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Training Manual

Risk Management Survey and Loss Assessment in Shrimp Farming

ICAR - CENTRAL INSTITUTE OF BRACKISHWATER AQUACULTURE

75, Santhome High Road, MRC Nagar, Chennai, Tamil Nadu 600 028

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Preface

Indian shrimp sector is one of the fastest growing sub-sectors in Indian economy. The country is producing about 8.43 lakh tonnes/annum of farmed shrimp from an area of 1.67 lakh hectares. India is the second largest producer of shrimp in the world and the annual forex income from frozen shrimp export is to the tune of US$ 7.8 billion, which accounts for about 67 percent of the annual seafood exports. Andhra Pradesh, Odisha, Tamil Nadu, West Bengal, Gujarat, and Maharashtra are the major shrimp producing states in India. In recent past, shrimp farmers are facing many challenges due to varied degree of production and price risks. Natural disasters like cyclones, floods, heavy monsoon rains are affecting the shrimp industry in the East Coast. Diseases like *Enterocytozoon hepatopenaei* (EHP), White Spot Syndrome Virus (WSSV), White Faeces Syndrome (WFD) are some of the major diseases which could reduce the production and profitability of shrimp all over the country.

In this scenario, ICAR-CIBA has taken a series of initiatives to facilitate risk management by mainstreaming adoption of shrimp crop insurance. We organized a Sensitization Programme for banks and insurance officials from India on risk management in shrimp aquaculture during 1-3rd March 2023, besides helping develop customised insurance products by the industry. Now, ICAR-CIBA, jointly with ICAR-CIFE Mumbai, is organizing a series of Certificate Courses on Shrimp Crop Insurance and Loss Assessment to train a cadre of professionals from across the country. The Course provides an overview of shrimp aquaculture, institutional and regulatory framework, diversification of species and systems, health management, soil and water quality management, nutrition and feed management, capital requirements and profitability of shrimp farming, basics of crop insurance, survey/loss assessment, ICT applications for shrimp farm management, innovations, start-ups and incubation in shrimp sector, etc.

I am happy to state that the organizers of the programme have prepared this training manual covering all the above vital topics which are much relevant to the title of this sensitization programme. I am sure this programme and this manual would be of immense help to all the diverse stakeholders including farmers, insurance and fisheries professionals. I congratulate the Course Director Dr. T. Ravisankar, Principal Scientist & SIC, Social Sciences Division and other colleagues for organizing this series of training programmes. In addition, I also congratulate all the authors who have assisted in preparation of this Manual. I wish the programme all success.

कुलदीप कुमार लाल
(KULDEEP KUMAR LAL)

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Current status and prospects of shrimp farming in India

Balasubramanian, C. P. Shyne Anand, P.S. Aravind, R., and Panigrahi, A

Shrimp is the most successful species in the blue revolution, and shrimp farming is one of the few remarkable success stories of modern aquaculture. Aggregate production of the shrimp is showing an upward trend in India as in other shrimp farming countries, for example: estimated farmed shrimp production in India during 2022 was about 0.9 million ton. This impressive growth in production of the farmed shrimp attained during the last few decades does not indicate the industry is without problems. Aquaculture of shrimp is severely impacted by frequent disease outbreak, issues in production and marketing, however, it is still among the most successful aquaculture crops. In this lecture note, we attempt to provide an account on how shrimp farming evolved in India, the present status of shrimp aquaculture in India, the state of art of shrimp production and issues and way forward.

Shrimp aquaculture: Farming to industrialization

History of shrimp farming in India is almost similar to the other South East Asian countries. In early 1920s, juvenile shrimps were extensively fished from the paddy fields bordering the backwaters and estuaries of Kerala (pokkali), West Bengal (bheries), Karanataka (Ghazan) and Goa (Kazhan), and were exported to Myanmar to market as a shrimp product known as ‘prawn-pulp’. Later due to the innovation in the preservation techniques in India, the demand for larger shrimps has increased considerably, and, therefore it was essential to grow the shrimp in the farm field to meet the demand of export industry. Thus, the paddy field shrimp fishery has been evolved into a primitive form of aquaculture where, the naturally immigrating shrimp seeds from coastal waters are entrapped and prevented from returning to sea, and reared for few months, without any feed or aeration. Later, to augment the production, farmers started the practice of stocking the ponds with wild caught seeds (George and Rao, 1963), and thereafter, when commercial hatcheries started, with hatchery reared seeds are stocked. This form of improved extensive type of shrimp culture is still prevailing in Kerala with a production of about 400 kg/ha to 1000 kg/ha for a short period of culture without supplementary feeding), where it can be understood that this type of culture is a form of ecosystem based culture or an organic shrimp aquaculture, in perennial farms and pokkali rice farming fields.

Although shrimp farming has been prevailing in coastal states of India for several decades, the industry only really began to intensify in the early 1990s, after the successful demonstration of commercial tiger shrimp hatchery in AP, through an MPEDA and DBT project, by TASPARC, The first recorded data for farmed shrimp production in India were 20 mt in 1970 and first major change became obvious in 1990 when it reached 35580 mt. Farmed shrimp production showed a remarkable growth during early 1990s, and it has grown from almost 35000 in 1990-91 to 83,600 mt in 1998-99 with a 135% increase

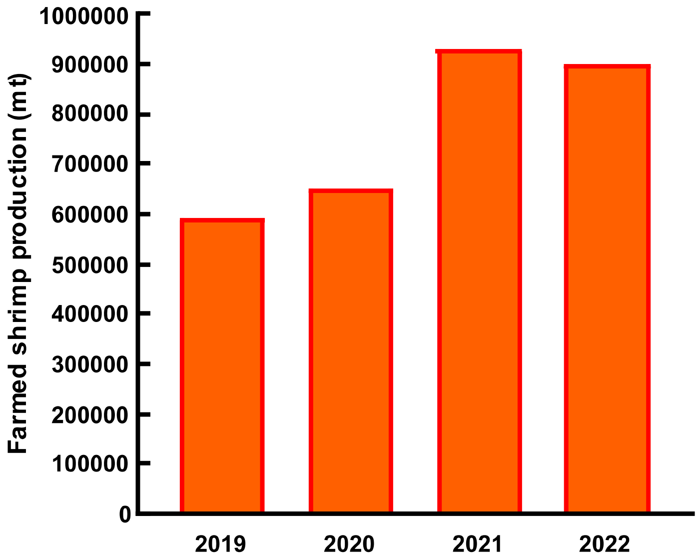
Shrimp aquaculture in India has faced several challenges after the first white spot panzootic in mid 1990s. Although WSSV was detected in 1993 itself, the largescale crop failure occurred after 1995. This large-scale production failure, however, did not reduce the estimated total production, possibly, due to the increase in the total area under culture. One of the most striking events in Indian shrimp farming scenario happened when Supreme court of India has made a verdict in 1996 to ban all nontraditional shrimp farming in the coastal zone of India. Subsequently Parliament of India passed Coastal Aquaculture Authority Act in 2005 to provide the regulatory frame work for carrying out coastal aquaculture adhering to the principles of sustainable aquaculture. To facilitate the act, Coastal Aquaculture Authority (CAA) was established in 2006 for regulating the activities connected with coastal aquaculture in the coastal areas.

Introduction of *Penaeus vannamei*

Diseases have been the major constraint of shrimp farming in India since 1995. it was almost acknowledged that the seed stock raised from the wild broodstock cannot sustain the production in the culture system, because most wild brood stocks are infected with several pathogen. The use of post larvae generated from the specific pathogen free (SPF) broodstocks along with strict biosecurity measure are the most effective management option to ensure successful crops. *P. vannamei* was introduced to several South East Asian countries including India. In India, from 2010, a dramatic growth of farmed shrimp production due to the introduction of *P. vannamei* was recorded, with almost 1lakh mt in 2009 to almost 9 lakhs mt in 2022 (xxx). This was possible due to the competitive aquaculture traits of genetically improved SPF *P. vannamei*, for example: high survival rate, fast growth rate, tolerance to high stocking density, lower dietary requirements, more efficient utilization of plant protein in the formulated diet and stronger adaptability to low salinity. Also, the biological advantages such as column feeding habits, and ease to reproduced in captive condition, contributed in the successful growth of vannamei farming.

Current status

According to the estimate of the industry farmed shrimp production in 2022 was 902, 525 mt which is lesser than the production of 2021 (930,000). However, the production was increasing from 2019 onwards (Figure).



Farmed shrimp production in India
(Crop review by Society of Aquaculture professionals)

State wise shrimp production during 2020-2021

Penaeus monodon			*Penaeus vannamei*	
States	**Area under production (ha)**	**Production (mt)**	**Area under production (ha)**	**Production (mt)**
West Bengal	50000	19190	6059	35392
Odisha	551	878	10649	43677.4
Andhra Pradesh	2591	5222	71921	634672
Tamil Nadu and Pondicherry	30	81	8600	44735
Kerala	2813	1129	157	420.85

Karnataka	2175	1000	970	2185.84
Goa	0	0	0	0
Maharashtra	0	0	1184	4252.1
Gujarat	35	116	8986	50410
	58195	27616	108526	815745.2

Among the coastal states, Andhra Pradesh produced almost 78% of total production followed by Gujrat (6%) and Odisha (5%). The published data of society for Aquaculture

The data published by the industry for the year 2022 is given in the following table

States	2021	2022
Gujarat	28000	35000
Rest of west coast	8000	11200
Tamil Nadu	23000	26000
Andhra Pradesh		
South AP	114000	120000
Krishna	130000	100000
West Godavari	270000	240000
North AP	160000	140000
Odisha	70000	73000
West Bengal	88000	61825
Other states	9000	30000
Domestic	30000	66000
Total	930000	902525

Professionals (SAP) included domestic consumption, and this production data is almost matching with production statistics published by the Government. Although a meager increase in production in all the region during the year 2022, there was a substantial reduction in Andhra Pradesh. The reduction in the production is mainly attributed to the low price and many farmers did not stock their ponds. The region wise details of shrimp production is given:

Gujarat: Gujarat is the major state among the west coast shrimp producing states, and there was an increase in production when compare to 2021. This may be due to the farming of SPF *P. monodon*. Occasional problems of WSSV and EHP in the vannamei farms have been reported. Maharashtra, Goa, Karnataka, and Kerala are the other shrimp farming states on the west coast with a total production of 11200 mt.

Tamil Nadu: There is a marginal increase in the production during 2022, however, only 60% of total farms were used for culture. Three major areas of shrimp farming in Tamil Nadu are: Ponneri, Mahabalipurm to Cuddallore and Chidamparam

Andhra Pradesh: This state is categorized into four regions: South Andhra Pradesh, Krishna, West Godavari and North AP. There was a decrease in the production in all regions except south A P. South Andhra Pradesh covers Nellore, Prakasam and Guntur districts. The success rate is reported to be high in these districts. Some areas, particularly Kavali area had consistent high production due to the strict adherence of crop holydays during Feb to May every year. This region had the marginal rise in the farmed shrimp production while all other regions showed decrease in the production. In Krishna district most farms are at low saline regions, and previously were used for the fish culture. Shrimp is also produced in polyculture with fish. West Godavari is the largest region in terms of farming area, and shrimp production reached as high as 270000 in 2021, and reduced to 240000 in 2022. The higher production in this area may be due to the expansion in culture area, reduced number of days in culture and rotation of crops from shrimp to fish during July to November. North AP includes east Godavari district and other northern regions. Many shrimp hatcheries are located in east Godavari district, and about 40% of PL are produced in this district.

Odisha: There is also slight increase in the production compared to 2021. Most shrimp farms practices, and about 8000 mt of shrimp is produced by the traditional shrimp farms of the state. This state is prone to natural calamities such as cyclone and storms.

West Bengal: The major shrimp farming state on the east coast, the production was dropped from 88000 in 2021 to 61825 mt in 2022.

Hatchery segment

According to the statistics published by Coastal Aquaculture Authority of India, a total of 462 registered *Penaeus vannamei* hatcheries are found in India, and most hatcheries are located in Andhra Pradesh and Tamil Nadu. In 2021 post larvae production is reached an all-time high of about 100 billion. Additionally, six SPF *P. monodon* hatcheries are presently functioning in India. In 2021, around 2.8 lakh broodstocks of *P. vannamei* were imported.

Shrimp production systems: State of Art

Coastal aquaculture Authority ensures the following legal criteria for the selection of site for constructing shrimp farming.

- No license for aquaculture should be granted allowing aquaculture within 200 m of the high tide line or any area within the coastal regulation zone. However, this is subject to the provision that it does not apply to any aquaculture farm in existence at the time of the establishment of the Aquaculture Authority. Noncommercial and experimental aquaculture farms operated by any research institute of the Government or by the Government
- Mangroves, agricultural lands, saltpan lands, ecologically sensitive areas like sanctuaries, marine parks, etc., should not be used for shrimp farming.
- Shrimp farms should be located at least 100 m away from any human settlement in a village / hamlet of less than 500 population and beyond 300 m from any village / hamlet of over 500 population. For major towns and heritage areas it should be around 2 km.
- All shrimp farms should maintain 100 m distance from the nearest drinking water sources.
- The shrimp farms should not be located across natural drainage canals / flood drain.
- While using common property resources like creeks, canals, sea, etc., care should be taken that the farming activity does not interfere with any other traditional activity such as fishing, etc.
- Spacing between adjacent shrimp farms may be location specific. In smaller farms, at least 20 m distance between two adjacent farms should be maintained, particularly for allowing easy public access to the fish landing centers and other common facilities. Depending upon the size of the farms, a maximum of 100 - 150 m between two farms could be fixed. In case of better soil texture, the buffer zone for the estuarine based farms could be 20 -25 m. A gap having a width of 20 m for every 500 m distance in the case of sea based farms and a gap of 5 m width for every 300 m distance in the case of estuarine based farms could be provided for easy access.

- Larger farms should be set up in clusters with free access provided in between clusters.
- A minimum distance of 50-100 m shall be maintained between the nearest agricultural land (depending upon the soil condition), canal or any other water discharge / drainage source and the shrimp farm.
- Water spread area of a farm shall not exceed 60 per cent of the total area of the land. The rest 40 per cent could be used appropriately for other purposes. Plantation could be done wherever possible.
- Areas where already a large number of shrimp farms are located should be avoided. Fresh farms in such areas can be permitted only after studying the carrying / assimilation capacity of the receiving water body

The technical consideration for selection of site for construction of shrimp farms are: 1) adequate quantity of water with optimum salinity should be available. Salinity should not be lower than less than 5 ppt and above 35 ppt, and the pH should be between 7 and 8. The quality of the soil is also should be suitable for the shrimp culture, and following criteria should be considered.

