

Impact of Covid-19 Pandemic on Fisheries Sector and Mitigation Measures: A Brief Review on Indian Perspectives

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Abstract

The terrific coronavirus disease first started as a locally circulating infection in 2019. The WHO characterized COVID-19 virus disease as a pandemic on 11th March, 2020. This pandemic specified as the greatest global humanitarian challenge the world had faced since the World War II. The COVID- 19 pandemic induced a total 68 days nationwide and different state wise continuous specific lockdowns in India, has a huge economic shock. It stalled the economy with complete closure imposed on enterprises across all sectors in all over the world. That overall unfavourable condition also triggered a massive reverse migration from the urban to rural areas in large parts of the country. Though in initial lockdown phases the agriculture activities were exempted, but the fisheries value chain faced large-scale disruptions. The Govt. and other organizations have taken different mitigation measures to push the sector in the previous sustainable position. Although there were huge negative impacts but the pandemic & it's regarding lockdowns seem to have numbers of positive impact on the fisheries sectors.

Key words: Indian Fisheries, COVID-19 Pandemic, Impact, Lockdown, Mitigation measures

COVID-19 pandemic not only affected the public health systems but also puts great pressure on global trading system, food products, agricultural and its allied sectors [8]. COVID-19 does not infect aquatic species [27], yet it has unique effects on fisheries and aquaculture food systems. But a false fear of spreading Corona virus through sea fishes' spreads among the people when it was known that initially corona affected people had a history of exposure to the seafood market of Huanan in China [5]. About 26.8% share of global total employment is from the agriculture sector [116]. From February to June 2020, an estimated of 45 million people were experienced extreme food insecurity due to the COVID pandemic [122]. This pandemic penetrates adverse effect on that large number of global employees. About 14 million people in India are economically dependent on fisheries and aquaculture [47], [53]. A report on COVID-19 by Asian Development Bank (ADB), showed that in India the losses of personal consumption in between \$387 million and \$29.9 [123]. In several rural region of India, the pandemic and its related lockdown penetrate adverse impacts on household income, food security, welfare, and access to local loan markets [76]. In India, the pandemic harmed the fishing sector by reducing consumption, demand, selling price, export orders, stocking, and transport. Fish & fishery products deteriorate in inadequate storage [54]. Fishery-

dependent linked sectors faced a gloomy demand outlook and supply changes. China, a major consumer and producer of aquaculture items, was affected by COVID-19, which harmed developing countries like India [51]. During the epidemic, the Indian government halted net making and mending, land-based operations in fish landing centers and harbors, ice making facilities, marketing agencies, and transportation to and from fish landing centers, and fish markets [26]. Due to the congested conditions in fisheries, social distance was difficult, hence a complete shutdown was necessary [73].

Although there is a long list of negative effects of COVID on Indian fisheries, the most fascinating topic is the beneficial element. Due to the lack of human disturbance, fish populations grew, water pollution decreased, planktons rose, and aquatic animals got a vacation from noise pollution. The Indian government, concerned state governments, and private and public organizations took various mitigation efforts to restore fisheries balance.

Indian fisheries profile in the pre-COVID period

The COVID pandemic shock squeezed demand and supply, causing a global economic slump [24]. India's fish production in 2019-20 was 14.16 MMT, up 4.35% from the previous year [95]. Fourth largest seafood importer in the world

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[82]. India exported 12,89,650.90 tons of fish worth \$6.68 billion in 2019-20 [102]. Andhra Pradesh produced 36.1 lakh tons of fish in 2019-20, followed by West Bengal and Gujarat with 16.19 and 6.99 lakh tons of fish production [51]. In 2019-2020, Andhra Pradesh topped inland production, followed by West Bengal and Uttar Pradesh. Gujarat topped marine production [51]. Hilsa, Indian oil sardine, sea catfish, lizard fish, barracudas, seer fish, silver bellies, clupeids, skipjack tuna, mackerels, crust crab, yellow fin tuna, non-penaeid & penaeid prawn were prominent landed marine fishes in India. 78% of

overall catch was fresh-marketed, 8% was frozen, and 4% was curried [102]. West Bengal produced 52,262 million fish fries in 2017-18. According to the NFDB (2019), the marine fisheries sector employs more than 16 million people in 3477 marine fishing villages throughout 70 coastal districts in India. All of these show the importance of India's fishing industry and coastal regions for livelihood and nourishment [51].

Impacts of COVID-19 pandemic on Indian fisheries sectors *Negative impacts*

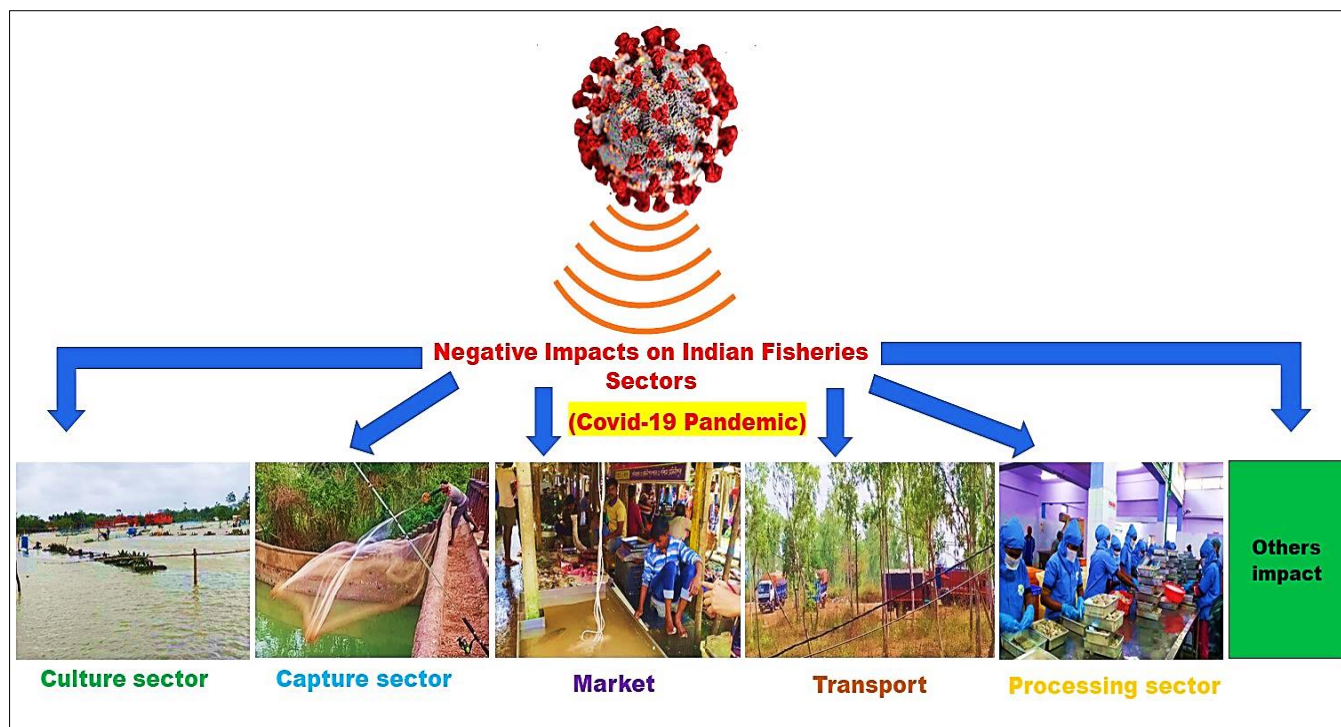


Fig 1 Negative impacts of covid 19 pandemic on Indian fisheries sector

Impact on culture sector

Unstable production cost and farmgate price

Pandemic immediately affected India's culture sector. Pandemic and lockdowns disrupted domestic and international transport of production inputs, raw materials for culture, and fish for export [68], causing uncertain production costs and farm gate prices for fish and fishery products. Pangasius fish, which was marketed for INR 76 before the lockdown, fell to INR 64 due to insufficient marketing during the epidemic, causing fish farmers to lose 13.5% [86]. Similar trend was found with carps, whose market preference dropped from INR 105/kg to 92/kg, a 12.4% drop, and carp producers lost INR 13/kg against a production cost of INR 105/kg [96]. Indian fisheries farm gate prices declined 4.8% overall [86]. Punjab (21.7%), Madhya Pradesh (19.8%), Haryana (19.3%), and Uttar Pradesh (10.7%) reported price drops. Kerala (24.15%), Goa (15%), and Tripura (17.5%) reported price increases. White-leg shrimp (*Litopenaeus vannamei*) sold for INR 180/kg versus INR 220/kg manufacturing cost, an 18.2% loss [96], [86]. Farmers experienced hefty production costs during the lockdowns because to the exorbitantly high cost of DORB (De-Oiled Rice Bran), which was sold for INR 20/kg in 2020 (Table 1).

