and marketing	➢ Enforcing the processors to adhere to the minimum support price fixed by the government. ➢ Updating communication portals to forecast shrimp demand at local and international markets and shrimp prices.	➢ Establishment of cold storage facilities and promotion of domestic market for farmed shrimp.
4	Labour and social system	➢ Special arrangements to bring back migrant labourers and provision of essential goods for their sustenance. ➢ Immediate relief package and free supply of essential goods for sustenance of their livelihood.	➢ Implementation of social security measures like minimum wages, health cover, life insurance and gratuity for full-time labourers.

the lockdown and other restrictions continue in the next cropping season.

4. Mitigation measures suggested and Government initiatives

The Governments both at the national and state levels took instant remedial measures like notifying aquaculture as an essential activity thereby easing the restrictions for the movement of inputs and people, fixing a minimum procurement price for the farmed shrimp and opening departmental retail outlets etc. However, the implementation of these mitigation measures at the ground level need additional efforts and follow-up using the government mechanism. In addition, the Government of India has announced a major scheme, the Prime Minister Fisheries Development Scheme (Pradhan Mantri Matsya Sampada Yojana-PMMSY) for facilitating a 'Blue Revolution' by leap-frogging aquaculture production. The PMMSY envisages harnessing the fisheries potential through various measures such as strengthening value chain, measures for doubling the income, employment generation, economic and social security for fish farmers adhering to sustainability principles. The outlay for the scheme is Rs.20,050 crores (approx.267 Million USD) with a plan to implement it over a five year period from 2020–21 to 2024–25 in all the States/Union Territories of India. Further, based on the results of the present study, short and medium-term measures have been suggested to minimize the adverse impact of the pandemic and similar unforeseen risks in future (Table 4). It is important that stakeholders of different segments need to communicate frequently and work together with the government departments to develop essential policies to ensure sustainable shrimp aquaculture in the country.

5. Conclusion

This sectoral assessment has clearly indicated that COVID-19 lockdown and subsequent disruptions in the supply chain movements adversely impacted the activities in shrimp aquaculture sector and led to a direct economic loss to its different stakeholders. India's dependence on the exotic SPF vannamei brood stock from overseas suppliers will lead to a long-term impact if the embargo on international cargo movements continues. Further, restrictions which forced the skilled and farm-workers to be confined at home and in-house migratory workers to leave for their homes, negatively affected all the components of the sector and their livelihood. The Indian shrimp industry would incur an approximate economic loss to the tune of 1.50 billion USD for this year alone. Farmers and hatchery operators are looking for massive relief packages from the government to minimize the negative economic impact and sustain this dynamic agribusiness sector which earned a foreign exchange of 5.0 billion USD for the country last year. This investigation has provided an initial assessment of the pandemic based on the stakeholder's perspective. However, the situation is dynamic and further follow-up assessments at the state and national levels may be required to fully understand the impact that this pandemic has had on Indian shrimp aquaculture sector.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgement

The authors sincerely thank the stakeholders in the shrimp farming sector: the hatchery operators, farmers, processors, field professionals and development officials for responding to the survey and providing their valuable inputs. The authors sincerely acknowledge the support and guidance rendered by the Fisheries Division of the Indian Council of Agricultural Research, New Delhi. The help rendered by Dr.G.Gopikrishna, retired Principal Scientist and Head, Division of Genetics, Nutrition and Biotechnology in correcting the manuscript is sincerely acknowledged.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.aquaculture.2020.735922.

References

Anne, A., Gournis, E., Bradley, K., 2018. Use of rapid online data collection during a large community enteric outbreak in Toronto, Canada. J. Public Health Informat. 10 (1).
Bandara, B.E.S., De Silva, D.A.M., Maduwanthi, B.C.H., Warunasinghe, W.A.A.I., 2016. Impact of food labeling information on consumer purchasing decision: with special reference to faculty of agricultural sciences. Procedia Food Sci. 6, 309–313.
Bennett, N.J. Elena, Finkbeiner, M., Ban, Natalie C., Belhabib, Dyhia, Jupiter, Stacy D., Kittinger, John N., Mangubhai, Sangeeta, Scholtens, Joeri, Gill, David, Christie, Patrick, 2020. The COVID-19 Pandemic, Small-Scale Fisheries and Coastal Fishing Communities, Coastal Management. https://doi.org/10.1080/08920753.2020.1766937.