Soil should be favorable for the growth of beneficial algal bloom

Enough clay content should be there to prevent seepage

Favorable chemical condition

Recent innovation

Shrimp aquaculture in India is not stuck in the status quo, and new interventions have been tried. Shrimp farming, particularly *P. vannamei* farming is evolved from a simple culture where larger ponds are stocked shrimps at low stocking density, which is prevailing in Ecuador, to a small pond with water recirculation, waste capture, environmental control, high stocking densities with strict biosecurity. In order to improve the production and better control over the production cycle, a two-phase culture system has been evolved: A nursery phase for 21 to 30 days that is followed by a grow out phase for 2 to 3 months. In shrimp farming industry, the nursery systems provide numerous benefits: improved inventory, size uniformity, less predation, reduced pond grow-out duration, an increase in the number of harvests per year, better feed conversion efficiencies, greater biosecurity, compensatory growth during grow-out stages, short culture duration and higher grow out yields (20-30 increase % productivity compared to the traditional single-phase grow-out system). Several types of nursery rearing system have been developed with various levels of success:

- Clear water nursery systems
- Biofloc based nursery systems
- Recirculatroy based nursery units
- Hybrid nursery systems
- HDPE lined pond (0.5-2000 m2) with well-prepared dyke

Among these Biofloc technology (BFT) is one of the novel strategies to augment the development of sustainable shrimp farming. BFT needs a specific Carbon to Nitrogen ratio, and heterotrophic bacteria able to utilize nitrogenous waste metabolites and preserve the water quality. The produced flocs are used as additional nutritional sources. The production rate is high in the biofloc system. Despite the benefit of the biolfloc, it has limitations: high aeration to suspend the particle in water column, high infrastructure and installation expenditure, greater energy consumption, high carbon foot print and complicated management protocol to suspend solids.

In a system popularly known as mixotrophic, heterotrophic and microalgae are supplemented, further, organic carbon provides without specific C:N ratio. ICAR-CIBA has developed a modified copefloc system to optimize the nursery rearing of penaeid shrimp. Copefloc is developed using filtered fermented juice of rice ban, molasses and yeast, and which is inoculated with copepod species. Nursery tanks are stocked with *P. vannamei* post larvae (12 day). Nursery tanks are stocked with *P. vannamei* PL at a rearing density 1000 to 10,000 PL/m^3. Copefloc is added on alternate days, and 20% water is exchanged weekly. The salinity is maintained at23 ppt. Fermented juice is added on weekly basis and copepod density is maintained above 1000 no/L through-out the culture period. The amount of nursery feed required during the culture period was significantly less (20±1.1%) in copefloc system compare to the control. Copefloc reared *P. vannamei* showed compensatory growth with low feed conversion ratio in the grow-out culture ponds directs its importance in shrimp farming sector.

Nursery rearing system can either developed out door at on fam site as well. However, indoor nursery system is more biosecure than the on-farm unit. HDPE lined on farm units are used successfully by farmers in Andhra Pradesh.

Back to black tiger shrimp

Black tiger shrimp, Penaeus monodon was the dominant marine shrimp in India and in world markets. However, later in 1990s the culture of tiger shrimp began to fail. The reasons are many: frequent disease outbreak, harvest size became smaller and feed efficiency dropped, and eventually culture became non profitable. This failure of the black tiger shrimp farming opened the way for SPF *P. vannamei* from Americas. However, the last few years witnessed rise in *P. monodon* farming due to the availability of SPF *P. monodon*. The resurgence of P. monodon is not only due to the new genetics but also this species tolerates *Enterocytozoon hepatopenaei* (EHP) and white feces syndrome E(WFS) better than vannamei.

An experimental culture of SPF *P. monodon* was conducted by ICAR-CIBA in experimental station of CIBA at Navasari, Gujart. SPF monodon was stocked at a rearing density 15/m^2 and culture for 105 days, and animals were fed with formulated feed of 38% protein. The animal reached a final average body weight of 29.5 g with a survival of 71%.

Shrimp culture in Plastic lined ponds

In general, shrimp farming is carried out in coastal brackishwater/seawater region. Many times soil type may not be suitable for farming. For example, soil with soil with seepage and low water holding capacity are not suitable for construction of ponds. Similarly acid sulfate soil will develop a low pH, which is unsuitable for shrimp growth and survival. Organic soil do allow stable embankments and have elevated oxygen demand. Further, these ponds are not dryable and after few crops the culturing in these ponds will be difficult. Lining the ponds with plastic is one of the bests method to alleviate these problems. Although the studies on pond lining have been carried out during the inception of shrimp farming, it is only in the last few years that this technology has been widely applied to aquaculture. Both HDPE (high density polyethylene) and Poly Vinyl Chloride (PVC) are used for lining. This material can resist deterioration by UV light and allows them for may years. The recommended thickness for a shrimp pond liner is at least 0.75 mm, and many suppliers of HDPE and PVC liners guarantee their product use under normal conditions for five to 10 years. Lined shrimp ponds that are well-designed, built and managed can efficiently manage organic matter and sludge. Note central drain and accumulated sludge in centre of pond.

Advantages

- The use of plastics to line pond aquaculture bottoms and embankments prevents contact with acid-sulfate soils to avoid low pH in pond bottoms and water, which normally would create problems in shrimp ponds, especially during the rainy seasons.
- Pond water quality is more easily managed because there are no negative effects on pond water quality from contact with bottom and dike soils. Liners effectively prevent soil-water interaction and prevent the issue of soil acidity, stop salinization of neighboring areas, and control seepage of water into the ponds in areas with a high water table.
- Liners shorten pond cleaning and preparation time, requiring only four to eight days to complete the process compared with 30 to 45 days for the normal earthen pond cleaning and extensive drying process. Therefore, the number of crops per year can be increased to make annual pond productivity higher.
-
- In addition, harvesting can be more effective during the rainy season because plastic-lined pond can still be cleaned. And no tractor earth work is required after the liners have been installed.
-
- During the culture period, suspended solids and other waste can easily be removed by gravity flow through drains (typically in the center of the pond), so that less organic matter will accumulate in the ponds.
- Liners prevent the erosion of dikes and levees from waves, wind, and aerator-generated water currents, which reduces pond maintenance and repair expenses. And lined ponds can generally be aerated more intensively, supporting higher stocking densities and yields per unit area.
- Because the pond bottom is cleaner, at harvest time there are fewer shrimp with dirty gills (accumulated organic sludge), and cleaner shrimp will command better prices.
- More importantly, lined ponds can easily be managed to prevent from EHP

Disadvantages

- The high cost and labor intensive
- Difficulty in initiating in plankton bloom
- Once culture starts phosphorus accumulates and more often plankton bloom occurs. This can cause low night time dissolved oxygen levels and plankton die-offs, which can also cause dissolved oxygen deficiencies.
- And because of the frequent incidence of increased blooms of phytoplankton and associated problems with dissolved oxygen depletion, more mechanical aeration may be required in lined ponds than in those ponds without liner, especially during the second half of the culture period.

Pre stocking management measure for grow out shrimp culture

Success of any shrimp culture depends to some extent on the better management practices involved in pond preparation and pre-stocking management steps. Pond preparation is one of the most important pre stocking management measures essential for optimum growth of shrimp in grow out farming systems. There are various points to be taken care during the pond preparation for shrimp culture.

1. Drying the pound bottom

After each harvesting cycle, the pond bottom is allowed to dry and crack. It helps to oxidize the decomposed organic components, leftover in the pond after the previous culture. Generally pond bottom is allowed to dry for 7-10 days and, it allows soil crack to a depth of 25-50 mm. It helps to reduce the risk of disease outbreaks and improve shrimp production.

1.2. Ploughing or raking

Ploughing or raking the pond bottom help to exposes the nutrient rich sub soil and fast mineralization and oxidation of the organic compounds and harmful gases. Tiling and ploughing is not generally recommended in acidic soils as it increases the soil pH.

1.3. Top soil removal

The top black soil and bottom sludge to be removed to prevent development of anaerobic condition during culture period. The sludge must be disposed away from the pond site, so that it does not seep back into ponds. Grow out pond with high stocking density, entire pond top soil is removed whereas modified extensive ponds, areas of the pond where there is a high accumulation of organic matter from previous crops, such as feeding zone should be removed.


Top soil removal


Pond bottom after top soil removal

If ponds are undrainable / have acid sulfate soil in low lying areas

- Inlet gate to drain gate : 1:500 slope for draining
- Very low pH (<5), acid sulfate (soil red patches)
- Repeated water intake and flush
- Minimum exposure of bottom sand
- Application lime at soil bottom based on soil pH
- 200-1000Kg/ha (Ideal pH 6.5 to 7.5)
- Application of soil amendments: wet patches nitrate salts at 20-40 g/m2 (The nitrate salts enhances the organic matter degradation nitrogen source for microbes)
- Soil redox potential: must be below -180 to -200 Mv
- If ponds are EHP infected pond:6ton/ha CaO apply in moist soil to reach pH 12 for minimum a week period

Water intake

- Pump fed or Tide fed (Take highest tide level)
- Water intake: Four step filtration: 20,40, 60 and 80 meshes

- Areas with high turbidity (250-500 ntu) : Sedimentation tanks followed by Reservoir –Application of PAC (5-7 ppm) & KMno4(3 ppm)
- Bleaching powder – available Chlorine minimum 10-15 ppm (50-60 ppm)
- Dose depends on organic load/ WSSV viral loads
- Stringent measures to be followed to prevent entry and growth of any unwanted and pathogenic agents in culture ponds. It can be achieved via proper filtration of intake water using appropriate mesh screens, disinfection of intake water. Generally bleaching powder @ 600 ppm is recommended for reducing the load of harmful bacteria and virus in the cultured water. Optimum water quality criteria for intake water are given in table 2. Keeping a suitable reservoir also facilitate chemical treatment to reduce disease outbreak and to make water management more effective during production cycle.

Biosecurity measures

- Bird scares like meshed screen, noise cannon, plastic bags and glittering tapes can be used as safety measure
- Pond fencing: to prevent intrusion of any animals in to farm.
- Foot dip ($KMnO_4$:500 ppm)
- Hand dip (**Povidone-iodine** :100 ppm)
- Separate feed bucket etc. for each pond to avoid cross contamination

Liming

During pond preparation liming is applied to optimize pH and alkalinity conditions of soil and water. The type and amount of lime to be added depends mainly on the soil and water pH, which should be checked before lime application. The recommended levels of lime application during pond preparation are given in Table 1. The soil and water pH can be measured with a pH meter. Generally agricultural lime or dolomite can be applied if soils of pH >5, and Quick lime or hydrated lime can be applied if soil pH below 5. Where disinfectants like bleaching powder (calcium hypochlorite) is used, applies lime only 3-4 days after the application of disinfectant as lime reduce the effectiveness of the disinfectant.

Table. 2. Optimum water quality criteria for intake water

Sl. No.	Parameter	Normal Range
1.	Temperature (^{0}C)	25-33
2.	Salinity (ppt)	10-34
3.	pH	7-9
4.	Transparency (cm)	25-50
5.	Dissolved Oxygen (ppm)	4-6
6.	Total Alkalinity (ppm)	50-300
7.	Nitrate- N (ppm)	< 0.03
8.	Nitrite- N (ppm)	< 0.01
9.	Ammonia- N (ppm)	< 0.01

4. Fertilization of pond water

The purpose of fertilization is to ensure the growth of primary producers in culture ponds. They initiate natural food web in the aquatic ecosystem and directly or indirectly contribute shrimp growth also. It also helps to maintain desirable level of transparency (25-40 cm) which prevents development of harmful benthic algae. Phytoplankton in culture ponds also help to improve the water quality parameters in grow out ponds.

Fertilizers can be applied depending on the fertility status of the soil. Organic fertilizer like dry cow dung at the rate of 500 – 2000 kg ha^{-1} and inorganic fertilizers like urea and single superphosphate (SSP) at 25 – 100 kg ha-1 can be applied depending on the organic carbon content and available N (50-75 mg/100 g soil) and P (4-6 mg/100 g soil) content in the pond. Of the original dose, 10% can be applied fortnightly to maintain the desired level of algal bloom. The Secchi disc transparency should be in the range of 25-40 cm. Brownish green colour of pond water indicate that the pond is ready for stocking the seed.

4.1. Application of organic juice

Yeast based organic preparation are recently being used in zero water exchange shrimp culture ponds as a probiotic. It can be prepared using ingredients like 60 kg paddy flour, 30 kg molasses and 2-4 kg Bakers yeast, *Saccharomyces cerevisiae*, per ha ponds. Allow these ingredients to get ferment in 48 h and apply. Organic juice can be applied in biweekly interval to improve the fertility status of water @ 1-2 ppm.

Pond stocking

Seed quality: Variability in the post larval production has made the culture technology unreliable, and limits the feasibility of shrimp culture. Several well established criteria are used to evaluate the quality of seed including origin and hatchery reputation, visual evaluation, stress test and screening for various pathogens. The component of PL quality may be endocrine status of oocytes in the ovary or sperm, diet of the boodstocks or genetics of the broodstock

Shrimp seeds are produced in the salinity above 28 ppt, but in general seeds are stocked in the grow out system having much less salinity of the hatchery system or some cases above the salinity of the hatchery. Further post larvae are transported in the polyethylene bag, which is kept in the styrofoam box. Temperature of the water is artificially reduced by keeping ice box in between the polyethylene bag. Therefore, temperature of the transportation bag is far less than pond water. In general, farmers float the bags in the pond for 30 minutes to 1 h. Although temperature could be acclimatized by this method, other water parameters would be similar. Therefore, PL should be acclimatized to the pond condition by maintaining separately in tanks and adding pond water to the tank. `

Issues and way forward

The major issue in the present-day shrimp farming is price has become reduced due to the over production. All Asian countries have been facing the same problems and issues. Shrimp has a short production cycle which makes it easy to move in and out of production. But this is only a short-term solution. The long-term solution is to increase the production efficiency. There are opportunities such as domestic marketing, and supply of different products such as ready to eat, ready to heat and ready to cook products. Thus, product diversification is one of the strategies to make shrimp farm more profitable. The move to production of black tiger shrimp is another opportunity.

- Some of the other strategies to increase the production efficiency are:
- Reduce the crop length
- Lower stocking densities
- Modification in the infrastructure: for example pond lining, to prevent EHP
- Better water treatment
- Addition of nursery system
- Break between the crop and pond preparation
- Area specific crop holidyas
- Shrimp polyculture
- System diversification

The strength of the industry can often be measured by the investments and growth. Innovation should drive in the more efficient nursery rearing system, alternative feed ingredients, green energy and more efficient RAS system. In order to move forward we need to focus on predictability and efficiency

Institutional and Regulatory framework for aquaculture in India

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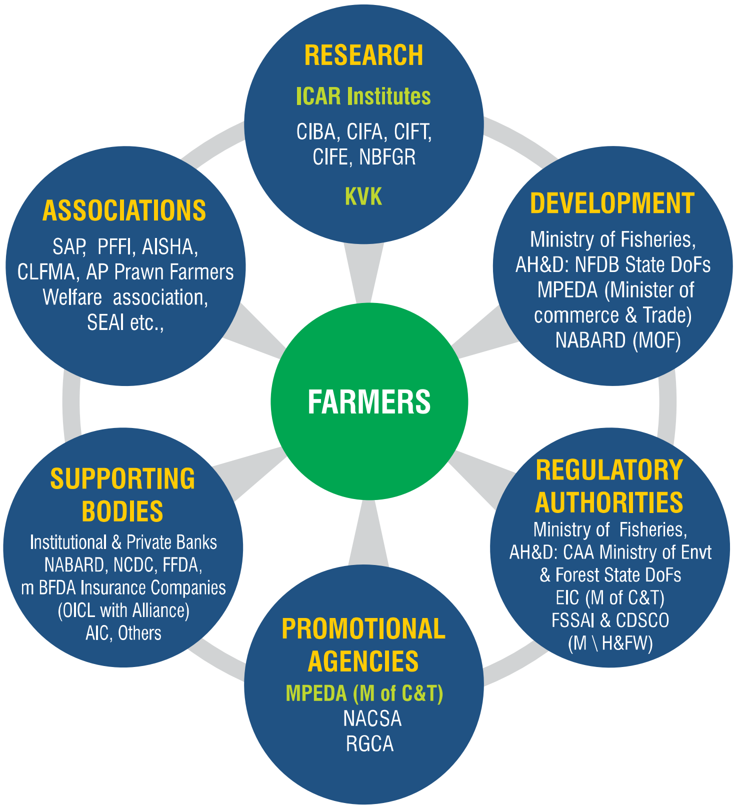
Indian aquaculture is one among the dynamic sector having significant growth rate in recent years. Research, institutional, promotional, development and regulatory framework needs to have proper synergism for sustainable growth of this sector, ICAR research institutes developed various technically feasible and economically viable technologies which need proper transfer mechanism with suitable convergence with the institutional and regulatory bodies to up-scale those technologies among the farmers and various stakeholders.