Date in (Table 1) state-wise impact of COVID-19 on farm gate prices of commodities in Indian Fisheries sector; source- NABARD August, 2020 Report [86]. Negative sign denotes decrease, positive sign denotes an increase, 0=no change.

State/Union-Territory	Farm gate price decline/increase (%)
Andaman and Nicobar	-15
Andhra Pradesh	-4.1
Assam	4.4
Bihar	-9.8
Chhattisgarh	1.7
Dadra Nagar Haveli	0
Daman and Diu	0
Goa	15
Gujarat	-8.1
Haryana	-19.3
Himachal Pradesh	-12
Jammu and Kashmir	6.4
Jharkhand	4.3
Karnataka	-0.7
Kerala	24.1
Madhya Pradesh	-19.8
Maharashtra	-0.5
Manipur	13.3
Meghalaya	15
Mizoram	5
Nagaland	22.5
Odisha	3.4
Puducherry	45
Punjab	-21.7
Rajasthan	-12.8
Sikkim	0

Tamil Nadu	4.6
Telangana	1
Tripura	17.5
Uttar Pradesh	-10.7
Uttarakhand	-9
West Bengal	-6.3
All India	-4.8

Lack of fish seed availability

Most Indian fish producers obtain seed from authorized hatcheries. During pandemic, interstate transfer of fish seed from West Bengal to Andhra Pradesh, Bihar, Jharkhand, Madhya Pradesh, and Uttar Pradesh was restricted due to lockdown, fear of virus, labour scarcity, and lack of transport system. Few West Bengal hatcheries finished summer breeding in 2020, but seed farmers could only stock 10-15% of seed before lockdown. Due to the lockout, few IMC hatcheries sold fish seed [52]. Although the Indian government exempted hatchery operations, fish seed, feed, and staff from lockdown [110], aquaculture could not acquire momentum due to difficulties maintaining social distance and completing farm activities with few people [63].

Delaying in stocking of fish seed

Aqua-medicine, disinfectants, labour crises, seed and feed hindered stocking activities [80]. Due to poor prices, farmers weren't interested in harvesting fish, which delayed restocking during lockdown [61]. Due to lack of farming activities, fish producers experienced financial restraints and underfed their cattle. In 2020, Andhra Pradesh and other states only stocked 15-20% of summer crops [96].

Farm repairs and maintenance problems

In India normally farmers are undertaking repairs to fish ponds and existing machinery during summer season. But there was a shortage of technicians for repair and maintenance of farm machinery [93] and availability of spare parts was become difficult for agriculture implements outlets due to the pandemic and lockdown situation [67]. Overall business volume came down to 7-10% when compared to normal days in India [84].

Renovation and digging of new fish ponds were became impossible due to:

- Non-availability of excavators & earth movers.
- Exorbitantly high hiring charges.
- Limited working hours, premium price of HSD (High Speed Diesel), Oil.
- Acute shortage of labour [80].

The lockdown was imposed to arrest the terrific spread of corona virus was severely impacted viability of machine operations to a minimum of 6-8% [84].

Fish feed production under stress

Pandemic was expected to lower consumer demand for animal protein, affecting the feed sector. Fish feed production was stressed due to a lack of road transport for corn, soya, de-oiled rice bran, and oil cakes [52]. Due to restricted supplies and delayed deliveries, animal feed prices rose [96]. Between February and April 2020, India's feed mills bought fewer raw materials [42]. India's purchases decreased 64%. In a CGIAR (Consultative Group on International Agricultural Research, October 2020) [58] report, Assam was the hardest afflicted region in India with no feed obtained and feed mills halted in April, 2020. Odisha's feed purchases fell 47%. In April 2020, India's feed mills produced 46% less than in February. In April 2020, just 25-50% of feed mills bought inputs in India [58], [71].

Problems in inputs procurement

India's epidemic reduced fisheries input purchases. In April 2020, Indian farmers lowered inputs by 54% from February [58]. Different inputs-making sectors were exposed to COVID-19's unfavourable worker implications [73]. Border restrictions, additional processes, and checks caused congestion and delays, affecting perishables. Social distance standards lowered import and export inspectors at international and domestic borders, increasing customer clearance time.

Fish farm workers crisis and impact on workers

During harvesting and after, fisheries require a lot of manual labour. Over 50% of fishery workers are migrants and were not available [69] locally because most of them went to their home states while local workers did not come to work due to village head limitations to stop the spread of Covid-19 [43]. Only 18% of laborers worked in fish farms. Normal harvesting requires 50 people, but farmers can't find even 10% [96]. Some Northern India markets had 1-2% laborers [96]. Only 1100 of 4000 migrant workers in Delhi's Ghazipur mandi were available to conduct sales and other activities [121]. Fish-farm employees in the culture-sector couldn't meet their family costs. People who had migrated from Tamil Nadu, West Bengal, Odisha, Jharkhand to Gujarat, Andhra Pradesh, Kerala, and Karnataka were forced to return home and faced a financial hardship. Due of the rigorous lockdown, many workers were unable to earn money [121]. Due to lockdown, they had no food and shelter where they worked [3]. Many migrant workers were beaten by state police and died on the way home from exhaustion and starvation [121].

Impact on fish hatcheries

Fish hatcheries also suffered massive losses. From March through May, hatcheries were closed [71]. After hatcheries became partially operational, average operating days fell. March, April, and May produced no hatchlings, fry, or fingerlings [96].

Approximately 63,430 bloodstock animals were imported in the 1st quarter of 2020 till the lockdown was announced by the Government of India [83]. By March 2020, hatchery operators discarded 1 to 1.5 billion PLs owing to lack of demand from fish growers [60], [104]. Because of that the hatcheries have faced about \$10 million loss during that time [103]. Drivers weren't available to transport fish seed to other places.

Impact on shrimp farming sector

Shrimp farms under stress

In India's shrimp industry, the 1st and early 2nd quarters are called the summer crop and are the busiest time for PL stocking [93], [61]. About 30-35% reduction was seen in stocking numbers of shrimp seeds between March and June [103]. The official lockdown at the end of March affected the supply of PLs and the stocking of ponds, resulting in a sharp drop in inputs pricing and availability [60]. Most farmers who replenished their ponds between January and March 2020, harvested tiny shrimp. In India, 27% of farmers had constructed their ponds but not stocked shrimp in April [7], [35] (Fig 2). About 25% of farms had less than 30 DOC, 34% had 30 to 80 DOC, and 14% had shrimp over DOC [35]. Pandemic and lockdown reduced shrimp growing area by 40% and raised production costs by 15-20%, reducing producers' profits by 40% [46]. The area of shrimp farms predicted to be in production by 2020 was 1,30,000 hectares, a 13.6% reduction from the previous year [7], [46]. In a review report by Mukherjee et al. stated that From March-July lockdown period

60% of the shrimp farms has completed their yields, but due to the restriction in inter and intra state movement, lower demand level, many shrimp farmers was in panic situation regarding the harvesting [85].