FAO, 2020a. How is COVID-19 affecting the fisheries and aquaculture food systems. Rome. https://doi.org/10.4060/ca8637en.
FAO, 2020b. The impact of COVID-19 on fisheries and aquaculture – a global assessment from the perspective of regional fishery bodies: initial assessment. May 2020. Rome 1. https://doi.org/10.4060/ca9279en.
Garret, H.E., Woodworth, R.S., 1969. Statistics in Psychology and Education. Vakils, Feffer and Simons Pvt. Ltd, Bombay, pp. 329.
Geetha, R., Ravisankar, T., Sairam, C.V., Kumaraguru Vasagam, K.P., Vinoth, S., Vijayan, K.K., 2019. Aquastat India 2019. In: ICAR – Central Institute of Brackishwater Aquaculture (CIBA), pp. 219 Chennai, India.
Geldsetzer, P., 2020. Use of rapid online surveys to assess people's perceptions during infectious disease outbreaks: a cross-sectional survey on COVID-19. J. Med. Internet Res. 22 (4), e18790. https://doi.org/10.2196/18790.
Harper, C., Leon-Himmelstine, C., George, R., Marcus, R., Samuels, F., Bastagli, F., Jones, N., Daigle, M., 2020. Covid 19 – Why Gender Matters. Overseas Development Institute (ODI). https://www.odi.org/blogs/16856-Covid-19-why-gender-matters (accessed on 25 April 2020).
IFPRI, 2020. Global Food Policy Report: Inclusive Food Systems Needed to Boost Development, Resilience. https://www.ifpri.org/news-release/2020-global-food-policy-report-inclusive-food-systems-needed-boost-development.
International Monetary Fund (IMF), 2020. World Economic Outlook, April 2020: The Great Lockdown. https://www.imf.org/en/Publications/WEO/Issues/2020/04/14/weo-april-2020 (accessed on 25 June 2020).
Ivanov, D., 2020. Predicting the impacts of epidemic outbreaks on global supply chains: a simulation-based analysis on the coronavirus outbreak (COVID-19/SARS-CoV-2) case. Transp. Res. Part E. Logist. Transp. Rev. 136. https://doi.org/10.1016/j.tre.2020.101922.
Johns Hopkins Coronavirus Resource Center (JHU), 2020. COVID-19 Map. https://coronavirus.jhu.edu/map.html (accessed on 25 June 2020).
Katharina, D.S., Gemma, L.F., Owen, Luke, Persello, Séverine, 2016. Exploring the role of smartphone technology for citizen science in agriculture. Agron. Sustain. Dev. 1–9. https://doi.org/10.1007/s13593-016-0359-9.
Katole, R.T., Chinchmalatpure, U.R., More, G.B., 2015. Identification of agricultural problems of village using participatory rural appraisal technique. Agric. Update 10 (3), 206–210.
Laborde, D., 2020. International Food Policy Research Institute. Food Export Restrictions during the Covid-19 crisis (accessed on 25 April).
MPEDA, 2019. Marine Products Export Development Authority, Govt. of India. www.mpeda.gov.in (accessed on 25 April 2020).
Rimiki, S., Ray, M.N., Bora, L., Borah, M.C., Payeng, S., Faventy, E.L., Borah, B., 2017. Participatory constraint analysis of rearing *Niang Megha* pigs by the tribal farmers of Meghalaya. J. Entomol. Zool. Stud. 5 (5), 1349–1352.
Sabarathnam, V.E., Vennila, S., 1996. Estimation of technological needs and identification of problems of farmers for formulation of research and extension programmes in agricultural entomology. Exp. Agric. 32, 87–90. https://doi.org/10.1017/S0014479700025898.
Schmidhuber, J., Pound, J., Qiao, B., 2020. COVID-19: Channels of Transmission to Food and Agriculture. FAO, Rome. https://doi.org/10.4060/ca8430en.
Stephens, E.C., Martin, G., van Wijk, M., Timsina, J., Snow, V., 2020. Impacts of COVID-19 on agricultural and food systems worldwide and on progress to the sustainable development goals. Agric. Syst. 183, 102873. https://doi.org/10.1016/j.agsy.2020.102873.
Torero, M., 2020. Without food, there can be no exit from the pandemic. Countries must join forces to avert a global food crisis from COVID-19. Nature 580, 588–589. https://doi.org/10.1038/d41586-020-01181-3.
Undercurrent News Dt. 1/5/2020. https://www.undercurrentnews.com/2020/05/01/andhra-pradesh-govt-sets-maximum-price-for-shrimp-pls-with-post-lockdown-shortage-expected/ (accessed on 01 July 2020).
Wang, C., Horby, P.W., Hayden, F.G., Gao, G.F., 2020. A novel coronavirus outbreak of global health concern. Lancet 395 (10223), 470–473. https://doi.org/10.1016/S01406736(20)30185-9.