In this background, this Chapter highlights on various institutional and regulatory framework exists for shrimp aquaculture in India.

1. Research: ICAR (Indian Council of Agriculture Research under Ministry of Agriculture and Farmers Welfare

The Indian Council of Agricultural Research is an autonomous body responsible for co-ordinating agricultural education and research in India. ICAR has eight research institutes and one Deemed University, which undertakes the research, extension and education on a national perspective on aquaculture and fisheries. ICAR institutes transfer the developed technologies though ITMU (Institute Technology Management Unit) by signing MOUs with the farmers, and various stakeholders, Agri Business Incubation: ABI (focus on incubation and business development programme, including entrepreneurship skill development activities through startups) and SCSP/TSP programs (livelihood enhancement for SC and ST communities).

KVK (732 number) operated through SAUs, ICAR Research Institutes, State Departments of Agriculture and NGOs, and about 30% of KVK coordinates the district level fisheries and aquaculture development through skill development training programmes, production and supply of seeds and other critical inputs and through various extension programmes like field visits, group discussions, kisan ghosti, exhibitions, kisan melas, technology dissemination through pamphlets and other extension materials etc.

ICAR- Central Institute of Brackishwater Aquaculture (CIBA), do basic and strategic research for sustainable brackishwater culture system, species and systems diversification in brackishwater aquaculture & human resource development through training, education and extension. ICAR- Central Institute of Fisheries Technology (CIFT) engaged in research related to fishing and fish processing in the country. ICAR- Central Institute of Fisheries Education (CIFE) produce specialized human resources, besides engaging in basic, strategic and applied research and providing policy support to fisheries development. ICAR- Central Institute of Fisheries Technology (CIFA), with the advent of genetically improved rohu and catla, GI-scampi, new and innovative technologies enhance the skills of farmers and several other stake holders. ICAR- National Bureau of Fish Genetic Research (NBFGR) assesses and conserves the fish genetic resources for intellectual property protection, sustainable utilization and posterity.

2. Development

Department of Fisheries under Ministry of Fisheries, Animal Husbandry and Dairying.

It was created in 2019. DOF is responsible for planning, monitoring and the funding of several centrally sponsored developmental schemes related to fisheries and aquaculture in all of the Indian States. The Ministry of Fisheries, Animal Husbandry, and Dairying oversees the development and regulation of the fisheries sector in India, including shrimp aquaculture. It formulates policies, programs, and schemes to promote sustainable shrimp farming practices, enhance productivity, and ensure the welfare of fishers and aquaculturists.

PMMSY: Pradhan Mantri Matasya Sampada Yojana (2020-2025): Rs 20,050 Crores

Launched in 2020, PMMSY is a flagship scheme of the Government of India that focuses on the sustainable development of the fisheries sector. There is immense scope in aquaculture sector through both horizontal expansions and vertical intensive farming using advanced technologies of recirculating aquaculture systems (RAS) and integrated multi-trophic aquaculture (IMTA).The main objectives and targets of PMMSY are

- Enhance fish production and productivity through expansion, intensification, diversification and productive utilization of land and water
- Modernize and strengthen the value chain including post-harvest management and quality improvement
- Double fishers and fish farmers' incomes and generate meaningful employment
- Enhance the contribution of the fisheries sector to Agricultural GVA and exports
- Ensure social, physical and economic security for fishers and fish farmers
- Build a robust fisheries management and regulatory framework
- Enhancing aquaculture productivity to 5 tons per hectare from the current national average of 3 tons.
- Doubling export earnings to Rs.1,00,000 crores by 2024-25 from Rs.46,589 crores in 2018-19.
- Generating 55 lakh direct and indirect employment opportunities along the value chain.

It has two separate components namely (a) Central Sector Scheme (CS) and (b) Centrally Sponsored Scheme (CSS). The entire project/unit cost will be borne by the Central government in case of CS scheme. The Centrally Sponsored Scheme (CSS)

Component is further segregated into Non-beneficiary oriented and Beneficiary orientated sub-components/activities. For the Non-beneficiary orientated sub-components/ activities to be implemented by the States, the entire project/unit cost will be shared between Centre and State in 60:40 ratio. For the Beneficiary orientated sub-components/ activities, to be implemented by the States, the Government financial assistance of both governments together will be limited to 40% of the project cost for General category and 60% of the project cost for SC/ST/Women. Assistance will be shared between Centre and State at 60:40 ratio.

Table 1: Various Govt initiatives in fisheries sector

Year	Initiatives
2015-16	Blue revolution scheme launched (Rs 300 Crores)
2018-19	FIDF launched (Rs 7522 Crores)
2018-19	KCC extended to aquaculture farmers
2018-19	Exclusive DOF created
2019-20	Separate MOFAH &D created
2020-21	PMMSY launched (Rs 20050 Crores)

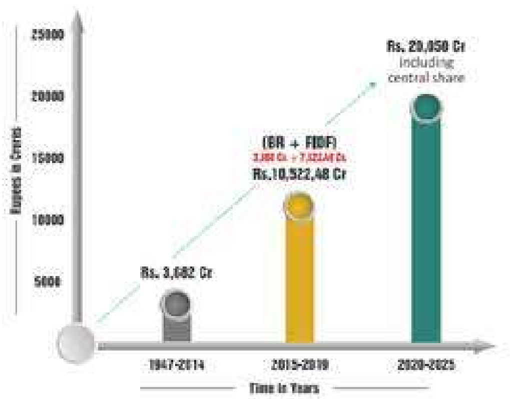


Fig 1: Fig1: Investment in PMMSY by GOI

Fisheries Infrastructure Development Fund (FIDF)

DOF has created a dedicated fund namely Fisheries and Aquaculture Infrastructure Development Fund (FIDF) during 2018-19 with a total funds size of Rs 7522.48 crore to address the infrastructure requirement for fisheries sector. FIDF provides concessional finance to the Eligible Entities (EEs) including State Governments/Union Territories, State entities, cooperatives, individuals and entrepreneurs amongst the others for development of identified fisheries infrastructure.

There are several investment activities that fall under the roof of the FIDF Scheme. Any project under FIDF is eligible for loan up to 80% of the estimated/actual project cost. The rest amount is to be contributed by the beneficiary as margin money. The catch lies in lower rates of interest for such projects i.e., interest subvention up to 3% per annum but lending rate cannot be below 5% per annum for development of identified fisheries-based infrastructure facilities with maximum repayment is over a period of 12 years inclusive of moratorium of 2 (two) years on repayment of principal. National Bank for Agriculture and Rural Development (NABARD), National Cooperatives Development Corporation (NCDC) and all scheduled banks are the designated NLEs in disbursal of the fund. The details are given below

Description of Items	Rate of assistance
Construction of new ponds	Rs 2.00 lakh/ha in the plain areas. Subsidy @ 20% with a ceiling of Rs. 40,000/ha for all farmers except SC's/ST's for whom it will be Rs 50, 000/ha (25%) Rs 3.0 lakh/ha in the hill States/Districts and North-Eastern region. Subsidy @ 20% with a ceiling of Rs 60,000/ha for all farmers except SC's/ST's for whom it will be Rs 75, 000/ ha (25%).
Renovation or construction of brackishwater fish farms	Beneficiaries will be small shrimp farmers having land holding of 2 ha or less. 25% cost subject to a maximum of Rs 40,000/- per ha as subsidy.
Reclamation/ Renovation of ponds/ tanks	Rs 60,000/ha. Subsidy @ 20% with a ceiling of Rs 12, 000/ ha for all farmers except SC's/ST's for whom it will be Rs 15,000/ha (25%).
Cost of inputs	Freshwater prawn culture - Unit cost Rs 1.20 lakh per ha. Subsidy @ 20% with a ceiling of Rs 24,000/- per ha
Aerators/Pumps	50, 000/unit of two-1hp aerators/one 5hp diesel pump. Subsidy @ 25% with a ceiling of Rs 12,500/- for each set of aerators/pump for all categories of farmers who have reached a level of production of 3000 kg/ha/year. Maximum of two-1hp aerators/one 5hp diesel pump for one-hectare water area will be admissible.
Establishment of freshwater prawn seed hatchery	i) Unit cost is Rs 30 lakh for a large freshwater prawn hatchery with a minimum capacity of 25 million PL/year. (ii) Unit cost is Rs 8 lakh for a small hatchery of 5-10 million PL/Year capacity. Subsidy @ 20% with a ceiling of Rs 1.60 lakh to entrepreneurs as one time grant.

Provision of soil and water testing kits to each FFDA	Unit cost of each soil and water testing kit is Rs 30,000. The kits are sanctioned once to each FFDA as one time grant.
Transportation of fish/ prawn seed	This will be applicable only for the hill States/Districts and North-Eastern Region. Subsidy @ Rs 20 for 1000 fry transported to all FFDAs. Not applicable to individual fish farmer.

Expenditure on all items above will be shared on 75:25 basis between Government of India and States. The above assistance under FFDA programme is available only once to a beneficiary. Subsidy for the construction of new ponds and tanks, reclamation/ renovation of ponds/tanks and first year inputs to an individual beneficiary up to 5 ha is available with or without institutional finance in the plain areas and 1.0 ha in the hill States/Districts on pro-rata basis.

Fisheries Kisan Credit Card Scheme

Government of India in the year 2018-19 announced extension of the facility of Kisan Credit Card (KCC) to fisheries and animal husbandry farmers to help them to meet their working capital needs. The KCC facility will help fish farmers to meet their short term credit requirements of rearing of fish, shrimp, other aquatic organisms.

Fishers and fish farmers (Individual & Groups/Partners/Share Croppers/ Tenant Farmers), Self Help Groups, Joint Liability Groups, Women Groups are entitled to get the KCC facilities. The existing KCC holders will get the credit limit of Rs. 3 lakh including fisheries activities and new card holders will get Rs. 2 lakh exclusively for fisheries. Under the scheme, interest subvention is made available for fisheries farmers @ 2% per annum at the time of disbursal of loan and additional interest subvention @ 3 % per annum in case of prompt repayment. All the eligible beneficiary from fisheries sector can approach any commercial bank, cooperative bank and RRB for availing the KCC facility

State Departments of Fisheries (DoFs)

The role of various DOF, State Governments is of paramount importance with regard to governance, management, technology transfer to the stakeholders and the implementation of schemes, with fisheries being a State subject.

Andhra Pradesh

The AP State stood first in the country in terms of total aquaculture area and production. Under the Centrally Sponsored Scheme Component of PMMSY, an investment of Rs. 1955 crore has been envisaged for development of fisheries in the State of Andhra Pradesh. Incentives and subsidies of AP Fisheries Policy 2015 are

- For shrimp processing units including cold chain maintenance, Capital subsidy of 50% inclusive of land cost with upper ceiling limit of Rs.5 crores, is provided.
- For fish processing / filleting units including cold chain, land cost etc., subsidy of 50% with upper ceiling limit of Rs. 7 crores is provided.
- Interest subvention of 6% is provided on bank loan subject to maximum of Rs.2.5 Crores for 5 year period to aqua processing units, ice plants and cold storages
- For Reefer vans, a subsidy of 50% with maximum of Rs. 10.00 Lakhs per vehicle.
- Power is supplied to Shrimp and Prawn culture farms at Rs.3.75 ps/ unit.
- Financial assistance extended for farm mechanization like pumps and aerators with 50% subsidy.
- Solar pumps, solar lights and solar based aerators is given on 60% subsidy to the prawn and shrimp farms up to maximum of 2 ha per farmer per annum.

The strategies for Development of Fisheries Sector by AP DOF are eestablishment of AQF & BMC for *P. vannamei*, Hatcheries for Mud crab & Sea bass, inspection of shrimp hatcheries & Aqua Shops, aquaculture zonation, Networking of Aqua labs, on-farm Demonstration of BMPs & Innovative culture practices in 181 Aqua clusters (Chandranna Aqua Rythu Kshetralu), registration of coastal Aquaculture & fresh water Aquaculture to reach 100% saturation and guidelines for Inland Shrimp Naupilii / larval rearing centers

Telangana

Telangana government introduced Integrated Fisheries Development Scheme (IFDS) scheme in 2018. Its goal is to ensure the welfare of fishers and their livelihoods. IFDS aims to increase fish production and productivity via forward and backward linkages. It is working to create modern infrastructure for fish farming. This scheme has provisions for supporting community-based organisations and self-help groups engaged in fisheries.

West Bengal

The Brackishwater sector is an important area of pisciculture in the three coastal districts of West Bengal. To assist the " Yass " affected Brackish water Fish Farmers in Purba Medinipur, North and South 24 Parganas a flagship project namely Swarna Matsya Yojana (2021-22) with the outlay of Rs 16 Crores was created with the schemes of

Polyculture of Tiger Shrimp (P. Monodon) With Mullets (Bhangon and Parse)" in Brackish Water Fisheries Sector: Government assistance is of Rs. 35000.00. Shrimp and Mullets seed is provided under these schemes. Feed and other components are being arranged by beneficiaries.

Monoculture of Vannamei shrimp (Litopenaeus Vannamei): Government assistance is of Rs. 35750.00. Only Vannamei Shrimp seed is provided under this schemes. Feed and other components are being arranged by beneficiaries. Assistance under above mentioned schemes are available for Purba Medinipur, South-24-Parganas and Nort-24-Parganas in terms of Shrimp, Seed (Avg.PL-15-20 size), and aerator as Government Contributions. Beneficiary contributions are Lime, Urea, Single Super Phosphate, Mullet feed, Shrimp feed, Probiotics, and Prophylactics. The unit area of the Scheme is 1.0 bigha.

Odisha

The various schemes for development of aquaculture in Odisha are

Excavation of New Tanks under the State Plan Scheme 'Development of Brackish Water Fisheries' for the Financial Year 2021-22: to increase production of brackish water shrimp and fish, thus increasing the livelihood/income and exports of coastal communities

Promotion of Intensive Aquaculture through Biofloc Technology: Bio-floc fish farming is a new method of intensive fish farming. Each Bio-floc tank size is (4 m dia x 1.3 m depth) and capacity of 12,500 liter. Two tanks are considered as one unit. The unit cost of the project for 2 tanks is Rs.1.5-2 lakhs, for 4 tanks Rs.3-4 lakh and for 6 tanks it is Rs.4-5 lakh.

Development of Brackish Water Fisheries through Construction New Pond for Shrimp Farming: This is a state plan scheme which aims to support new brackish water shrimp farmers for taking up BW shrimp/fish farming. The unit cost is Rs.10.00 lakh/ha. (capital, 7L and Input, 3L)

Establishment of Need Based New Brackish Water Hatchery: This scheme focuses on establishing shrimp hatcheries with min capacity of 10 million post larvae shrimp per year. It is to be implemented in all 7 coastal districts of Odisha. Min. requirement of land is 0.4 Ha and total cost is 50L.