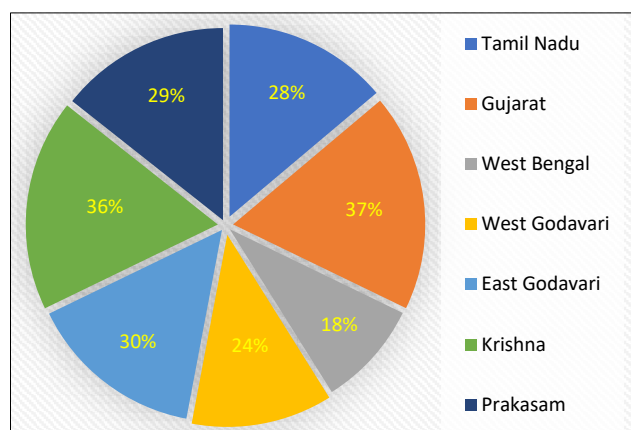


Fig 2 Estimated percent of shrimp pond area stocked in India as of April 2020. (Source: George *et al.* 2020) [46]

Shrimp feed industry

During the 1st quarter of 2020, approx. 350,000 MT of shrimp feed were produced in India, but the output for April month was approx. 80,000 MT, which was 40% lower than April, 2019 [46]. For shrimp feed fishmeal is one of the major ingredients, but in 1st quarter of 2020, India was produced approx. 46% less fishmeal than the amount of 120,000 MT produced in 1st quarter of 2019 [113]. In 1st quarter of 2020 fish oil production was dropped by 28% compared to previous year [113].

Impact on capture sector

Impact on fishing operation

The Indian fishing sector ranges from subsistence fishing to large-scale mechanized commercial fishing [53]. Fishermen who were already at sea during and after the lockdown couldn't land their catches [111]. About 8,000 fishers from Maharashtra and Gujarat were already at sea as the lockdown started [109]. Thousands of fishermen stranded around the coastlines [111]. Several fishing association and civil societies and industry experts stated that around 1 lakh migrant workers had been stranded onboard of fishing boats at harbours in Maharashtra alone [108]. While 4,000 fish workers were stranded onboard in Varval dockyard and according to TFWU over 5,000 workers were from Andhra [57]. The fisherman had little amenities onboard. The harvested fish was not preserved properly, and in Maharashtra and Kerala, the fish was tossed back into the sea to protect higher-priced species with abundant ice. Different media report stated that about 10,000 MT of fresh fish catch have dumped back at sea during the first lockdown week [33]. Not all fishermen could resume fishing again when the government of India issued relaxations and changed marine and inland guidelines. In Tamil Nadu and Karnataka, only three fishermen were allowed on non-motorized/motorized (10 hp) boats [53], [111]. These guidelines led to more fishermen boarding ships. Distancing, masks, and hand sanitizing made fishing difficult [3].

Fishing community related challenges

The pandemic and its associated lockdown not only affect the supply chain and transportation system but also adversely affect the overall livelihood of the fishing community. Many households are facing financial crisis due to loss of jobs of fish [72]. All states rely heavily on migrant

fishing workers [2]. Migrant workers from West Bengal, Odisha, Assam, Madhya Pradesh, Andhra Pradesh and Uttar Pradesh make up most of the workforce in coastal states [121] (Fig 3). All nine coastal states and four coastal union territories of India were affected by the pandemic and its closure of landing ports and harbors [119]. From March 24, 2020 until June 15, 2020, east coast fishermen were banned from the sea. West coast: June 1-July 31 [81]. East coast fishermen were unable to fish for 75 days and west coast fishermen for 130 days [92]. According to the V. Ravindran, State Coordinator of NETFISH of Tamil Nadu, about 200,000 small scale fishers have been affected during the pandemic situation [109].



Fig 3 Migrant fishers stranded in verval, Gujarat boarding the bus back to Andhra Pradesh. Photograph courtesy of: Laxman C Vadiya (Sanhati, 18th May, 2020) [119]

Stranded fishermen were malnourished. Most places urged boat owners to feed and water stranded fish workers [3]. Some boat owners fed the workers for a few days, but their resources deteriorated when fishing stopped, so they couldn't continue. As the lockdowns continued, most boat owners refused to support the crew, leaving them without money or food [119] (Fig 4).

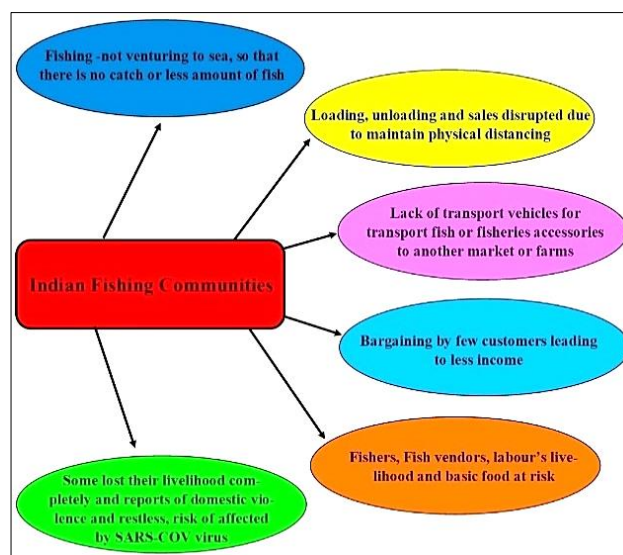


Fig 4 COVID-19 impact on the Indian fishing communities

Impact on wetland capture fisheries [38]

Fishing days

In India the wetland fishers were not allowed to fish during 1st phase due to strict lockdown enforced by the local authorities. Wetland fishers from Bihar, West Bengal, and Assam were lost 73%, 56% and 30% of fishing days respectively. It is estimated that the fishers from the three

following states were lost almost 20, 25 and 9 fishing days respectively [38].

Fish catch

The fish harvest during March to May of 2020 was 32%, 44% and 20% lower than the previous year in Bihar, West Bengal and Assam. Explanations for the reduced fish catch included reduction in fishing days, restrictions on group fishing due to covid measured and time allowed for harvesting operation [38].

Income

In India, the pandemic situation and lockdown made the wetland fishers partially jobless. The wetland fishermen lost several fishing days during the lockdown, which suffered an average loss of INR 500/ fishing day. Fishers of Assam, West Bengal, and Bihar lost 70%, 56%, and 60% income in 1st phase of lockdown and 30%, 44%, and 40% in the 2nd and 3rd phases of lockdown. The income loss to each fisher during lockdown was INR 10,000/-, 12,500/-, 4,500/- respectively in Bihar, West Bengal, Assam, and on an average of INR 9,000/- for an Indian wetland fisher [38].

Impact on sports fishery in India

India earns foreign currency via tourism, particularly fishing. Several Indian carps (Mahaseer, trout) are good sport. Mahanadi, Yamuna, Cauvery, Ganges, Brahmaputra, Sutlej, and smaller Himalayan rivers and streams are popular for sport fishing.

During the pandemic crisis and travel ban, foreign and domestic visitors couldn't travel [30]. So, India's developing sports fishery has declined. The pandemic affected those who rented anglers' rods, lines, hooks, bait, and other angling gear in the angling places. Even modest boat owners in angling sites who rented boats to anglers and tourists suffered losses from the pandemic [6].

Impact on market

Reduction in domestic consumption

Due to false perception regarding the origin of the novel corona virus from the seafood market of Wuhan, China, consumers were in panicked regarding fresh fish or seafood consumption [9]. Some people were saying that Corona virus could spread through consuming fish using different social media [93]. In that scenario, the trade of fresh fish and frozen seafood was damaged to a certain extent [9].

Unstable market price and sell of fish

Price of fish and shrimp were in heavily decreased trend due to the COVID-19 pandemic in India. Nationwide lockdown and unavailability of foreign and local buyer led to market instability and price reduction. Although small amount of fishing was allowed during the lockdown but due to the restrictions on selling of fish in the markets was headache for the sellers [106]. The price of large size of shrimp (30 pieces /kg) was \$5.74 in week 33, 2020 in Andhra Pradesh vs. \$4.80 at the same time in Gujarat [86]. The supply of fish was half of normal times in the market and that demand supply gap led to the 20–40% increase in farm gate price of carps and catfishes in Bihar, West Bengal and Assam. Around 15% of the fish demand of Assam met by fishes imported from other states of India. Due to transport restriction, fish supply from other states was completely stopped and that led to increase of fish price by 25–40% higher than the period before lockdown [86].