Promotion of Intensive Aquaculture through Polylining Technology in Fisheries during the year 2020-21: The aim of the scheme is to support 455 brackish water farmers for installation of polylining units for promoting sustainable intensification of the brackish water shrimp farming. The Unit cost for installation of a polylining unit is Rs.2.10 lakh with 40% subsidy assistance to General and 60% assistance to SC/ ST/ woman beneficiaries. Subsidy support is only infrastructure costs and doesn't include any operational costs.

Tamli Nadu

The Government through various initiatives with funding support from under Blue Revolution, National Agriculture Development Programme (NADP), NFDB, Special Area Development Programme (SADP), NABARD etc., has upgraded the Government fish farm facilities and encouraged the farmers to create fish seed production and rearing centers. The Government have focussed its attention on development of inland fisheries resources and to enhance the inland fish production into three times under Blue Revolution schemes.

Gujarat

Gujarat state having an area of 89,000 Ha is potential for development being more suitable for Brackish Water Aquaculture. Presently Brackish water Aquaculture practises are carried out by the local fishermen, and entrepreneurs in the Southern Districts of the State namely, Valsad, Navsari, Surat, Bharuch and newly start in Saurastra region. State Government implementing various schemes with the outlay of Rs 545 crores in 2022-23 for the development of Brackish Water Aquaculture. Under these schemes financial assistance provide for establishment of hatcheries, shrimp farm Construction, shrimp farm renovation, For Infrastructure Development (Road) and other ancillary items

Goa

The schemes in Goa envisage increasing the coastal aquaculture activities through implementation of good management practices and resulting in increase in total fish production in the State. The Scheme have three components a) Financial Assistance for Construction and Renovation of farms: Financial Assistance is provided as subsidy i.e. 25% subsidy of the cost of construction or renovation of farm/bandhs etc limited to Rs. 2.00 lakh per ha. Aquaculture farmers will be eligible for renovation of farm after 5 years of its construction b) Financial Assistance for purchase of farming equipments: 50% of the cost limited to Rs. 1.00 lakh per ha will be provided as subsidy for purchase of farm equipments like Aerators, pumps, crates, ice boxes, etc. Farmers will be eligible for the subsidy after 5 years. c) Financial Assistance for purchase of feed: 25% subsidy is provided on the cost of feed limited to Rs. 30,000/- per crop per ha for 2 crops in a year. Farmers will be eligible for the subsidy every year.

Under central schemes, Construction of New Ponds for Brackish Water Aquaculture: (a) Financial assistance of 40% will be granted limited to unit cost of Rs. 8 lakhs for General Category. (b) Financial assistance of 60% will be granted limited to unit cost of Rs. 8 lakhs for SC/ST/Women

Input cost for brackish water aquaculture: a) Financial assistance of 40% will be granted limited to unit cost of Rs. 6 lakhs/Ha. For General Category (b) Financial assistance of 60% will be granted limited to unit cost of Rs. 6 lakhs/Ha for SC/ST/Women Construction of Biofloc ponds for Brackish water/Saline/ Alkaline areas including inputs of Rs 8 lakhs/0.1 Ha (a) Financial assistance of 40% will be granted limited to unit cost of Rs. 18 lakhs/0.1Ha. For General Category (b) Financial assistance of 60% will be granted limited to unit cost of Rs. 18 lakhs/0.1Ha for SC/ST/Women

Karnataka

In Karnataka, shrimp and brackish water fin fish culture 50% subsidy will be given for a unit cost of Rs.1 lakh per hectare for encouraging prawn and fish farming in inland and backwater resources. Under PMMSY, Rs 58.7 crores has been sanctioned

Maharashtra

Under Pradhan Mantri Matsya Sampada Yojana, Rs 153 crores was sanctioned for 1500 beneficiaries during 2022-23 to address critical gaps in fish production and productivity, quality, technology, postharvest infrastructure and management

Kerala

In 2023, the government has declared its intention to promote aquaculture and mariculture in Kerala. An amount of Rs 82.11 crore has been earmarked for the inland fisheries sector and Rs 67.50 crore has been allocated with an aim to double the current aquaculture production to 50,000 tonnes. Rs 5.88 crore has been allocated in the budget for the promotion of vannamei Shrimp farming. An amount of Rs 5 crore has been set apart for innovative aquaculrue activities and the expansion of Shrimp farming

National Fisheries Development Board (NFDB)

NFDB operates under the Ministry of Fisheries, Animal Husbandry, and Dairying and serves as the nodal agency for the development of the fisheries sector in India. National Fisheries Development Board (NFDB), Hyderabad is the Nodal Implementing Agency for FIDF Scheme.

- NFDB implements various schemes and initiatives to support the development of shrimp aquaculture, including financial assistance, capacity building, and technology transfer programs.
- The National Fisheries Development Board (NFDB) was established in 2006 as an autonomous organization under the administrative control of the Department of Fisheries, Ministry of Fisheries, Animal Husbandly and Dairying, GOI to enhance fish production and productivity in the country and to coordinate fishery development in an integrated and holistic manner. One of its main objectives is to provide focused attention to fisheries and aquaculture (Production, Processing, Storage, Transport and Marketing).

3. REGULATORY AUTHORITIES

Coastal Aquaculture Authority (CAA): *Ministry of Fisheries, Animal Husbandry, and Dairying (MoFAD):*

The Coastal Aquaculture Authority Act was enacted in 2005 to regulate coastal aquaculture activities in coastal areas in order to ensure sustainable development without causing damage to the coastal environment. The Coastal Aquaculture Authority (Amendment) Bill, 2023 passed by the both Houses of the Parliament of India.

One of the major tasks accomplished by the CAA was the registration of shrimp farms on the recommendations of the State and District Level Committees. It is mandatory that all persons carrying on coastal aquaculture shall register their farm with the Coastal Aquaculture Authority. Registration is made for a period of five (5) years, which can be renewed further. The registration process would be continued in respect of new farms as well as farms that may be renovated for taking up coastal aquaculture activities in future. The principal Act has a provision of imprisonment for a period up to 3 years for carrying out coastal aquaculture without registration.

Licensing and Regulation: CAA issues licenses and permits to shrimp farmers for setting up and operating aquaculture farms along the coastal areas of India.

Guidance and Compliance: CAA provides guidance to shrimp farmers regarding the legal requirements, best management practices, and environmental regulations related to shrimp aquaculture.

a) In the case of coastal aquaculture farms up to 2.0 hectare water spread area, sub-Divisional Level Committee upon satisfaction of the information furnished therein, shall recommend the application directly to the Authority for consideration of registration

b) In the case of coastal aquaculture farms above 2.0 hectare of water spread area and upto 5.0 hectare of water spread area, the Sub-Divisional Level Committee shall recommend the application directly to the Authority for consideration of registration only after making such inquiry including inspection as it thinks fit, to satisfy itself that the registration of such farm shall not be detrimental to the coastal environment;

c) In the case of coastal aquaculture farms above 5.0 ha of water spread area, the Sub- Divisional Level Committee shall recommend the application to the District Level Committee for consideration of registration,— (i) after making such inquiry including inspection as it thinks fit, to satisfy itself that the registration of such farm shall not be detrimental to the coastal environment; (ii) after making further inquiries to ascertain that the coastal aquaculture farm conforms to the stipulations laid down in the Guidelines for regulating coastal aquaculture referred

The Authority or the Central Government shall issue a prior permission for the construction of Hatchery, Nauplii Rearing Hatchery or Live Feed Unit, Broodstock

Multiplication Centre or Nucleus Breeding Centre on being satisfied that the application complies with the Guidelines referred to in clauses

Ministry of Environment and Forests (MoEF)

MoEF oversees the environmental impact assessment (EIA) process for large-scale shrimp aquaculture projects. Farmers planning significant expansions or new ventures must obtain environmental clearances from MoEF, demonstrating their commitment to sustainable practices and environmental protection.

Export Inspection Council (EIC), Ministry of Commerce and Trade

The Export Inspection Council (EIC) was set up by the Government of India under Section 3 of The Export (Quality Control and Inspection) Act, 1963 (22 of 1963). EIC ensures the quality and safety of exported shrimp products. Farmers must comply with EIC standards and guidelines to ensure that their shrimp products meet international quality requirements. EIC certification enhances the marketability of shrimp products and enables farmers to access export markets.

Food Safety and Standards Authority of India (FSSAI) and Central Drugs Standard Control Organization (CDSCO), Ministry of Health and Family Welfare (M H&FW):

- **Food Safety Compliance:** FSSAI and CDSCO regulate the safety and quality of shrimp products for domestic consumption. They establish standards, specifications, and regulations governing the production, processing, packaging, and labeling of shrimp products.
- **Monitoring and Enforcement:** FSSAI and CDSCO conduct inspections and audits to ensure compliance with food and drug safety standards and regulations. They monitor shrimp farms, processing facilities, and distribution channels to safeguard public health and consumer interests.
- Regulatory authorities play critical roles in ensuring the legality, safety, and sustainability of shrimp aquaculture practices in India. Farmers must adhere to regulatory requirements and standards set forth by these authorities to operate responsibly, protect the environment, and maintain the quality of shrimp products for both domestic and international markets.

4. Promotion

Marine Products Export Development Authority (MPEDA)

MPEDA operates under the Ministry of Commerce and Industry and is responsible for promoting and regulating the export of marine products, including shrimp, from India.

- **Market Development**: MPEDA facilitates market access and promotes Indian shrimp products in domestic and international markets through trade fairs, buyer-seller meets, and promotional campaigns.
- **Quality Control and Certification:** MPEDA ensures the quality and safety of exported shrimp products by implementing quality control measures, certification programs, and adherence to international standards and regulations.
- **Training and Skill Development:** MPEDA organizes workshops / seminars / symposia / farmers' meets/antibiotic-campaigns etc for shrimp farmers to enhance their understanding of market requirements, quality standards, and export procedures.
- Liaison with State Govts. / Research Institutes / Financial Institutions / Insurance Companies and other developmental agencies.
- Registering of qualified and experienced Technical Consultants for Aquaculture.
- Registering of hatcheries to follow Code of Practices.
- Promoting diversification in export-oriented aquaculture.

Schemes of MPEDA for shrimp aquaculture

Name of the Scheme	Objective	Quantum of subsidy
Financial assistance for New Farm development in undeveloped areas.	Assistance is given to shrimp scampi farmers for setting up of new farms for augmenting production.	25% of the capital cost or @ Rs.50,000/ha Water Spread Area. A farmer is eligible to avail maximum subsidy of Rs.2.50 lakh for developing shrimp/ scampi farms in 5.00 ha. water spread area

Name of the Scheme	Objective	Quantum of subsidy
Promotion of commercial hatcheries for seed production of exportable species.	Assistance for setting up hatcheries for production of healthy and quality seeds for aquaculture.	(a) 25% of capital cost to the maximum of Rs.3.00 lakh/ hatchery/ for a small-scale hatchery of 10 to 30 million post larvae production capacity. (b) 25% of capital cost to the maximum of Rs.6.00 lakh / hatchery / for a medium scale hatchery of 30 million and above post larvae production capacity.
(a) Financial assistance for establishment of effluent treatment system (ETP) in shrimp farms.	ETS is mandatory for shrimp farms above 5 ha water area. Hence, this scheme was introduced to assist farmers to set up ETS in their farms.	25% of the capital cost or Rs.1.5 lakh whichever is less per unit of 5 ha area, subject to Rs.6.00 lakh per beneficiary.
b) Financial assistance for establishment of effluent treatment system (ETP) in shrimp hatchery.	ETS hatchery also considered mandatory in pollution point of view and hence the scheme was introduced to assist hatchery operators to set up ETS.	25% of the capital cost subject to maximum of Rs.1.5 lakh per unit (One unit per hatchery).
Development assistance for setting up of PCR labs in private hatcheries/ Pvt. Lab	To ensure quality of shrimp seed PCR labs are required in hatcheries. Hence, this scheme was introduced to screen any viral infection in seeds/ brooders.	50% of capital cost to the maximum of Rs.5.00 lakh per unit.

Name of the Scheme	Objective	Quantum of subsidy
Financial assistance to set up chill room facilities in shrimp farming areas	In order to help the farmers to market their produce in fresh condition for obtaining better prices, this scheme was introduced.	25% of the cost of establishment subject to a maximum of Rs.3.00 lakh per beneficiary.
Financial assistance for purchase of water quality testing equipment.	To help the farmers for better management of their farms, this scheme envisages to extend financial assistance for purchase of water quality testing equipment.	25% of the cost of the water testing kits/equipment subject to maximum of Rs.30,000/- per beneficiary.
Financial assistance for procurement of quick testing kit for antibiotics.	GOI has made mandatory for all EU approved units to procure and install Quick Testing Kit for testing antibiotics residues. NonEU units can also procure and install the Quick Testing Kit.	The quantum of assistance is 33.3% of the cost of the Microwell Reader and five Test kits as well as other accessories, subject to a maximum of Rs.1 lakh per unit.
Subsidy for small-scale hatcheries	For setting up of shrimp hatchery with a minimum production capacity of 10 million seeds per annum.	@ 15% of the capital cost or Rs.1.50 lakh for private hatcheries, 25% or Rs.2.50 lakh to co-operative sector and 50% of Rs.5.00 lakh to Govt. sector

Name of the Scheme	Objective	Quantum of subsidy
Subsidy for medium scale hatcheries	For setting up of shrimp hatchery with a minimum production capacity of 30 million seeds per annum	@ 25% of the capital cost, subject to Rs.5.00 lakh per beneficiary / hatchery (about 7 districts are excluded, being overcrowded already) 4 Subsidy for setting up of PCR labs in hatcheries To establish PCR labs in hatcheries @ 50% of capital cost, sub

National Centre for Sustainable Aquaculture (NACSA)

National Centre for Sustainable Aquaculture (NaCSA) was established by MPEDA as an outreach organization for uplifting the livelihood of small- scale shrimp farmers.

- **Promotion of Sustainable Practices:** NACSA promotes sustainable aquaculture practices among shrimp farmers and provides farmers with technical assistance, training, and guidance on adopting environmentally friendly and socially responsible farming methods.
- **Capacity Building:** NACSA conducts training programs, workshops, and demonstration projects to enhance the skills and knowledge of shrimp farmers.
- **Certification Programs:** NACSA offers certification programs, such as the National Sustainable Aquaculture Certification Scheme (SUS), to recognize and reward shrimp farmers who adhere to sustainable farming practices.

Rajiv Gandhi Centre for Aquaculture (RGCA)

RGCA is the Research & Development arm of Marine Products Export Development Authority (MPEDA) and is dedicated to augment the Indian seafood exports through sustainable culture technologies.

- **Technology Development and Transfer:** RGCA conducts research on shrimp breeding, hatchery management, disease control, and production systems to improve the productivity and profitability of shrimp farming operations.

- **Demonstration Farms:** RGCA operates demonstration farms and research facilities to showcase successful shrimp farming techniques and technologies to farmers. These demonstration sites serve as learning centers where farmers can observe and learn about new approaches and practices.
- **Training and Extension Services:** RGCA provides training and extension services to shrimp farmers through workshops, field visits, and farmer training programs. 5 Supporting bodies

National Bank for Agriculture and Rural Development (NABARD)

- NABARD is a apex banking institution under the Ministry of Finance that provides credit and financial support to shrimp farmers, hatcheries, and aquaculture enterprises for infrastructure development, working capital, and investment in technology upgrades
- NABARD offers subsidies, grants, and incentives for the adoption of eco-friendly practices, renewable energy solutions, and water conservation measures in shrimp aquaculture.
- NABARD supports capacity-building initiatives, entrepreneurship development programs, and skill enhancement training for shrimp farmers to improve their financial literacy, business management skills, and access to formal credit.

These agencies play crucial roles in providing policy support, technical assistance, financial resources, and market linkages to shrimp farmers, contributing to the sustainable development and competitiveness of the shrimp aquaculture sector in India.

Institutional & Private Banks

- Institutional and private banks offer financial services such as loans, credit facilities, and banking solutions to shrimp farmers.
- Shrimp farmers can access funds for activities including pond construction, stocking, feed purchase, infrastructure development, and working capital requirements.
- Banks provide tailored financial products and services designed to meet the specific needs of shrimp farmers, helping them manage their finances effectively and invest in their operations.

NCDC (National Cooperative Development Corporation)

NCDC has been promoting and developing fisheries cooperatives to cover fisheries within its purview. NCDC, as an End Implementing Agency (EIA) under PMMSY will play a key role in business development of fisheries cooperatives through formation of FFPOs under PMMSY scheme which would economically empower farmers across the country by conducting a series of awareness and training programs

- Creation of infrastructure facilities for marketing, transport vehicles, ice plants, cold storages, retail outlets, processing units, etc.
- Development of inland fisheries, seed farms, hatcheries, etc.
- Integrated Fisheries Projects (Marine, Inland and Brackish Water)
- Insurance Companies (Oriental Insurance Company Limited OICL with Alliance Insurance Brokers):
- Insurance companies such as Oriental Insurance Company Limited (OICL) and their intermediaries like Alliance Insurance Brokers offer insurance coverage tailored to the needs of shrimp farmers.
- They developed shrimp crop Insurance during 2023 with the technical support of CIBA to aid the farmers from disease incidence and weather risks. The premium rates are varied from 2-4% with the 20% premium support of NFDB.
- Insurance coverage helps shrimp farmers mitigate risks, protect their investments, and manage financial uncertainties associated with shrimp farming operations.
- Agriculture Insurance Company (AIC) and Others:
- Agriculture Insurance Company (AIC) is a specialized insurance provider that offers crop and livestock insurance solutions to farmers, including those involved in shrimp aquaculture.
- They developed shrimp crop Insurance during 2023 with the technical support of CIBA to aid the farmers from disease incidence and weather risks. The premium rates are varied from 2-4% with the 20% premium support of NFDB.
- These insurance schemes help shrimp farmers safeguard their income and investments against unforeseen events and market fluctuations, ensuring financial stability and resilience.

Supporting bodies play critical roles in providing financial assistance, insurance coverage, and risk management solutions to shrimp farmers in India. By offering access to finance, mitigating risks, and promoting sustainable practices, they contribute to the growth, resilience, and profitability of the shrimp aquaculture sector, thereby benefiting farmers, rural communities, and the economy as a whole.

ASSOCIATIONS

Fish Farmers Development Agencies (FFDAs)

One of the most important and effective national programme for the promotion of rural aquaculture development was the Fish Farmers Development Agencies (FFDAs) through PMMSY. FFPOs can be registered under either Cooperative Societies Act / Companies Act

In order to form and promote FFPOs in a uniform and effective manner, the following implementing Agencies will be responsible: (i) State/UT Fisheries Departments and their entities (ii) NFDB (iii) Small Farmers Agriculture Consortium (SFAC) (iv) NCDC (v) NABARD. The FFDAs provide a package of technical, financial and extension support services to fish farmers. The agency arranges suitable area on long-term lease, identifies beneficiaries, provides incentives in the form of subsidies/grants for pons construction/ rehabilitation and input supplies. Centrally sponsored schemes like the 422 FFDAs cover almost all districts in the country by DOF

Brackish water Farmers Development Agency (BFDA)

A national program of Brackishwater Fish Farmers Development Agencies (BFDAs) on the pattern of the FFDA was first started in West Bengal, Orissa, Andhra Pradesh and Kerala and then in other maritime states of the country to arrange inputs and credits along with the training of the farmers. 39 BFDAs in the maritime districts have also contributed to aquaculture development through DOF

Society of Aquaculture Professionals (SAP)

SAP is a professional organization dedicated to promoting the interests of aquaculture professionals in India, including shrimp farmers. It focuses on capacity building, knowledge sharing, research, and advocacy to support the sustainable development of the aquaculture sector.

The Prawn Farmers Federation of India (PFFI)

PFFI represents the interests of prawn and shrimp farmers across India. It works towards advocating policies favorable to shrimp farming, providing technical support, disseminating best practices, and addressing challenges faced by shrimp farmers.

All India Shrimp Hatcheries Association (AISHA)

AISHA represents shrimp hatchery operators and stakeholders in India. It focuses on promoting high-quality shrimp seed production, disseminating technical knowledge, advocating for the interests of hatchery operators, and ensuring the sustainability of seed production practices.

Compound Livestock Feed Manufacturers Association (CLFMA):

CLFMA represents the interests of livestock and aquaculture feed manufacturers, including those producing feeds for shrimp. It advocates for policies supporting the feed industry, promotes research and development in feed technology, and provides a platform for collaboration and information exchange among feed manufacturers.

Andhra Pradesh Prawn Farmers Welfare Association

This association represents shrimp farmers specifically in the state of Andhra Pradesh, which is a significant hub for shrimp aquaculture in India. It addresses the needs and concerns of shrimp farmers in the region, facilitates knowledge sharing, and advocates for policies conducive to the growth of shrimp farming.

Seafood Exporters Association of India (SEAI)

It works towards promoting Indian seafood products in international markets, addressing export-related challenges, advocating for favorable trade policies, and facilitating market access for Indian exporters. Associations play pivotal roles in shaping the policies, practices, and development of the shrimp aquaculture sector in India. Through advocacy, capacity building, knowledge dissemination, and collaboration, they contribute to the sustainability, growth, and competitiveness of shrimp farming operations across the country.

Conclusion

The Institutional regulatory framework for shrimp aquaculture outlined above reflects India's commitment to promote shrimp farming as a important component of economic growth. These initiatives not only aim to boost shrimp production but also emphasise sustainable practices, infrastructure development and capacity building. These schemes have a crucial role in transforming the shrimp aquaculture sector. They will ensure food security and livelihood opportunities for millions of people in coming years.

Diversification of brackishwater aquaculture systems and species :Opportunities with focus on eco-based farming

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Introduction

Aquaculture is emerging as a new hope to feed the growing population that put thrust on each and every resource to be utilized sustainably for production of food. Inland saline water aquaculture is one of- the important avenue for it as vast unutilised resources are available. Brackishwater aquaculture in India is almost synonymous with shrimp farming. In 1950s it was all traditional farming which is basically the paddy field shrimp fishery which has been evolved into a primitive form of aquaculture where, the naturally immigrating shrimp seeds from coastal waters are entrapped and reared for few months, without any feed or aeration. With time as the demand for shrimp increased as export commodity, shrimp farming further evolved in to selective stocking and feeding with modified extensive farming and thereafter as commercial hatcheries, intensification and high-density farming started. Farmed shrimp production showed a remarkable growth during this period of early 1990s, and thereafter production stagnated from 1996 to 2000, mainly due to WSSV pandemic, and related crop failures. From 2000 to 2006 shrimp farming gradually increased and peaked with a maximum production of about 1.4 lakh tonnes in 2006, but production reduced drastically in 2008. Again, 2009-2020 witnessed a remarkable upsurge of farmed shrimp, due to the introduction of, the exotic American shrimp, *Penaeus vannamei*, resulting in an increased production of about 1,25,000 tonnes in 2012-13 to 6,43,037 MT in 2021-22 (MPEDA). Now India ranks second in global total fish production stands at 16.187 million tonnes (2021-2022) which is about 7.7% of total global fish production (PIB, Govt. of India), as a contribution the recent advances in aquaculture sector embraces the theme to produce more with less environmental impact, maximum societal benefit and diversified aquaculture practices.

2. 1. System Diversification

Over the years, ICAR-CIBA has generated significant information on shrimp, fish, crab hatchery and grow-out production, nutrition and feed-technology, disease diagnosis and management to address the growing needs of brackishwater aquaculture sector and provided a platform for interaction with stakeholders. Intensive farming systems such as biofloc-based farming models, IMTA, Integrated aquaponics and RAS are getting popularity due to better financial returns from these farming practices. The low input based on traditional integrated agriculture-aquaculture systems such as paddy cum fish culture, live-stock fish culture, and polyculture is sustainable traditional farming models, High-volume production systems through In-Pond Raceway System technology (IPRS) have proven to increase quality as well as yield up to several times of that of traditional pond culture. Diversification of species and production systems and adopting sustainable intensive systems and Artificial intelligence (A.I.) based smart systems are the need of the hour for doubling production and income. Following technologies have the ecosystem approach-based footprints and are discussed here.

A. Organic production system for brackishwater species

Organic aquaculture is a process of production of aquatic plants and animals with the use of only organic inputs in terms of seeds, supply of nutrients and management of diseases. Organic production system is an ecosystem based approach to aquaculture. Organic foods have a separate niche market and many farmers are attracted to these farming practices due to lower cost of production and better economic returns. In India, INDOCERT provides certification for organic production systems. Although organic aquaculture is in a very nascent stage in India, its traditional system is close to the organic way of farming.

Organic Aquaculture: Periphyton Based Farming

CIBA has attempted research effort to enhance the production and sustainability of shrimp farming within the frame work of EABA. Periphyton based farming is an attempt in this direction. Periphyton refers to the entire complex of attached aquatic biota on submerged substrates comprising phytoplankton, zooplankton, benthic organisms and detritus. The study conducted by CIBA clearly indicates that periphyton has a beneficial effect on growth and production of shrimp. Better growth rate with a productivity of 1640 to 2796 kg/ha/crop at a stocking density 8-12 individuals/m^2 was observed. Further, the rate of return over operational cost was higher in periphyton-based system (92%) compared to the conventional farming (54%). This level of improvement of pond production with cheap on farm resources enhance the productivity of shrimp ponds without deteriorating ecosystem.

B. Biofloc based technology for brackishwater species

Biofloc technology is a relatively new technology to support high density, better water quality, water conservation, bio security, lower feed requirement and reduce the production cost. The concept of biofloc technology work around the formation of dense heterotrophic bacterial community. Eventually the system becomes bacterial dominated rather than algae dominated and forms microbial flocs by utilizing the waste materials in the pond. Biofloc is the conglomeration of microorganisms (such as heterotrophic bacteria, algae (dinoflagellates & diatoms), fungi, ciliates, flagellates, rotifers, nematodes, metazoans & detritus). Constant aeration and intermittent addition of carbon source as organic matter for the bacteria is needed to prevent the collapse of the system.

In a typical brackishwater pond, 20–25% of fed protein is retained in the fish/ shrimp, rest thing wasted as ammonia and other metabolites. Manipulating the C:N ratio in the pond enhances conversion of toxic nitrogenous wastes into microbial biomass available as food for culture animals. CIBA has initiated efforts to develop a biofloc model suitable for Indian brackishwater farming systems. A series of experiments in pilot scale was conducted at CIBA showed measurable gain in the production as well as FCR in tiger shrimp *P. monodon* farming by following these eco based techniques. Several studies indicates that bio-floc with periphyton systems (BPT) increased growth, survival and protective response.

Biofloc based Nursery rearing

A nursery system can be defined as the intermediate step between the early post-larval (PL) stage and the grow-out phase especially in shrimp culture. Intensive nursery systems present several benefits such as optimization of farm land, increased shrimp survival and enhanced growth performance in grow out ponds. This phase is decided as an intermediate step between hatchery-reared, early post larvae (PL) and the Grow-out phase.

Strategies for this phase involve holding postlarvae at very high densities in small tanks for 15 − 60 days with precise technical management, feeding and water quality monitoring. In some countries, e.g., Brazil and Ecuador, intensive nursery (60 PLs L−1) of short duration has been used to produce 20- or 25-day-old PLs in a two-phase production system. Higher income generation due to higher stocking density in nursery system to achieve higher profitability.

Advantages of biofloc based nursery technology

- Daily water and pond environmental changes (pH, O2, CO2) during nursery are minimized for optimal performance.
- Decreased nutrient conversion rate due to continuous consumption of high nutrient feed by autophagy or root microbes.
- Reduced size variability in growth event shrimp compensated by better growth performance.
- Stimulates immune system under these systems, resulting in healthy shrimp.
- It improves productivity, natural feed, FCR, economic gain; and reduced costs (15-20% lower cost production).
- Pathogenic bacteria (Vibrio's) are reduced by probiotic intervention and toxic metabolites (NH3-N, NO2-N) in the nursery.
- Through the microbial association technology, the nursery shrimp culture system uses twice the number of proteins (feed & converted waste), improving digestion (with enzymes and growth promoters) and increasing growth.

Biofloc-based grower stage shrimp culture system

Biofloc technology is a cutting-edge method of recycling pond waste with carbon sources and probiotics to produce natural feed, which improves pond quality, water quality, and productivity while lowering costs. ICAR-CIBA have standardised the biofloc production protocol for biofloc based grow-out systems, nursery culture, protein levels in feed, carbon source selection, carbon: nitrogen ratio, periphyton substrate selection and applications, and probiotic & non-probiotic shrimp culture systems. In one pond based experiment, higher survival rate was recorded in bio-floc groups followed by SF groups than control. Similarly, ABW, FER, FER and production was significantly ($P < 0.001$) increased in BF groups followed by SF groups when compared to control. The FCR was significantly reduced in the BF and SF groups than control groups ($P < 0.002$).

Growth parameter	Control	Semi floc	Biofloc	P = value (*)
Survival rate (%)	72.87[a]±7.03	85.67[b]±3.45	95.23[b] ±3.25	0.043
ABW (g)	22.43[a]±1.01	26.43[b]±1.75	34.53[c]±2.01	0.001
FCR	2.30[a]±0.26	1.63[b]±0.15	1.33[b]±0.12	0.002
FER	0.44[a]±0.06	0.62[b]±0.06	0.75[c]±0.07	0.002
PER	1.25[a]±0.14	1.75[b]±0.16	2.15[c]±0.19	0.002
Production (tone/ha)	10.25[a]±1.75	17.71[b]±1.27	19.46[c]±2.12	0.002

C. Biofloc and periphyton-based eco-friendly farming

Biofloc is an assemblage of beneficial microorganisms predominantly composed of Heterotrophic bacterial communities over autotrophic and denitrifying bacteria. The other constituents include algae (dinoflagellates & diatoms), fungi, ciliates, flagellates, rotifers, nematodes, metazoans & detritus. Biofloc technology (BFT) enables high stocking density with biosecurity, and because of its *in situ* bioremediation, it maintains the water quality even in zero water exchange conditions. This will reduce the feed administration and production cost, also as the nitrogen is recycled the culture system does not require additional water exchange and considerably reduces water consumption. The biofloc is a rich nutrient media that can provide the host shrimp with constant nourishment. Under the Government of India's (PMMSY) Scheme, increasing production using the least number of natural resources is considered as one of the most exciting prospective technologies. In several regions of Africa and Asia, it has long been common practice to aggregate fish using submerged substrate in the open water. Production of fish or shrimp can be increased sustainably by integrating periphyton into biofloc farming systems.