Reduction in demand

Disruptions in the global supply chains and compressed production activities have reduced the demand for intermediate goods and commodities [116]. After India's month-long blockade, demand dropped. Closing the food court, hotels and restaurants, caterers, processing units, and institutional users like schools and office canteens caused a demand shock [24]. During the COVID-19 epidemic, export and import slowed globally, and a statewide lockdown forced processors to shut down, resulting in an overabundance of shrimp and low demand. When there a news appeared in media, of throwing of dead bodies of suspected covid patients in river Ganga, people in fear have stopped eating fish. Because of that a drop have been seen in demand of river fishes [110].

Chinese, EU, Japanese, and US markets cut, delayed, or canceled orders for Indian shrimp [51]. Demand decline led processing plants to pull back, resulting in raw material surplus [18].

Impact on fish handling and marketing

With auctioning at harbours nearly stopped, marketing in several states was taken up by fishermen's groups or village/harbour councils/committees [3]. Kerala regulated the admission and departure of trucks into the fishing harbor and the number of laborers for loading/unloading to limit the number of workers [53]. During the shutdown, Karnataka's fishing boats couldn't dock. Kasimedu in Chennai, Tamil Nadu, and Munambam in Ernakulam, Kerala, had little activity [53]. All landing centers forbade retail sales. The grouper fishers of Andaman Islands switched from multi hook and line gear to nets for marketized multi fishes to the local markets because transport restrictions and reduction in demand due to pandemic [99].

In various landing centers, fishermen and other stakeholders claimed physical issues [29] such as social distancing, scarcity of cleaning products such soaps, sanitizers, chlorinated water, and masks [109].



Fig 5 A bumper catch of catfishes dumped at Vanakbara port in Diu due to the absence of buyers, traders, transport and storage facilities. Photo courtesy- Siddharth Chamudiya [81]

Impact on traders and retailers

Restrictions on market access and falling demand led to longer storage of fish and fish products, which increased food loss, waste [18], and expenses for dealers and merchants, thereby seen a drop of fish and fish food sales. In several areas although markets were closed or semi-closed due to the pandemic restrictions, fish merchants have to pay the shop owners being insisted by them. It was a major headache for the fish traders as their earnings during lockdown period were very low compared to pre-Covid period [94]. Indian dealers expected a 20-40% decrease [71]. In India, seafood sales fell 76%. All dealers and retailers in Assam stopped working in April 2020. Between February and April, trader income fell 59% [58].

In April, 55% of traders tried to get inputs and 65% tried to sell products, a 26% decline from February 2020. In India, farm fish prices fell 62% in Andhra Pradesh and 5% in Odisha between February and April. Between February and April, Indian retailers' sales fell 84%. In April 2020, major store sales fell 80% in Andhra Pradesh and stopped in Assam [86]. In India, shops have trouble acquiring fish and transportation, limiting their product selection (Fig 5).

Impact on sea-food export

The covid-19 pandemic hit the seafood industry in the financial year 2020-21 by registering a decline of 10.88% in terms of quantity, according to the data released by MPEDA [83]. India exported 11, 49,341 MT of seafood worth US\$ 5.96 Billion in 2020-21 compared to 12,89,651 MT in 2019-20 [117]. The sea-food export during 2020-21 declined by 6.31% in terms of Rupee, 10.8% in terms of US dollars (Table 2) [51]. Capture fisheries contribution was reduced from 56.03% to 53.55 % in terms of quantity and reduced from 36.42% to 32.01% in terms of USD value [83]. In 2020 India's shrimp export shown decline than the previous years (Fig 6). The unit value of aquaculture products was increased by marginal value 0.1 USD from 7.49 to 7.59 USD but the unit value of capture fisheries items was reduced marginally from 3.37 to 3.10 USD in 2020-21 [83].

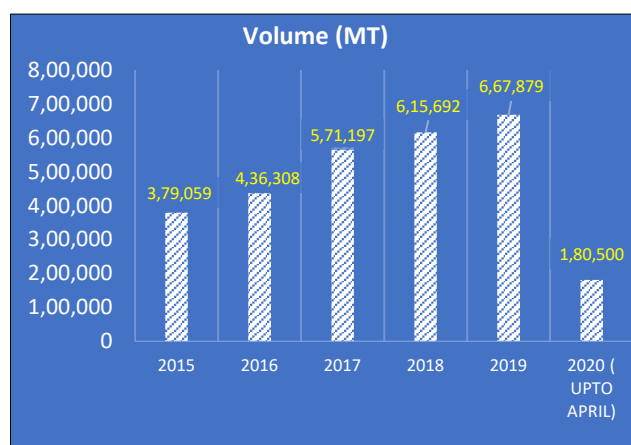


Fig 6 Decreasing of India's shrimp exports in 2020
(Source: Ministry of Commerce and Industry, GOI, 2020)

Shrimp exports during 2020-21, were declined by 9.47% in USD value and 9.50% in terms of quantity. The export of *Vannamei* shrimp was decreased from 5,12,204 MT in 2019-21 to 4,92,271 MT in 2020-21 [83]. The export of Frozen fish declined by 15.76% in terms of quantity and 21.67% in terms of USD value in 2020-21 compared to 2019-20. Frozen squid has shown a decline of 30.19%, 9%, and 13% in terms of quantity, rupee value and USD earnings respectively [51]. During that period export of chilled items was shown a decline

of 16.89%, 24.35%, and 27.90% in terms of quantity, rupee value and USD earnings respectively [51].

Table 2 Seafood export performance during 2020-21 compared to 2019-20 (Source- MPEDA) [83]

Export details	2020-21	2019-20	Growth (%)
Quantity in tons	11,49,341	12,89,651	-10.8
Value in crores	43,717.26	46,662.85	-6.31
USD in million	5,956.42	6,678.69	-10.81
Unit value (USD/Kg)	5.18	5.18	0.00

Impact on ornamental fish trade

Transport restrictions worldwide halted domestic and international ornamental fish trade. The government's closure of aquarium shops in India cut off the supply chain from grower to trader [55]. Kolkata, Chennai, Kerala ornamental fish farms suspended operations. Overstocking ponds and tanks caused significant maintenance costs and stocking loss owing to mortality in some regions [55]. Out-of-stock medications and prophylactics prevented disease management. Non-availability of fish meals and accessories costs hobbyists. Live food, including freeze-dried goods, was out of stock at the company, which hurt fish breeders [55]. Transport issues hampered India's ornamental aquaculture industry. Most fish farmers couldn't get good brooders during the epidemic, affecting fish breeding [28].

Impact on transportation

Fish transport problems inside the country

Fish transportation services are necessary to keep the fish supply chain [12] moving from farms/ harbours to markets and processing factories, both within and across states [26]. India's domestic fish transportation dropped 85%. Many transporters were not allowed to carry during the pandemic because drivers could accidentally be exposed to the new coronavirus [12], [17]. Many places were labeled red zones, restricting vehicle mobility and disrupting the transfer of perishable fish and fisheries supplies. Fish, ice, chemicals, and instruments caused many fish processors problems.

International fish transport problems

Most value chains slowed, reducing demand for foreign transport services [105]. Comparing the first quarter of 2019 to the first quarter of 2018 [16], maritime container lines lost 4% of volume [14]. The covid epidemic caused a halt in shipping, cancellations, blank sailings, and port closures. In late January and early February 2020, fewer container ships visited India's ports. Engineers couldn't repair cargo ships or boats due to travel restrictions [63]. Problems hindered several freight owners from transporting products [16]. Due to the initial pandemic wave, most countries suspended international cargo and freight travel, affecting live fish and fisheries products [14].

Impact on processing sector

Production disruptions

To preserve social distance and safety, catch fisheries were halted, which benefited fish stocks but hurt the processing business [92]. Lockdown caused a shortage of seeds, feed, and fertilizers for culture fishing [12]. Due to uncertainty about marketing facilities and customer demand, stay-at-home rules, inter-state and intra-state migration, processing unit owners ceased manufacturing [53]. India processed and sold 86% less fish in April 2020. Only 33% and 50% of Indian processors could access inputs and transport in April, while 40% could access transport for sales & buyers. COVID-19 have impacted the earnings of Micro, Small and Medium enterprises by 20% to 50% [115].