D. Polyculture based production systems

ICAR-CIBA carried out several experiments to evaluate the production potential of polyculture of brackishwater fin fishes and shell fishes. In an experiment to evaluate the poly culture in an extensive system, farm level performance of two systems were evaluated: shrimp with mullets (*Mugil cephalus*, *Liza parsia* and *L. tade*), and shrimp milk fish (*Chanos chanos*). In the 180 day culture experiments, it was found that the production is similar in both systems. However, tiger shrimp out performed in mullet-shrimp system than the milk fish shrimp system. It indicates that the mullet is more compatible with shrimp than milk fish. Further, this study also concludes that resource poor farmers can adopt this system as the input cost and expenditure is low.

E. Seaweed integration with brackishwater aquaculture species

There are attempts from research organization as well as private sectors to integrate shrimp aquaculture with seaweeds to make the intensive aquaculture more environmentally non degradable. Pacific Reef Fisheries, Pvt Ltd. started growing sea weed, Ulva spp in the 5 ha race way of their 98 ha *P.monodon* farm, and reported that this would be sufficient to remove the Nitrogen and Phosphorous from the effluent water from the shrimp farm. Further, the secondary crop provides additional income. CIBA have initiated research in this direction developing model farming with seaweed integration.

F. Integrated multi-tropic Aquaculture (IMTA)

Integrated Multi-Tropic Aquaculture is the farming of different aquaculture species together in a way that allows one species' wastes to be utilized as feed for another.

Shrimp-seaweed-mollusc system

In this farming model, nutrient loads generated from fed species such as finfish or shrimp act as fertilizers or inputs for the non-fed secondary species such as molluscs or seaweeds co-cultured in the system. Farmers can combine fed aquaculture (e.g., fish, shrimp) with inorganic extractive (e.g., seaweed) and organic extractive (e.g., shellfish) aquaculture to create balanced systems for environment remediation (biomitigation), economic stability (improved output, lower cost, product diversification and risk reduction) and social acceptability (better management practices). This forming model can be developed for augmenting the average productivity of open waterbodies.

Open-water Integrated multi-trophic Aquaculture (IMTA)

An open water brackish water cage unit (BCU) loaded with 800 Laters calcarifer fry was installed in the Gad River, Juva Pankhol, and Malvan Cage. In addition, fifty green mussel ropes (Perna virdis) Seabass reached 990.10 g after nine months of raising, with a total yield of 360 kg and a 63% survival rate. Brackishwater Aquaculture performed five successful breeding trials between June and July 2018.

G. Integrated Aquaponics System

The phrase "aquaponics" comes from the words "aquaculture," which is the practice of raising fish in a confined environment, and "hydroponics," which is the practice of cultivating plants and fish together (the growing of plants usually in a soil-less environment). Aquaponics systems are available in a range of sizes, including tiny indoor units and huge commercial systems. Moreover, they might be freshwater systems or contain brackish or saline water.

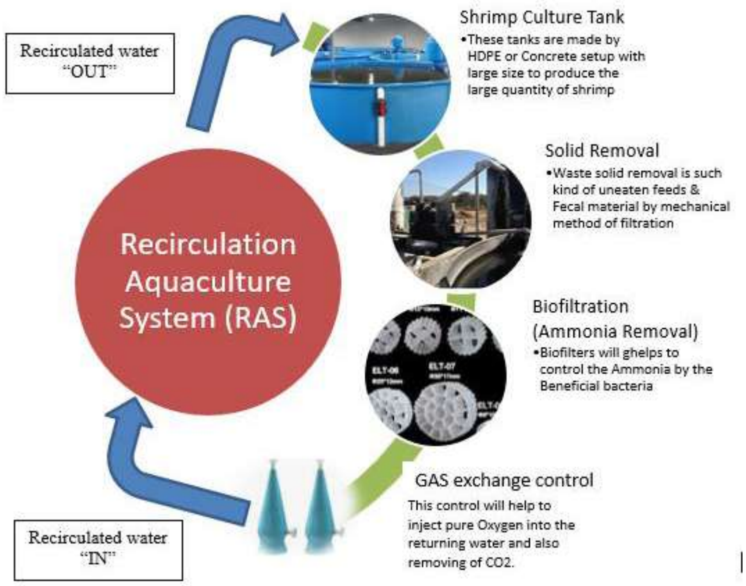
H. Bio secured zero water exchange shrimp farming technology (BZEST)

Bio secure zero-exchange system for shrimp represents an emerging technology that provides a high degree of pathogen exclusion with minimal or zero water exchange. This zero water exchange shrimp farming system is an evolving culture practice with use of probiotics (Panigrahi, *et al*. 2007) and zero tolerance to banned chemicals and antibiotics. CIBA has developed a BZEST for application in the shrimp farming sector, which is characterized by the improved productivity and better FCR. This BZEST system is amenable for control of disease through Best Management Practices and preservation of water resources.

I. Recirculation aquaculture System (RAS)

In a sense, the Recirculation Aquaculture System (RAS) is a life support system for fish and shrimp. It is typically described as intense aquaculture in which little more than 10% of the system's total water volume is changed each day and the water is reconditioned as it flows through the system. Furthermore, Processes like solids capture, biofiltration, and gas exchange have been improved using RAS.

Recirculation Aquaculture System (RAS) working flowchart



RAS systems going to get bigger and more reliable, RAS has also seen significant advancements in terms of scale, production capabilities, and market adoption. RAS are extremely productive intensive farming systems for varied marine products that can run all year, in a range of locations, including close proximity to major seafood markets, and are not impacted by seasonality or environmental factors while providing a strong revenue source. Because sustainability and the environment are closely related, RAS is regarded as an environmentally benign aquaculture production technology. It is therefore viewed as an environmentally sustainable farming method with superior biosecurity requirements. Moreover, the product's carbon impact can be managed because RAS can be created based on market accessibility.

J. Closed/semi-closed intensive shrimp farming system

The Better management practices (BMPs) followed by semi-closed intensive shrimp farming have average productivity of 8-10 tons per ha. The success of the farming model can be credited to zero tolerance to antibiotics, and customized indigenous-based probiotics. Presently India is able to produce an average 7.5- 8 lakh ton shrimps with an export earned USD 7 billion due to technological intervention and intensified farming practices. Better management practices (BMPs) will help farmer to continue long term success.

Pond automation and IoT

Integration of technologies will helps in achieving higher production, many automations are already available in market like, usage of IoT for maintenance of water quality parameters in nurseries and farms, IoT application in Feeding & Feed Management, Feeding shrimps using Aqua robots, Automatic power factor control, Precision Farming by using drones and robots to observe, measure and respond to spatial and temporal variability to improve production sustainability.

II. Species Diversification

CIBA has successfully bred several candidate species of brackishwater finfish and shellfish. The hatchery production technology of several of the diversified finfish species such as Asian sea bass (*Lates calcarifer*), grey mullets (*Mugil cephalus*), milkfish (*Chanos chanos*), Pearl spot (*Etroplus suratensis*) are available for brackishwater aquaculture. Nursery rearing and grow-out technologies for few of the candidate species have been developed and demonstrated. Similarly, mud crabs, species of *Scylla*, are one of the most traded sea food commodities in India. The technology for seed production, nursery rearing and grow out production have been standardized and under various stages of technology transfer.

Other Penaeid species: Species such as ***Penaeus indicus***, ***Metapenaeus kutchensis, Penaeus monodon***, ***Marsupenaeus japonicus*** and species of genus ***Metapenaeus (merguinesis)***, are valuable species for aquaculture in India. The hatchery production of these species are standardized and many experimental grow out culture have been conducted. These species have regional importance and have high market values. Strategies have to be developed for the popularization of these species.

Indigenous vis-à-vis exotic species

Availability of captive broodstock; ability to conduct domestication and genetic selection work; availability of SPF and SPR lines; elimination of problems associated with wild broodstock and/or PL collection; and faster generation times are the advantageous attributed to *P. vannamei* growth. However, few of the indigenous species holds excellent potential for growth and can be adopted for profitable coastal aquaculture.

A. Penaeus monodon (Black tiger shrimp) - *SPF*

- Shrimp culture in India began during the late 80's and was dominated by black tiger shrimp, *Penaeus monodon* until 2012, following which *P. vannamei* grew in popularity among farmers since its introduction in 2009.
- By 2012, *P. vannamei* production in India had exceeded that of *P. monodon* and the industry witnessed a major growth in terms of production and that reached roughly 1.0 million tonnes in 2021.
- *Penaeus monodon* production rapidly declined during this period (2012-2021) before the introduction of **SPF tiger shrimp** in India during 2021, following which the production started witnessing an upward trend.

B. Penaeus indicus: The Indian white shrimp

The Indian white shrimp, *Penaeus indicus*, a native candidate shrimp of Indian subcontinent, and cultured in India, Middle East and Eastern Africa is a proven brackishwater aquaculture species, one of the first shrimp species farmed along the coastal region till 1990s, prior to the demonstration of scientific shrimp farming using tiger shrimp. Commercial shrimp farming with selective stocking of shrimp seed was initiated with the establishment of shrimp hatcheries of *P indicus* and *P. monodon* in India in the late 1980s. However, due to predominance of commercial tiger shrimp culture from 1990's due to farmer's preference and better economic returns over investment, Indian white shrimp has not been given the prominence that it deserves. Subsequent to the outbreak of WSSV in Asia and India since 1994, and related crop failures among the Indian shrimp farming, genetically improved exotic specific pathogen free (SPF) shrimp, the *Penaeus vannamei*, got introduced to India to combat the WSSV inflicted disease problems. The introduction of vannamei now register a total take over in the shrimp farming scenario, registering a farming coverage of almost 90%. This total dependence of shrimp farming on a single exotic species, with emerging problems of inbreeding, issues in seed quality and emerging disease problems necessitates the need of taking up a proven candidate species native to Indian subcontinent like indicus, for stock improvement through a selective breeding programme.

ICAR-CIBA has taken up demonstration of high semi-intensive culture practices of this shrimp over a range of production systems across different states to increase adoption by farmers. Captive breeding of Indian white shrimp is refined and production of high quality disease free seeds is possible to be produced. The seed production technique was refined, and subsequent farming demonstration evinced interest in farmers to culture Indian white shrimp, thus making Indian *P. indicus* a potential species for diversification. Multi-location culture trial of Indian white shrimp *P. indicus* was shown to be successful and reveals following aspects.

Species suitability for high density culture

- It has excellent growth potential and up to 18-20g grows better or as fast as *P.vannamei* across different culture system
- It is easier to culture in high stocking densities
- Initial culture studies have shown that a production of 3-4 tons/ha can be achieved at 25-30 nos/sqm nearly at par with *P. vannamei* at similar stocking density. Further demonstration trials aiming higher level of production are underway in multi-location across India.
- With further intensification, a production of 5-7 tons is reported to be achieved in this species. A density dependent growth pattern was observed.
- It is tolerant to wide range of salinities 5 to 45 ppt (except very low to zero salinity)

- This species is found to be compatible in the polyculture system with other fin fishes like mullets, milkfish and pearl spot and with other Penaeid shrimps.
- Various eco-based culture techniques and their potential for high density culture and technical efficiency of this species are being evaluated and initial studies are encouraging.
- It is an easy to breed this species and hence domestication of the species is very much possible with the production of SPF stock because of the shorter generation period and easier captive breeding.
- Has similar market values like other white shrimps like *L. vannamei*

C. Ginger shrimp (*Metapenaeus kutchensis)*

Greasy back shrimp with a a short growing period of 2-3 months in ponds, attaining market sizes of 10-15 g. Larval rearing is easier compared to *P. monodon, P. indicus and P merguiensis and adults are m*ore resistant to handling.

D. *Penaeus merguiensis*: *The Banana shrimp*

Almost similar to *P.indicus* occurring along the Indian Ocean, Oman to Indonesia and Australia. It can be grown at high densities and resistant to lower temperatures upto 15^{O}C with quick turnover rate in ponds of sizes of 10-20 g at high density and 20-30 g at low density can be attained after three months with harvests of 300-400 kg/ha/crop. Moreover, an ideal alternate crop to *P. monodon* during dry months. Thus, the main reasons for diversification of species is a necessity to resolve some of the compounding issues such as

- Countering some of the diseases that are rampant for now dominating in cultured species which may not be as potent in the new introduced species
- Highly dynamic international prices can be controlled with the shortage of dominating species at a time
- Improvement of domestic market with replacement of short duration small size culture able species
- Development of localized and native species culture for domestic and international market based on demand.

4. Genetic Improvement program and SPF development

The native species of each country has its potential for diversification. The Genetic improvement program of **Indian White shrimp** will aim to sustain the Indian Shrimp Aquaculture industry through the supply of domesticated SPF (Specific Pathogen Free) Indian White Shrimp broodstock for seed production and farming thereby augmenting aquaculture production and export. There is enough indication through preliminary trials that this species could be an indigenous alternative for *P. vannamei*. Commercial availability of SPF or High-health stock will be an added advantage.

P. indicus **Research and high-density culture demonstration by ICAR-CIBA**

Health management in shrimp aquaculture system

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Introduction

India as a world's top aquaculture producer, has exported 1369264 metric tonnes of marine products worth of 57586.48 crores during 2021-22. It is observed that the frozen shrimp was the major commodity weighing 728123 MT (53.18%) worth of 42706.04 crores (74.16%) [Handbook on Fisheries Statistics, 2022]. Out of total marine products export in India, the export of shrimp during 2022-23 has achieved the export worth of Rs. 43135.58 crores registering a growth of 444.682 (711099 metric tons) and 520.775 (US$ 4.6 billion) per cent in quantity and US$ realization compared to the same period of 2009-10, respectively. Such an important shrimp aquaculture has been continuously plagued by emerging viral, bacterial and parasitic diseases leading to high economic losses to the farmers. Hence, insurance and farm level early diagnosis could help the farmers to take timely decision either on treatment or emergency harvest and insurance claim.

Important diseases in shrimp aquaculture system

Shrimp aquaculture was started as a traditional practice during which very low stocking density was adopted. During this period only some of the bacterial and parasitic diseases were prevalent. However, intensification of culture practice brought severe stress and diseases started emerging.

Some of the important diseases/pathogens are listed below

I	World Organisation for Animal Health (WOAH, formerly called as OIE) listed diseases/pathogens	Etiology	Current status
1.	*Enterocytozoon hepatopenaei* (EHP)	Protozoan	Present in India
2.	Infectious Hypodermal and Haematopoietic Necrosis virus (IHHNV)	ssDNA virus	Present in India
3.	Infectious Myonecrosis virus (IMNV)	dsRNA virus	Present in India
4.	Taura Syndrome virus (TSV)	ssRNA	Not found in India

5.	White Spot Syndrome Virus (WSSV)	dsDNA virus	Present in India
6.	Yellow Head Virus genotype 1 (YHV)	ssRNA virus	Not found in India
7.	Decapod Iridescent Virus 1 (DIV 1)	dsDNA virus	Not found in India
8.	Acute Hepatopancreatic Necrosis Disease (AHPND)	Bacterium	Not found in India
9.	Necrotising hepatopancreatitis, NHPB (*Hepatobacter penaei*)	Bacterium	Not found in India
II	**Non-WOAH listed diseases/pathogens but of concern to India**		
1.	Spherical Baculovirosis (*Penaeus monodon*-type Baculovirus) (MBV)	dsDNA virus	Present in India
2.	Laem-Singh Virus	ssRNA virus	Present in India

Gross lesions of important shrimp diseases

		
Shrimp affected WSSV showing typical white spot on the carapace of black tiger.	Shrimp affected with IHHNV showing typical abdominal bent in vannamei.	Shrimp affected with IHHNV showing rostral deformity in vannamei.
		