Employment crisis

Globally around 32 million fishers worked in small scale seafood sector, while 78 million engaged in the processing and sales lines [99]. During the pandemic period, the processing plant workers faced a new form of immobility due to the suddenly ceased fishing activities or shutdown of processing plants [104]. In both cases, they lost their jobs or reduced salaries as maximum processing and fishing firms were self-financed, and the owners were unable to continue the daily wages of workers; the scenery was quite same globally [74], [119]. The industries were facing labour shortage due to quarantine restrictions, social distancing, red zone areas and reverse migration of migratory workers towards their hometown [104], [115] and many were stuck due to the interstate border closed [121]. That overall situation created an employment crisis in the sector.

Lack of raw materials and logistic problems

In the early phases of the lockdown, fishing was forbidden, leaving the processing sector without raw materials [23]. The processing sector was spared from the limitations and remained active during the lockdown, but the lack of raw materials, accessories, and logistical assistance made it impossible to thrive [48]. The logistical manpower reduction reduced processing capacity and output [29]. Lack of packaging and processing chemicals hampered facility production. Social distance and PPE for workers were significant challenges for seafood processors [89]. Cancelled international transports boosted air freight prices for high-value seafood [23]. Due to restricted state and district boundaries and mobility limitations, processors couldn't acquire raw materials and logistical support [29]. International organizations and institutions shared similar views [47-50].

Other impacts

Overall reduction in fisheries production

In India culture production was damaged by reduced, delayed, or cancelled export orders from China, the EU, Japan, and the USA or by a lack of local demand [28], [51]. Production loss due to lack of seed [74], feed, chemicals, medicine, etc. The suspension of tourism and related companies, such as hotels and restaurants, diminished demand, notably for fresh or live fish, which hurt India's culture production sector [16], [89]. All states except Telangana (7% increase) saw fishery production fall. Maharashtra (23.5%), Madhya Pradesh (22.7%), and Andhra Pradesh (22.7%) saw the largest declines (21.7%) [86] (Table 3). Sanitary measures (distance between crew members at sea, masks, etc.) and lack of appropriate equipment (e.g., masks and gloves) made fishing difficult (and in certain cases more dangerous) and halted activity.

The lockdown cost the sector Rs 224 crore every day, according to the Central Institute of Fisheries Technology (CIFT) [7], the country's only fisheries and fish-processing research center. The survey projected that the mechanized sector lost Rs-197 crores a day, while small-scale, non-mechanized fishing lost Rs 27 crores a day [11], [57].

Impact on women SHGs

During the last year's covid pandemic, women SHGs in India's fishing industry suffered [57]. Many women's SHGs depended on fishing, and fishery-related enterprises such as fertilizer manufacture, seafood processing [59], and ice plants were under pressure during the pandemic [69], [120].

Many SHG women traveled to processing industries [59], culture sectors, ice plants, harbours, and fish landing centers. Border restrictions, lockdowns, and other tactics to

limit COVID-19 affected the groups' income chain [57]. Women were less able to recover from the epidemic than men because of hurdles and disadvantages [69], [81]. In Kerala's Ernakulam district, 35 SHGs led oyster cultivation with 545 beneficiaries [120]. During the pandemic, oyster farming plummeted. 60% reduction in average activity [120].

Table 3 State-wise average increase / decrease in magnitude of production in fisheries sector (%); source- NABARD August, 2020 Report [86]. Negative sign denotes decrease, positive sign denotes an increase, 0=no change

State/Union-Territory	Fisheries production (%)
Andaman and Nicobar	-55
Andhra Pradesh	-21.7
Arunachal Pradesh	-5
Assam	-1
Bihar	-10.2
Chhattisgarh	-10.4
Dadra Nagar Haveli	0
Daman and Diu	0
Goa	-15
Gujarat	-6.5
Haryana	-13
Himachal Pradesh	-21.3
Jammu and Kashmir	-12.1
Jharkhand	-9.4
Karnataka	-16.5
Kerala	-6.3
Madhya Pradesh	-22.7
Maharashtra	-23.5
Manipur	-13.3
Meghalaya	-7.5
Mizoram	-8.3
Nagaland	0
Odisha	-1.5
Puducherry	-55
Punjab	-20
Rajasthan	-20
Sikkim	0
Tamil Nadu	-21.8
Telangana	7
Tripura	0
Uttar Pradesh	-11.3
Uttarakhand	-3.6
West Bengal	-10.8
All India	-13.6

Impact on fisheries research

Government and research institutions' shelter-in-place policies halted lab and field research [34]. Research activities, mostly maintenance-related (i.e., cared for live fish populations, maintained battery-powered monitoring equipment), and long-term monitoring were restricted [49].

In India, freshwater and marine fisheries research, including lab and field work, was suspended for two months. In India, study on subterranean (e.g., cave, aquifer) aquatic biodiversity during summer months (May through August) was helped by low water levels, and even short lockdowns during that interval resulted in a year of lost research [34].

Extinction risk to iconic species

Covid epidemic harmed India's aquatic fauna. Pandemic added 12 million people to extreme poverty [4], [39]. Without social security, 90% of India's workers relied on daily pay and food supply chains that were badly disrupted in rural India [43],

[91]. As novice fishermen lack understanding of responsible and controlled catch tactics, illegal, indiscriminate, and destructive methods were adopted, affecting all aquatic wildlife (e.g., dynamite, poisons) [31]. That includes harvesting species at high extinction risk, including the endemic hump-backed mahseer (*Tor remadevii*), a critically endangered part of India's freshwater megafauna [91] (Fig 7). Illegal fishers removed their final large specimens from South India's River Cauvery, driving them closer to extinction [39].



Fig 7 Critically endangered hump-backed mahaseer, *Tor remadevii*, caught from the backwaters of Harangi in Kodagu, Karnataka, India

(Photo Courtesy- Star of Mysore, 30th April, 2020)

Increase home sewage production and impact on freshwater fishes

The epidemic worsened pollution around Indian cities including Mumbai, Kolkata, Chennai, and Delhi [31]. In crowded Indian towns, disruptions to food supply networks led to dumping wasted food and drink, such as milk, into water bodies, lowering oxygen levels through eutrophication [20]. Aquatic biodiversity was harmed by altered sewage pollution patterns or collapsed sewage systems [44]. Increased usage of disinfectants (e.g., hand sanitizers, cleaning products) and their presence in freshwater systems increased freshwater species' habitat danger [31]. Specially the face masks, gloves have increased the probability of microplastic pollution in the waterbodies during the pandemic [13].

Relaxation of environmental regulations

After the second wave, the government prioritized economic recovery, sidestepping environmental laws and assessments [31], [34]. Several development initiatives were

undertaken across the world to take advantage of a flooded news-cycle, decreased environmental assessment capability, and a necessity for economic expansion owing to the lockdown [32], [15]. The Indian government explored a 3097 MW dam in the Himalayan Biodiversity Hotspot [31].

Monitoring and stock assessment reduced

The COVID-19 crisis resulted in disruptions to routine environmental monitoring [4] and impacted stock assessment practice, fisheries management across the world [49], [15]. Although closures of formal fisheries in many regions during lockdown caused temporary reductions in usual harvest pressures [48], interruptions to other food production sectors were led many local communities to rely on freshwater fisheries as an emergency food source [91]. Although reductions in monitoring capacity were initially predicted to be short-term, in several cases suspension was extended throughout 2021 in India [34].

Positive impacts

During the terrific pandemic where humanity retreats indoors, then there the non-human natural world rumbles out liberated. The wildlife was filled open spaces, notoriously dirty waterways and rivers looked cleaner, the air became fresher, hazards dispersed. The most highlighted direct and indirect positive impacts of the COVID-19 pandemic [4] on the fisheries sectors are:

A. Fish population flourishes

A global fishing ban was excellent for fish. COVID-19 added no-fishing days to India's calendar. Every year, the government executes a two-month annual fishing ban that starts in April on the east coast and June on the west coast, but 2020's nearly two-month nationwide absolute lockdown led to an extension of the prohibition. During the epidemic, the fast-growing, short-lived species adapted faster. A study by Jayanthi *et al.* [90] in the Gulf of Manner with the SIMPER test showed that coral reef fish species diversity did not alter greatly, but density did due to the increasing abundance of specific species such as *Lutjanus fulviflamma*, *L. fulvus*, and *Scarus ghobban*. Vaan Island's fish density grew 31%, Koswari, Kariyachalli, Vilanguchalli, and Pattinamaruthoor patch reef 11%, 18%, 29%, and 20%. *Chaetodon octofasciatus*, *Scarus ghobban*, *Abudefduf saxatilis*, and *Lutjanus fulviflamma* were prevalent during the research period [90].

Scarus ghobban, *Chlorurus gibbus*, and *Leptoscarus vaigiensis* were observed pre- and post-lockdown [90]. Pre-lockdown parrot fish density was 56/250 m² and rose 36% post-lockdown to 88/250 m². Parrot fish density increased 60%, 18%, 27%, 64%, and 28% on Vaan, Koswari, Kariyachalli, and Vilanguchalli islands, respectively [90]. Non-interference gave overfished natural water bodies a much-needed break. When commercial fishing slowed owing to the pandemic, some scientists observed changes of behavioural patterns in fish [101].

B. Reduction in water pollution and plankton increased

The coronavirus sickness and lockdown put millions in adversity, yet over 2 months into the lockdown, air [67] and water pollution levels dropped and wildlife was free [78]. India's water was dirty. Most rivers and streams were turned into sewer canals for commercial growth, making treatment difficult. Every day, 40 million gallons of untreated wastewater reach rivers and other waterways. In 2018, the Centre Pollution Control Board (CPCB) [36] observed an increase from 302 to 351 critically polluted river sections.

A study by some researchers on the water quality of Lake Hussain Sagar in Hyderabad resulted a significant reduction of pollutants level due to the restrictive measures during the pandemic [75]. According to CPCB real-time water monitoring data, following lockdown of the 36 monitoring units set at various sections of the Ganga River, 27 points had acceptable water for bathing, animals, and fisheries [36]. Dissolved Oxygen (DO) levels in Varanasi's Nagwa Nala rose to 6.8 mg/l on April 4 from 3.8 mg/l on March 6, a 79% rise [65], [36]. According to the CPCB's real-time water quality monitoring of the Ganga on April 19, the biological oxygen demand was < 3 mg/l, dissolved oxygen was >4 mg/l and pH 6 to 9, met the drinking water standards [36]. There was a considerable increase in the levels of DO in Ganga River after the implementation of strict lockdown in the city of Kolkata, compared to the earlier DO levels (mean of 2015 to 2019), increased by 35.71%, 35.06%, 33.97%, 35.06%, 35.65% and 34.50% at Ramakrishna Ghat, Shibpur Ghat, Princep Ghat, Botanical Ghat, Babughat and 2nd Hooghly Bridge respectively during April, 2020 [44].

Delhi, the pollution hub and number one for most of the time, improved Yamuna's water quality during the pandemic-lockdown period [65]. The pH of the Yamuna River was alkaline, ranging from 7.1 to 8.7 with a mean of 7.6 before the pandemic-lockdown period, and between 7.1-7.4 in Najafgarh and Shahdara drain post lockdown. Before lockdown, BOD ranged from 7.9 to 163 mg/l with a mean of 66.58 mg/l. During lockdown, it was 2-89 mg/l. DO in the Delhi section of Yamuna during the lockdown phase ranged from 1.2 to 8.3 mg/l, which was higher than the pre-lockdown phase [3]. In South India's Thirumanimuthar River, total coliform bacterial population ranged from 35 to 310 MPN mL/L pre-lockdown and 12-225 MPN mL/L during lockdown [62]. Reduced microbial load (*E. coli* and fecal *Streptococci*) due to non-functioning small and large industrial units, closure of hotels, restaurants, community halls, malls, food stalls, schools and colleges, stoppage of tourism/floating population, traffic movements, waste disposal, and absence of bathing in the river, which improved aquatic life [19], [64]. According to Karunanidhi et al. (2021), the Thirumanimuthar River's heavy metals load was decreased, which benefited the aquatic life [62].

Decrease in biological parameters in the Godavari and Krishna River was reported by the Maharashtra Pollution Control Board during the COVID-19 lockdown period. The enhancement of the rivers water quality due to immediate drop in visitors and 50% decrease in industrial and sewage waste disposal, was observed by Singhal and Matto [98]. Phytoplankton density and chlorophyll-a content in the Gulf of Mannar coastal water increased from pre-lockdown to post-lockdown period [90]. The mean value recorded for phytoplankton was $31,766.3 \pm 236.5$ cells/l in 2019 and it was increased to $70,781.3 \pm 145.2$ cells/l in 2020. While, chlorophyll-a was 0.7 ± 0.01 mg/m⁻³ in pre-lockdown phase and it increased to 1.8 ± 0.55 mg/m⁻³ during post-lockdown [90]. Due to lockdown imposed by the Government, the discharges from industries, tourism units were cut-off. In addition, the water transport system was also ceased due to which the stress on tiny aquatic producer community was withdrawn. This was reflected through higher standing stock of phytoplankton during April, 2020 (430.63×10^5 /L), compared to April, 2019 (226.75×10^5 /L) and April, 2018 (219.03×10^5 /L) as shown in Diamond Harbour along the Hooghly estuary [79]. This increase in standing stock has high probability to accelerate the estuarine fish resources in the years to come. But in a research Mishra et al. stated that there is decline in phytoplankton biomass along the waters of Indian coastal region due to a

reduction in nutrient load, particularly the bioavailable N during the lockdown [77].

C. Some aquatic life from declining trend to revival trend

Within weeks of the outbreak and shutdown, media globally reported on increased water quality [65]. The media generally reported on highly visible and iconic huge marine species, such as seabirds, migratory birds, elasmobranchs, and marine turtles [65]. Around the river Ganga, Yamuna, Kaveri and Mahanadi, the presence of migratory birds has increased up to 100%. On the other side presence of migratory bird has increased Increase each of 80% in case of Gandak and Gomati River and Narmada, Nagavali (70%) each [65]. Media highlights included finfish and invertebrates (crabs, cephalopods, gastropods). Central Marine Fisheries Institute (CMFRI) 2020 reported that Indian oil sardine was on the rise along the Kerala coast [22].

Thousands of Olive Ridley Sea Turtles hatched in North India, much more than last year. Tourism often disturbs Olive Ridley Sea Turtles' beach breeding sites. Quiet beaches allowed turtles to lay eggs [112], [88]. According to Mitra et al. (2020) [79] the Shannon Weiner species diversity index values for fish juveniles showed substantial temporal variability, with decreasing values from 2011 to 2019 and maximum in 2020 [79]. Gangetic or South Asian River Dolphins were spotted in Hooghly River in Kolkata, West Bengal after 30 years (Fig 8) [114]. Because of the shutdown, water pollution was reduced to an incredible degree, which may have triggered their return.



Fig 8 Gangetic dolphins spotted in Hooghly River during pandemic and lockdown
Photo Courtesy- Get Bengal (4th May, 2020)



Fig 9 Olive ridley turtle spotted on Odisha beach
Photo Courtesy-The New Indian Express (16th March, 2020).

D. Aquatic life got a rare break from noise pollution

Imagine the misery of aquatic life when sound travels farther and quicker in water. Noise from shipping and loud bangs from seismic air cannon testing traumatized marine life [88]. 20–200 Hz shipping noise levels affect aquatic life, which is reduced by 6 dB below 150 Hz (Geo-Noise 2020) [45]. Ambient noise from maritime traffic raises marine species' stress hormone levels, which can influence their reproductive success [45]. Marine researcher Michelle Fournette of Cornell, USA found that restricting movement in the water reduced stress hormones in Right whales [64]. Indian Ocean is the world's busiest ocean, with 70% of trade passing through it. Marine activities including fishing, navy drills, and others are important causes of noise pollution in the ocean. Pandemic lockdown gave Indian ocean aquatic animals a rare break from the noise (Fig 10).