Shrimp affected with IHHNV showing size variation and black gill in vannamei.	Shrimp affected with IMNV showing whitish and reddish necrotic areas in distal abdominal segments and tail fan and show cooked appearance in vannamei.	Vibriosis affected shrimp shows cuticular lesions with localized pits on external surfaces, localized blisters and swollen tail fan.
		
Shrimp affected with IHHNV and bacteria shows black gill in vannamei.	Shrimp affected with non-AHPND *Vibrio parahaemolyticus* shows pale to whitish hepatopancreas due to loss of pigment and shrunken, small or discoloured in vannamei.	Shrimp affected with EHP shows white gut in vannamei.

Disease detection and diagnosis

The correct diagnosis is obviously a critical step in any control program. The available diagnostic methods that may be selected for diagnosis of the shrimp diseases or detection of their etiological agents are based on:

1) Anamnesis.
2) Gross and clinical signs.
3) Direct bright-field, phase-contrast or dark-field microscopy with whole stained or unstained tissue wet-mounts, tissue squashes, and impression smears; and wet-mounts of faecal strands.
4) Post mortem findings.
5) Histology of fixed specimens.
6) Bioassays of suspect or subclinical carriers using a highly susceptible host (life stage or species) as the indicator for the presence of the pathogen.

7) Transmission or Scanning Electron Microscopy (TEM or SEM).

8) Antibody-based tests for pathogen detection using immune sera polyclonal antibodies (PAbs) or monoclonal antibodies (MAbs).

9) Molecular methods.

Disease prevention and control strategy

The disease prevention and control strategy is the best practice for successful hatchery and grow-out culture practices in shrimp industry.

1) Ponds should be dried before starting the culture.

2) Strict biosecurity measures to be adopted.

3) Sieve should be used at water inlet and the water should be bleached before stocking to weed out wild shrimp, fishes and intermediate hosts.

4) Good water quality should be maintained throughout the culture.

5) Zero water exchange or minimal water exchange from reservoir ponds.

6) Disease-free stock should be used from good genetic strain of broodstock.

7) Development and use of disease resistant stocks will help in prevention of catastrophic disease outbreak and loss.

8) Coastal Aquaculture Authority (CAA) guidelines should be followed for optimum shrimp stocking density in grow out culture system.

9) Quarantine measures should strictly be adopted to import broodstock to avoid entry of existing or emerging pathogen.

10) Adequate balanced good nutrition to be made available to avoid problems associated with cannibalism and horizontal spread of diseases.

11) Proper destruction and disposal of infected as well as dead animals to be regularly monitored.

12) Animals should be handled with good care to avoid unwanted stress.

13) Proper chemical prophylaxis and vaccine development is needed for immunological protection.

14) Regulations are required to prevent transfer of pathogens from one host population to another, nationally or internationally.

15) Sanitation and disinfection of hatchery and equipment are to be strictly followed.

Conclusion

Aquaculture is now integral to the economies of many countries. Growing demand for seafood and limitations on production from capture fisheries will inevitably lead to the increased intensification in commercialization of shrimp aquaculture. This in turn increases the number of diseases and leads to emergence of new diseases. The emergence and spread of infectious disease is usually the result of a series of linked events involving the interactions between the host (including the physiological, reproductive and developmental stage conditions), the environment and the presence of a pathogen. Focusing efforts on producing high quality seed, better pond manage to reduce stress and risk of infection, following routine farm biosecurity, responsible trade practices, response to disease outbreak, and improved better management practices shall aid in preventing the epidemics of diseases. Further health management is a shared responsibility, and each stakeholder's contribution is essential to the health management.

Soil and water quality management in shrimp farming under varying weather scenarios

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Introduction

A pond with good soil and water quality will produce healthier animals than a pond with poor quality. Understanding pond water and soil characteristics, and optimum requirements helps to decide the better management practices (BMPs) to be followed in terms of liming, manuring, fertilization, water management, etc. for reducing the risk of health problems, and reduce or mitigate the impacts of farming on the environment. The sensitivity of aquaculture to climatic variations is influenced by the scale, type and intensity of aquaculture systems and the environmental context in which it is practiced. The frequency and intensity of extreme weather events like heavy rain, flooding and cyclone would affect aquaculture badly. Climate variability, especially changes in temperature regimes, rainfall patterns and seasonal variations has enormous negative consequences in aquaculture production systems.

2. Water and soil requirements for brackishwater aquaculture

Water quality and quantity determine the success or failure of culture operation. An annual water budget should be calculated for a potential farm site so that the supply is adequate for existing and future needs. The sub-surface soils should be tested for compaction and seepage properties. The optimum ranges of water and soil parameters required for aquaculture are given in Table 1. Even if the site is good with optimum soil and water characteristics, problems such as excessive phytoplankton production, low dissolved oxygen, high ammonia, poor bottom soil condition and other problems may still crop up. Most of these problems can be avoided by proper management practices during the pond preparation and culture period.

Table 1. Water and soil requirements for brackishwater aquaculture

Water parameter	Optimum range
Temperature (°C)	28 - 32
pH	7.5 - 8.5
Salinity (ppt)	15 - 25
Transparency (cm)	30 - 40
Total suspended solids (TSS) (ppm)	<100
Dissolved oxygen (DO) (ppm)	4.0 - 7.0
Total ammonia-N (ppm)	<1.0
Unionised Ammonia (ppm)	<0.1
Nitrite-N (ppm)	<0.25
Nitrate-N (ppm)	0.2 - 0.5
Dissolved-P (ppm)	1.1- 0.2
Chemical oxygen demand (ppm)	<70
Biochemical oxygen demand (ppm)	<10
Hydrogen sulphide (H_2S) (ppm)	< 0.003

Soil parameter	Optimum Range
pH	6.5 - 7.5
Organic carbon (%)	1.5- 2.0
Available nitrogen (mg/100g)	50 -70
Available phosphorus (mg/100g)	4 - 6
Calcium carbonate (%)	>5
Electrical conductivity (dS/m)	>4
Exchangeable acidity (%)	20 - 35
Depth to sulfidic or sulfuric layer (cm)	50 -100
Clay content (%)	18 - 35
Textural class	Sandy clay, sandy clay loam and clay loam

3. Pond preparation

The main objectives of pond preparation are to provide cultured animals with a clean pond base and appropriate stable water quality. In newly dug-out ponds, the characteristics of the soil have to be understood first, and soil deficiencies should be identified and treated instead of waiting until poor bottom soil quality develops later. The pond preparation after harvest before initiating the next crop is entirely different from that of a newly dug-out pond and comprises of removal of waste accumulated during the previous crop by draining and drying the pond bottom. The pond bottom should be dried for at least 7-10 days or until it dries and cracks for the mineralisation of organic matter and the release of nutrients. Tilling bottom soils can enhance drying. The shrimp culture ponds with total alkalinity below 80 mg l^{-1} as $CaCO_3$ and any pond with soil pH below 7 usually will benefit from liming. Depending upon the phytoplankton density as exemplified by the turbidity of the pond water, the required quantity of the fertilizers may be applied in split doses for sustained plankton production.

3.1 Intake water treatment

Maintenance of good water quality is essential for both the survival and optimum growth of animals. Water treatment is an important step for the maintenance of good water quality at a later stage. Farmers should ensure that only treated water is used in the culture ponds for compensating the evaporation losses.

- Direct use of creek or seawater carries the risk of introducing the virus through aquatic crustaceans. There is a need to eliminate these from the water before use in culture ponds. The use of filter nets of 60-micron mesh/cm^2 in the delivery pipes/ inlet sluice should be strictly followed.
- Water from the source is filtered through filters to prevent the entry of parasites and crustaceans that are carriers of diseases.
- Inorganic turbidity (suspended solids) should be removed by providing a sedimentation/ reservoir pond before water is taken into production ponds.
- Chlorination as a means to sterilise the water is practiced by many farmers. To achieve this enough chlorine should be applied to overcome the chlorine demand of organic matter and other substances in the water. Water should be taken in reservoir ponds and treated with calcium hypochlorite @ 30 ppm. The permissible level of chlorine residuals in treated water for use in grow-out ponds should be nil.

4. Pond bottom soil management during the culture period

The aquaculture pond soil bottom is covered with sediment, and this sediment can be considered aquaculture pond soil. In describing various physical, chemical and biological processes occurring in the pond bottom, it is convenient to refer to the bottom deposit as sediment. Management measures should be taken to prevent large accumulation of fresh organic matter at the soil surface or in the upper few millimeters of the soil or the sediment-water interface (SWI). The oxidized layer at the sediment surface is highly beneficial and should be maintained throughout the culture period. The SWI is a distinctly vital region in the aquaculture pond environment where continuous chemical and microbial reactions take place and influence both the sediment and overlying water quality, acting as an early indicator of pond health. The low pH of the bottom sediment indicates unhygienic conditions and needs a regular check-up. The change in the bottom in terms of increasing organic load should be recorded regularly for the management of the pond bottom.

5. Water quality management during the culture period

Test indicators to ensure that the pond is ready for stocking are a secchi disc reading of around 40 cm or less, a stable pH, algal bloom which is brown with a yellowish hue in colour and water temperature above 25^0C. The parameters that should be monitored routinely are temperature, pH, salinity, dissolved oxygen and transparency. At the time of stocking shrimp PL should be acclimated gradually to the salinity of pond water to reduce stress and mortality. Due to the high evaporation rate in summer salinity may increase beyond 40 ppt, which can affect the growth of shrimp. Maintenance of salinity of 18 to 35 ppt with variations not exceeding 5 ppt will help in reducing stress on the shrimp. The pH should be at an optimum level of 7.5 to 8.5 and should not vary by more than 0.5 in a day. The optimum range of transparency is 25-35 cm. Transparency less than 20 cm indicates that the water is unsuitable for culture and should be changed immediately to flush out excess bloom. Periodic partial removal of cyanobacteria and algal blooms by flushing or scooping out the scum facilitates optimum density and prevents sudden die-off of the bloom.

Dissolved oxygen (DO) is the most important and critical water quality parameter because of its direct effect on the feed consumption and metabolism of shrimp as well as its indirect influence on the water quality. Water exchange is the best solution to prevent low DO problems in the pond where aeration is not practiced, but should only be used when necessary. The number of aerators required is about 1 HP per every 300 kg of biomass. The toxicity of ammonia nitrogen is attributed primarily to the un-ionized form and should be less than 0.1 ppm. Any detectable concentration of hydrogen sulphide is considered undesirable. In the presence of an optimum level of oxygen, the toxic substances are converted into their oxidized and less harmful forms.

6. Shrimp culture management under varying weather scenarios

Shrimp aquaculture is essentially dependent on the availability of good quality saline water. In a monsoon failure scenario (deficit rainfall), water scarcity will be a major problem in source waters (backwaters and creeks) of low tidal amplitude areas (Andhra Pradesh and Tamil Nadu) where the bar mouth of the various creeks normally is kept open by the inflow of freshwater during monsoon. Conversely, the water levels will be maintained in high tidal amplitude areas (West Bengal and Gujarat). Any increase in water levels due to excess rainfall (floods) may result in significant infrastructure damage.

The high temperatures/diurnal variations affect water quality such as shifts in dissolved oxygen levels linked to an increase in the intensity and frequency of disease outbreaks, more frequent algal blooms, and a negative impact on growth performance. Heavy rainfall decreases the salinity of culture ponds, changes in suspended sediment and nutrient loads, and depletion of dissolved oxygen and consequent production losses in inland and coastal ponds. The variability in the amount of precipitation under different scenarios of monsoon could negatively impact aquaculture. Timely onset and sudden withdrawal of monsoon cause an increase in the salinity of water during the later stages of the culture period. Delay in the onset of monsoon leads to high salinity build-up, especially in low tidal amplitude areas and conflicts with other users for using freshwater to dilute high salinity. Break in monsoon i.e., dry spell conditions for two to three weeks consecutively and early withdrawal of monsoon can lead to salinity build-up in creeks and less water availability.

A. General advisory to shrimp farmers to combat deficit rainfall (water scarcity) situation

- High salinity levels above 35 ppt will hamper the growth of the shrimp and result in uneconomical cultures. Hence, farmers are advised to wait for stocking the shrimp seed (PL) till the salinity comes to normal.
- In case of impending water scarcity, low stocking density should be adopted.

- It is not advisable to start a culture if water cannot be retained at least for a minimum of 3 months.
- Culture should be initiated with at least 1 m depth of water.
- Low water levels will lead to high temperature regimes in the ponds which will add to the stress of the cultured organisms.
- Feeding should be at the minimum to avoid organic loading in the pond water.
- In deeper ponds, to overcome thermal stratification and ammonia build-up, aerators should be operated especially during warm and sunny afternoons.
- Farmers are advised to maintain the reservoir pond and chlorinate the water for topping up/exchange of water to reduce the salinity of pond waters in summer.
- Shrimps should be harvested when the water level drops below 60 cm in the ponds and if there is no water to replenish.
- Change of culture species is recommended to avoid conflict with other users for freshwater to dilute high salinity.

B. General advisory to shrimp farmers to combat excess rainfall situation

- Farmers are advised not to stock shrimp PL immediately after heavy rains due to the low salinity and pH of pond waters.
- Shrimp larvae are produced in the hatchery at water salinities of 28-35 ppt, however, advanced post-larval stages are often stocked in ponds, where salinity is much lower. At the time of stocking, PL should be acclimatized to the salinity of pond water gradually @ 1 or 2 ppt per hour to reduce stress and mortality.
- During the culture period, in case of heavy rains, periodical application of lime has to be applied based on water pH.
- During excess rains, there is a greater possibility of occurrence of thermal stratification in the pond water column as well as salinity and DO stratification which may lead to changes in water temperature, DO depletion, increase of CO_2, decrease in pH, alkalinity and salinity. The farmers are advised to maintain a reservoir pond and chlorinate the water for topping up or water exchange and use aerators to decrease thermal stratification.

- In case of wide fluctuations in the salinity associated with sudden heavy rains, the feeding should be controlled to avoid feed waste accumulation on pond bottom soil.

Regular monitoring of water and soil quality parameters can give an insight into the physical, chemical, and biological environment of the pond ecosystem. Adoption of proper management strategies depending on the site environment/weather characteristics, culture system, and the type of management will lead to the sustainable development of shrimp farming.

7. Conclusion

The bankers and Insurance officials can check the water quality reports available with the farmers regularly during the culture period. If there are any drastic changes in water parameters viz., pH, salinity, dissolved oxygen etc. it is pertinent to ascertain whether these changes are a result of management practices or due to sudden climatic variations/extreme weather events. These sudden changes in water parameters are the stress factors and precursors for the incidence of diseases. This knowledge will help the officials in implementing shrimp crop insurance.