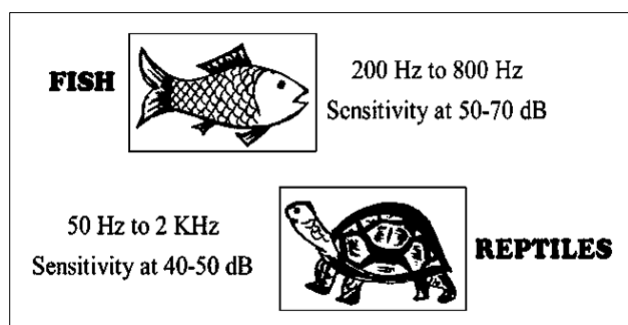


Fig 10 Noises fish and reptiles can hear

E. Angling grows popular in some places

On the one side, as the impact of the severe pandemic has been seen on sports fishery, but recreational angling has been seen grows in some places of India because angling became a therapeutic pastime during the lockdown restrictions. Munambam Beach and Kottayam of Kerala, Marina Beach, Kovalam & Royapuram fishing harbour of Tamil Nadu are of the popular places [107].

Mitigation measures for negative impacts undertaken by the Government and other organizations

This Covid pandemic has forced the national and international policymakers to focus on the sustainable recovery measures [25]. The central and state Government of India and other organizations took several significant steps to mitigate the negative impacts of COVID-19 pandemic on fisheries sector [17]. Even a survey on 1748 daily wages workers by Singh et al. (2020) resulted that despite of works, about 68.5% workers want to stay at home and waiting for the government schemes or helps to mitigate their problems [97].

Reduction of the fishing ban by the Central Government [118]

The government considered including the initial 21 days lockdown in the annual ban time so that fisher was able to start fishing early. This reduction in the annual fishing ban from 61 days to 47 days was claimed to be in lieu of lost fishing days. This amendment to the annual fishing ban is only for 2020, and it did little to solve current problems. The lifting of restrictions on mechanized and motorized fishing helped India's small-scale (non-mechanized) fishers and migrant workers [118].

Pradhan Mantri Matsya Sampada Yojana (PMMSY)

On 10 September 2020, the Prime Minister of India unveiled the Pradhan Mantri Matsya Sampada Yojana (PMMSY) to 'change' the fishing sector and bolster efforts to develop 'Aatmanirbhar Bharat' [54]. The PMMSY is a flagship scheme for focused and sustainable growth of the Indian

fisheries sector with a projected investment of Rs 20,000 crore, including Central Government [42], [89]. All States/Union Territories implement PMMSY from FY 2020-21 to FY 2024-25. This is the greatest ever investment in fisheries, which will double export profits to Rs 1,000,000 crore and create 55 lakhs direct and indirect jobs over the next five years. The plan aims to support fish producers and double their incomes [54], [89].

The budget regarding PMMSY, can be used for the following:

1. Overall fisheries infrastructure development, such as new fishing harbours and landing centers, specific fish market complex.
2. Setting-up new fish hatcheries.
3. Creation of strong and stealth supply chain, construction of cold chain and storage.
4. Research and Development in this sector.
5. Skilling and training (both technical and non-technical) to the people related to this sector.
6. Using new technologies like Artificial Intelligence, Cage Culture & Recirculating Aquaculture System (RAS), Block Chain and IOT etc., Post-harvest waste management.

Covid-19 recovery projects by the government for the fisheries sector

In the middle of the pandemic, the Indian government introduced the Draft National Fisheries Policy 2020 to integrate all components, including inland & marine, culture & capture, and post-harvest works, in a single document and create an environment to increase investments in the fisheries sector, double the incomes, and exports of fishers and fish farmers. The policy is production-driven, export-oriented, and dependent on capital investments, which strips small-scale fishers of access to commons and damages the environment.

Environmental and Social Commitment Plan (ESCP) [40]

1. The government implements the Fisheries Sector COVID-19 Response and Recovery Project (the Project) with MOFAHD of Government of India (GOI). IBRD will fund the Project.
2. The government would take measures to ensure the project meets environmental and social standards (ESSs). This Environmental and Social Commitment Plan (ESCP) outlines tangible measures and actions, specific documentation and goals, and timing.
3. MOFAHD shall monitor and report to the Bank on the implementation of the material measures and actions in ESCP as required by ESCP and the legal agreement. The Bank will monitor and analyze progress and completion of the material measures and actions during Project implementation [40].

Stakeholder Engagement Plan (SEP) [41]

Fisheries growth slowed in 2020-21. 2021-22 saw aftereffects [70]. Lower-income and historically disadvantaged groups are mostly employed. Most had depleted working capital owing to wastage and distress sales and were unlikely to recover production/capture at pre-covid levels. Millions of fish workers may not resume their jobs until 2022-23. The proposed Indian Fisheries Sector COVID-19 Response and Recovery Project (SEP) intends to preserve jobs in the fisheries sector by facilitating working finance and insurance, growing sustainable fisheries sector firms, and enhancing fish-food safety.

Component 1: Formalization, facilitating & working-capital finance for micro- and small-enterprises (total financing of US\$158.7 million).

- Component 2: Supporting small-scale participants in the Indian fisheries Sector to re-engage and expand Businesses (total financing of US\$109.7 million).
- Component 3: Food safety improvisation and quality monitoring systems, traceability, advocacy and awareness (total financing of US\$111.8 million).
- Component 4: Management of project, monitoring and reporting (total financing of US\$19.8 million) [41].

New digital platforms

e-SANTA [87]

Union Commerce and Industry Minister of India was inaugurated e-SANTA on 13th April, 2021. It is an electronic marketplace, providing a platform to connect aqua farmers and the buyers. It's enabled the farmers to get a better price and another side the exporters to directly purchase quality products from the fish farmers, enhancing traceability, a key factor in domestic and international trade. The term e-SANTA stand for a web portal, mean that 'Electronic Solution for Augmenting NaCSA farmers' Trade in Aquaculture. National Centre for Sustainable Aquaculture (NaCSA) is an extension arm of Marine Products Export Development Authority (MPEDA). According to the Govt [87]. e-SANTA will 'RAISE' farmers lives and income by:

Reducing the risk - Awareness of markets & products - Increase in income of the farmers - Shielding against wrong practices - Ease of processes.

According to the government of India e-SANTA is a Digital Bridge to end the market divide and it act as an alternative marketing tool between aqua farmers & buyers by eliminating the middlemen. It's also revolutionized traditional aqua farming by providing cashless, contactless and paperless electronic trade platform between the farmers and exporters. The Platform is available in many regional languages, which also helps the local population [87].

Matsya Setu app [100]

The central government released a mobile app to help fish farmers improve their output. The 'Matsya Setu' android app was developed by ICAR's Central Institute of Freshwater Aquaculture (CIFA), Bhubaneswar, with funding from India's National Fisheries Development Board. The app disseminates scientific aquaculture methods and freshwater aquaculture technologies. This app offers species- or subject-specific self-learning online course modules where recognized fisheries specialists teach breeding, seed production, and scientific culture of commercially significant fishes such carp, catfish, murrels, scampi, ornamental fish, and pearl farming. This platform teaches BMPs for managing soil and water quality, feeding, and health management in aquaculture operations [100].

Matsya Kiran app [66]

During the pandemic, the Telangana government released the Matsya Kiran app for fish farmers. Telangana's fisheries sector contributes 0.6% to GSDP, helping fisher households' socioeconomic development (Dept. of fisheries, Telangana, 2020) [66]. So, Telangana fish farmers discussed the app's features. This app covers culture practices, management practices, post-harvest procedures, modern agricultural techniques, state-specific fisheries information, and buy or sell. Books, websites, journals, and research papers were used to gather scientific knowledge for each feature [66].

CIFT response [10-11], [21]

During pandemic restrictions and lockdown in Kerala, CIFT (Central Institute of Fisheries Technology) offered its facility to examine seafood because all private labs were closed. The institute created guidelines in ten languages for fishermen, processors, markets, and landing center staff to operate a safe, commercial fishing industry during a pandemic. CIFT met with fisheries stakeholders to understand their needs and asked fishermen, exporters, and processors what they want from the government. CIFT presented fishers' needs to New Delhi's ministry, including cage culture, vessel modernization, and value addition. As fresh fish shops are usually non-operational during the pandemic, the Institute was advised to increase online fish marketing.

Tackling contaminated fish

Another major issue during the lockdown was fish from other states that contained ammonia/formalin, a preservative to prevent fish spoilage. CIFT developed a paper kit that could test the presence of chemicals in the fish. This was used to check the fish quality and also determined the preservative contained. CIFT also launched 'freshness indicator', a strip that consumers could use to check if fishes were spoilt [21].

Breaking price barriers

In the Federal State of Kerala, Matsya fed, the State Co-operative Federation for Fisheries Development Limited, was fixed the price of fish catch during the pandemic situation with the help of CIFT [21].

Mitigation advisory

The ICAR-CIFT brought out a COVID-19 mitigation advisory for fish transportation which emphasized the did and didn't for personnel involved in the transportation of fish and prevented the spread of the virus and also to safeguard their own health [10].

Developed Sanitizer

The ICAR-CIFT developed hand sanitizer based on the extract of red algae (sea weed) constituting chemical components with antiviral properties [11].

FAO response [50]

The Fisheries Division of FAO (Food and Agriculture Organization) was created a COVID-19 pandemic Task Force to coordinate departmental initiatives and provide coordinated support to measures and interventions addressing the impact of the pandemic on fisheries and aquaculture and prepared the response. FAO was primarily focused on supporting, restarting and strengthening the fisheries sector's supply chains and livelihoods in response to the crisis. Different actions took by FAO include:

1. Worked with members, fisheries industries, civil society representatives, and other stakeholders to monitor the situation and provided policy, management & technical advice, as well as provided technical support innovate and adapt practices along the entire supply chain.
2. Coordinated information and responses with international & regional partners, such as regional fishery bodies, inter-governmental economic organizations, research institutes and civil society organizations related to this sector.
3. Assessed the risks to global, regional and national food systems as new information & knowledge soundly based and to mobilize resources for coordinated the pandemic mitigation measures.
4. Worked with international financial institutions & donors to develop comprehensive and coordinated intervention

packages to address the most urgent priorities to reactivate fisheries supply chains.

5. Developed the guidelines “Best practices for developing surveys and questionnaires on the impacts of COVID-19” [50].

CIFRI, CIFA, CIBA, CMFRI, CIPHET response [1]

The Fisheries Research Institutes under ICAR continuously addressed the problems regarding different stakeholder groups (fish farmers of freshwater and coastal aquaculture, hatchery operators/ workers, feed plant workers, workers in processing factories, fishermen etc.) and developed several solution measures for wide circulation among farmers’/ extension workers and other stakeholders farmers of freshwater and coastal aquaculture, hatchery operators/ workers, feed plant workers, workers in processing factories, fishermen, students etc., during the pandemic period. In order to provide assistance to industry/ stakeholders/ consumers, Fisheries research institutes were taking the following initiatives:

- 1) ICAR-CIFRI (Central Inland Fisheries Research Institute) was erected with the state fisheries department and provided suggestions/guidelines on various aspects related to fisheries.
- 2) ICAR-CIFA (Central Institute of Freshwater Aquaculture) launched virtual Training Programme for Freshwater Pearl Farming.
- 3) ICAR-CMFRI (Central Marine Fisheries Research Institute) was initiated door delivery mechanism of fresh fish ready-to-cook vegetables to consumers through KVK (Ernakulam) WhatsApp message.
- 4) ICAR-CIBA (Central Institute of Brackish-water Aquaculture) were produced and supply shrimp feed to local farmers at Kakdwip, West Bengal.
- 5) Freshly harvested fish from the farms were sold through a counter opened near the Centre at Navasari, Gujarat & SHG women worked at the farm, provided fish to the village, with the involvement of Research Centre of CIBA.
- 6) ICAR-CIBA was continued the routine maintenance and upkeeping the broods for seed production of different fish species to continue the serial supply chains with the help of labors from the nearby fishermen villages.
- 7) ICAR- CIPHET (Central Institute on Post Harvest Engineering and Technology), Ludhiana, Punjab was provided advisories on the ways to process the raw material by minimally processing, shrink wrap packaging solution to extend shelf life by 1-2 week and also advised farmers prepare zero energy evaporative storage to store perishable products for 2-3 days.

ICSF trust relief works in India [56]

International Collective in Support of Fish-workers (ICSF) Trust undertook relief work among marginalized marine and inland small-scale fishing communities in the states West Bengal, Andhra Pradesh, Kerala and Maharashtra of India. ICSF worked through credible civil society organizations (CSOs) of the above states, mainly in the form of providing sanitary masks, sanitizer, provisions for cooking and cash assistance in a targeted manner. These efforts followed a ground-up approach whereby each CSO were applied its own criteria to identify beneficiaries in consultation with local communities in the targeted states [56].

Fish marketing initiatives by Odisha government during the COVID pandemic [37]

Odisha's Fisheries Department created "Chilika Fresh," run by FISHFED, to deliver fresh fish to consumers during

epidemic. Odisha FISHFED developed a new project to deliver fresh fish door-to-door during shutdown and pandemic restrictions. FISHFED, Odisha did not raise fish prices when IMC prices rose. Chilka Fresh's fish was in high demand because it was delivered door-to-door by "Fish on Wheel" and was inexpensive. In Bhubaneswar, 10 "Fish on Wheel" vehicles delivered fresh fish to urban consumers. Odisha maintained social distance in fish markets. Nimapda retail fish market in Puri, Odisha, preserves social distance during fish sales. In the fish market, the municipality marked 1-meter-apart circles [37] (Table 4), (Fig 11).



Fig 11-12 Fish species sold in fish on wheel in Odisha at the doorstep

Photo courtesy: Mr. B. B. J. Sahoo, AFO, Fisheries Department, Government of Odisha

Table 4 Fish species sold in fish on wheel and their price in Odisha (Data collect from Govt. of Odisha report, 2020)

Fish species	Price (Rs. /Kg)
<i>Catla catla</i> (live)	190
<i>Labeo rohita</i> (live)	160
<i>Lates calcarifer</i> (Bhetki)	550
<i>Tenualosa ilisha</i> (Hilsha)	1000
Mullet	440
Pomfret	850
Smaller mullets	160
Polynemidae species	240
<i>Labeo bata</i>	180
Small indigenous fishes	180
<i>Penaeus monodon</i>	550
<i>Litopenaeus vannamei</i>	400
<i>Penaeus indicus</i>	450
<i>Macrobrachium rosenbergii</i>	550
Smaller prawns	260
Mackerel	100
Lesser sardine	100

CONCLUSION

The COVID-19 pandemic threatens India's and the world's fisheries. Despite some good impacts and consequences, they are largely overshadowed by unfavorable ones. The epidemic has disrupted micro and macro fisheries globally. Due to this unfavorable scenario, India's fisheries

sector has lost economy, jobs, livelihoods, foreign and domestic commerce, and input supply chain. Indian fish growers would need continuous production to meet demand. In India, the marine fishery sector in deep sea lost Rs. 224 crore a day during the closure, according to a CIFT report. The Kochi institute predicted a monthly loss of Rs. 6,838 crore. No economic sector will be the same, or it will take a time to return to normal. All sectors must adapt to changing conditions. Now is the moment to develop sustainable, conservation-focused fisheries strategy. All parties should quickly organize to support the Fisheries sector. Immediate and targeted short-term solutions are needed.

Long-term, there is a need to develop a coordinated reaction and support network to change existing institutions, supply networks, and food systems to repair the circumstances and resilience of Indian Fisheries sectors. So, fisheries should adapt to the pandemic's problems.

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Conflict of interests

The authors declare that there is no conflict of interest.

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