Significance of nutrition and feeding in shrimp farming

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Introduction

Aquaculture and Fisheries remain important sources of food, nutrition, income, and livelihoods for hundreds of millions of people around the world including in India. Total fisheries and aquaculture production reached a record of 214 million tonnes in 2020, comprising 178 million tonnes of aquatic animals and 36 million tonnes of algae (FAO 2022). Global aquaculture production continued to grow amid the worldwide spread of the COVID-19 pandemic. Global aquaculture production consisted of; 87.5 million tonnes of aquatic animals predominantly used as food for human consumption; 35.1 million tonnes of seaweeds and other micro-algae for both food and non-food uses. Global consumption of aquatic foods has increased significantly. In 2019, global aquatic food consumption was estimated at 158 million tonnes and consumption increased at an average annual rate of 3.0 percent from 1961, compared with a population growth rate of 1.6 percent. In India, the total fish production during the year 2020-21 is estimated at 14.73 Million Metric Tonnes (MMT) with a contribution of 11.25 MMT from the inland sector and 3.48 MMT from the marine sector. The fisheries sector contributes about 1.24% to the gross value added (GVA) and 7.28% to the agricultural GVA. In India, the changing consumer preferences, advancements in technology and income growth are the real drivers that augur well for further expansion and demand of food from aquatic origin. Against this backdrop, this sector is poised for unprecedented growth and opening various avenues of entrepreneurship.

Aquaculture

Freshwater carps and brackishwater shrimp are the dominant cultured candidate species in India. Freshwater aquaculture contributes about 90% of the total aquaculture production. The farming of Indian Major Carps (IMC) is the mainstay in fresh water. Though the production is predominantly traditional, the conversion to feed-based aquaculture is getting momentum. However, feed-based aquaculture is growing rapidly for the species like tilapia, pangasius, and pacu. Shrimp farming is the face of brackishwater aquaculture in India and shrimp culture has been carried out as a traditional activity for ages in India. For a developing country like ours, shrimp farming is a high-potential sector with enormous scope for increasing foreign exchange and employment generation. The early nineties witnessed a phenomenal growth of the sector which was entirely dependent on the culture of a single species, the tiger shrimp, *Penaeus monodon*. During this period, the shrimp culture was a low-risk, high-profit venture. In the late 90s, there were serious problems with viral diseases and environmental safety issues, which arose mainly because of the lack of planning and regulation. The Central Institute of Brackishwater Aquaculture (CIBA) and National Bureau of Fish Genetics and Resources (NBFGR) aimed at evaluating the feasibility of the introduction of this new species and carried out the risk analysis for introducing the exotic shrimp, *Penaeus vannamei*. Since the introduction of vannamei in 2009, Indian shrimp farming has witnessed a rapid shift towards the culture of vannamei almost replacing tiger shrimp, except for the traditional culture practiced in West Bengal and Kerala, where still monodon and indicus are farmed. To sustain the rapid growth of vannamei farming, the feed industry also needs to support the sector with quality and cost-effective feeds, as feed alone contributes 50-60% of the operative cost in the semi-intensive shrimp culture practice adopted by Indian farmers.

Significance of feed in aquaculture

The significant increase in aquaculture has been possible with the corresponding increase in the availability of formulated feeds. Aqua feeds have been developed for sustainable and commercial culture fish and shrimps to meet the animal protein needs in developing countries. The principal cost in the manufacture of aqua feeds is that of raw materials; this could amount to as much as 80 percent, or more, of the manufacturing costs in commercial feed mills. Aqua feeds in India have evolved commercially in the late 90s for shrimp culture and then for fish during the last decade. In the brackishwater aquaculture sector, majority of the feed used is scientifically formulated compounded feed produced by multinational / Indian companies. There are some small players with a capacity to produce one tonne per hour are entering the market. In freshwater aquaculture, the traditional farm-made feed consisting rice bran with any of the oil cakes available in their locality. The sinking feed for carps and the availability of floating feeds for fish seems to make a steady and positive impact in changing the traditional feeding system and increasing productivity. However, farmers are more concerned about the cost of production and the final product quality and the majority of the farmers are using the formulated feed as a supplementary feed and not as complete feed. Here it is pertinent to note that the price of DORB has a direct bearing on the use of formulated feed. Currently, in freshwater aquaculture, extruder feeds are popular for species like pangasisus, tilapia, and pacu. Though the traditional bag feeding technique is followed for IMCs, about 15% of the production is under sinking and floating extruded feeds and thus opening big opportunities for the formulated feed market to grow in the freshwater sector also increasing aquaculture production through the feed.

Most of the corporate and big feed mills are having the state of the art facilities for the production of quality water stable shrimp feed pellets. The shrimp feed mills have facilities for coarse grinding, fine grinding, sieving, mixing and steam pelleting with three-stage pre conditioner combined with post-pellet conditioner is in vogue. Most of the shrimp feed produced in India uses a ring die pellet mill to produce a sinking compact pellet. In general, the shrimp feeds for tiger shrimp consist of three grades of crumble (C1, C2 and C3) and three to four grades of pellets in the diameter of 1.8, 2.0 and 2.2 mm. However, there is a gradual shift in sizes of the pellet in the feed meant for pacific white shrimp, Penaeus vannamei. Now the feed pellet sizes available as 1.0, 1.2, 1.4, 1.6, 1.8 and 2.0 mm are being used for feeding vannamei. Though the production of feed pellets at sizes less than 1.8mm is a high energy consumption process, feed millers and farmers are of the view that smaller pellets are better and could able to meet the requirement of the current practice of white shrimp farming at higher densities than *P.monodon.* The inherent advantage of smaller diameter pellet is that crumbling is a two-step process wherein bigger pellets (1.8 mm) are subjected to crumbling to get the required size (400 microns to 1.7 mm) and the time delay in crumbling operation is reduced in case of taking production with smaller size dies. Attempts have been made to produce extruded shrimp feeds with reasonable success and few firms started producing the extruded shrimp feeds.

Current status and future potential in India

Currently India is the third largest fish producing country in the world and accounts for 7.96 % of global fish production. The total fish production during FY 2020-21 is estimated at 14.73 MMT with a contribution of 11.25 MMT from inland sector and 3.48 MMT from Marine sector. The fisheries sector plays an important role in the national economy and the sector has been one of the major contributors of foreign exchange earnings, with India being one the leading seafood exporting nations in the world (Annual report 2021-22, DoF, Govt. of India). Last year India's aquaculture export exceeded 1 MMT and shrimp alone contributed 96%, coming from an aquaculture area of 1,75,000 hectares. (MPEDA, Govt. of India 2023). Andhra Pradesh is the hub of

Indian aquaculture. It holds 65 – 70% of India's total aquaculture production. West Godavari, East Godavari and Krishna districts of Andhra Pradesh are highly productive and sustainable farms due to the availability of perennial freshwater source and fertile lands. With the introduction of white shrimp farming, shrimp production in India is growing at every year irrespective of several challenges like emerging diseases, climatic conditions and price volatilities. In 2021, black tiger shrimp was again taken up with SPF status, with stronger and faster growing genetics with better disease tolerance to aid in the revival of black tiger shrimp farming. This will add stability and profitability to the aquaculture industry.

Aquafeed demand in India is more than 2.5 MMT of which 1.5 MMT is contributed by shrimp aquaculture sector and 1 MMT by fish aquaculture mostly the freshwater fishes. India currently has 70 aquafeed mills with a production capacity of more than 4 MMT. Although most of the feed mills are concentrated in Andhra Pradesh, some are coming up from other parts of India like West Bengal, Odisha, Gujarat, Chhattisgarh, Maharashtra, Uttar Pradesh, Bihar. This clearly shows that aquaculture industry is expanding very rapidly in many Indian states and feed requirement constantly growing to support the industry growth.

Among the aquafeed, Shrimp feed industry is more dynamic and profitable due to shrimp's attractive export market potential. The shrimp aquaculture industry is well organized and supported by constant scientific innovation in genetics, agriculture and feed technology. This ultimately paves the way for reliable growth and sustainable development. After the introduction of *Penaeus vannamei* in 2009-10, the shrimp feed business in the country underwent a major transformation. The rapid increase in shrimp production created huge feed demand and created opportunity for new companies to enter the feed business and existing feed companies to expand. Currently, we have 40 feed mills with the production capacity of 3.5 MMT can easily be support the shrimp farming expansion.

Feed Management

Feed represents the largest variable cost in shrimp aquaculture and is the single most factor influencing the growth of the shrimp as well as pond water quality and contributes directly for the improved profitability of shrimp aquaculture. Feed management can be defined as control and use of feed for aquaculture operation in such a manner that the utilization of feed is optimum with minimum wastage, negligible impact on environment, achieving best feed conversion ratio (FCR), better soil & water quality, maximum growth of shrimp and production. Here it is to be kept in mind that a best feed can produce poor results if the feed management is poor. Alternatively, a moderate feed can produce best results under good feed management and hence feed management assumes considerable significance Feed management starts from the procurement and ends with the best use of the feed for a good harvest on the final day of shrimp culture and the BMPs in feed management required to be followed by farmers for successful shrimp culture are given below.

How to select a quality shrimp feed?

A quality feed in the common parlance is that ability of the feed to give good growth and FCR without affecting the shrimp health and pond water quality. Hence, the quality is comprised of the physical, nutritional and biological quality of the feed. The first and fore most point in selection of the feed is its physical quality.

Physical quality

The feed pellets should be of uniform size and appearance, physical integrity and without any fine dust/powder. The feed should be fresh with good fishy odour and presence of too much or too less odour is not ideal. There should be any clumps and visible fungus. The physical integrity and nutrient leaching are of high importance in shrimp feed quality because of not only financial loss due to the loss of nutrient but also the implications it will have on environment. Farmers are evaluating the physical stability of the feed pellets to retain its physical integrity without nutrient leaching and disintegration. The feed should absorb minimal water so that it can become soft for ease of consumption.

Chemical quality

The aqua feed to be selected should match the nutritional requirements of shrimp. Though most of the feed manufacturers are giving the nutritional composition, the farmers should get verify the composition by analyzing its nutrient composition. The feed should be free from antibiotics and banned chemicals.

Biological quality

The feed should be attractable and palatable to the shrimp and there should not be any problem in intake. It should be highly digestible with negligible waste generation resulting in good growth with better FCR and should maintain the pond water quality within the optimal quality.

Conclusion

The Indian aqua feed industry has rapidly evolved over the years to cater to the needs of fast-growing aquaculture during the last decade. Scientific feed formulation and innovative feed management will open many avenues for entrepreneurs and ultimately support the rapidly growing aquaculture industry. This would provide economic and nutritional security to the Indian population through high-quality proteins and micronutrients. The nutritional richness of food of aquatic origin will further promote designer foods and create demand for increased food from aquaculture. There is a huge potential for entrepreneurship in the aqua feed sector in the years to come.

Capital and Credit requirements and profitability of shrimp farming

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The first-ever Indian shrimp export consignment was flagged off by Mr. Madhavan Nair, owner of a Kochi Company, from Port of Kochi in 1953. Only canned shrimp was exported initially, and later the industry switched to frozen shrimp along with other seafood items. The money brought in by exports of the seafood, especially shrimp, in the late 1960′s, made many policy makers, officials and farmers to take a serious note of the export potential of the brackishwater aquaculture sector.

Historical overview of brackishwater aquaculture in India

Brackish water aquaculture in India was in vogue as traditional practice in Pokkali paddy fields along the Kerala, traditional earthen ponds of Orissa and Goa, Bheries of West Bengal. Traditional aquaculture systems facilitated mostly one crop only in a year. The feed used was natural feed like rice bran and oil cakes, and the crop season was usually from December to April. No diseases were reported particularly. The yields were low, averaging around 150 to 200 kg/ha. The shrimp exports consisted mostly of sea capture and culture contributed negligible quantities.

The 1970s started with a new hope and fervor. Scientific shrimp farming started in the country with the work of Experimental Brackish water Fish Farm in Kakdwip, West Bengal, by the Central Inland Fisheries Research Institute under the Indian Council of Agricultural Research (ICAR) in 1973. Concurrently, shrimp seed production studies were initiated in Narakkal, near Kochi, in Kerala, by the Central Marine Fisheries Research Institute of ICAR. Narakkal KVK, under the Cochin-based Central Marine Fisheries Research Institute, did pioneering investigations into shrimp breeding and seed production. Indian Council of Agricultural Research started an All-India Coordinated Research Project on Brackishwater Fish Farming (AICRP on BWA) in 1975, with centres in West Bengal, Odisha, Andhra Pradesh, Tamil Nadu, Kerala, and Goa. The feed technology was improvised with preparation of farm made feeds as balls or pellets using fish oil, fish by catch and other plant sources like groundnut oil cake etc. The diseases reported were bacterial and fungal which were effectively cured by application of recommended chemicals. The yield was ranging between 1000-1500 kg/ha.

In the late 1980s, progressive farmers started import of technology from South East Asian Countries along with technicians. The use of machineries like aerators came into existence. Imported pellet feed were found to give higher growth and better yields. Semi-Intensive farming was initiated in many pockets of Andhra Pradesh and Tamil Nadu. The AICRP on BWA became an entity itself as ICAR - Central Institute of Brackishwater Aquaculture on 1st April 1987. In the same year, Hindustan Lever's Sandeshkali unit in West Bengal achieved a yield of 3.5 t/ha/crop and Victory Aquafarm, Tuticorin harvested a yield of 8 tonnes per ha of Indian white shrimp, with use of imported pellet feed. These reports ignited the interest of aqua-farmers in shrimp farming. In the late 1980s, MPEDA established the Andhra Pradesh Shrimp Seed Production Supply and Research Centre (TASPARC) based in Andhra Pradesh and Orissa Shrimp Seed Production Supply and Research Centre (OSPARC) based in Orissa which provided assistance and paved the way for the establishment of a many private hatcheries. The farmers used imported pellet feeds and were happy with the performance. Though bacterial, fungal, and parasite issues were there, the situation was manageable. India started getting attention from major import destinations of the USA, Europe and Japan.

The decade of the 1990s started with the grand entry of tiger shrimp (Penaeus monodon) in the aquaculture space of the country. A semi-intensive culture technology was demonstrated in a pilot-scale project by the MPEDA funded by the Department of Biotechnology. The semi-intensive farming technology demonstrated production levels reaching 4–6 tonnes/ha. Credit facilities from commercial banks and subsidies from the Marine Products Export Development Authority helped to boost the shrimp farming sector. The corporate sector jumped in and NABARD, Insurance companies supported the industry assiduously. In addition, a number of Central Sector development schemes were initiated; including setting up Brackishwater Fish Farmers Development Agencies (BFDA) in the maritime states for the development of shrimp farming. This paved the way for the establishment of a number of shrimp hatcheries and farms in the coastal states in the early nineties. Foreign feed and chemical inputs were relied upon mostly. India witnessed an extraordinary increase in the area under shrimp farming which occurred till 1995. The legal imbroglio and dreaded White Spot Syndrome Virus (WSSV) brought stellar growth to a grinding halt. In many of the major shrimp producing countries of Thailand and other South-East Asian nations, multiple shrimp diseases were reported. The global production started dwindling. All efforts were put to contain shrimp diseases. India could ensure the survival of shrimp farming against many odds, with the use of

Polymerase Chain Reaction (PCR) screening of seeds and cluster farming with the adoption of Better Management Practices

The period 2000 to 2010 saw the continuation of revival efforts which partly helped, farmed shrimp production recorded over a five-fold increase from 28,000 tonnes in 1988-89 to 1.5 lakh tonnes in 2006-07. The lull in the first decade of the new millennium was broken by the introduction of Specific Pathogen Free - Pacific white shrimp; *Penaeus vannamei* (SPF- PV) in 2009, after intense debate and conduct of a scientific import risk assessment study lead by ICAR-CIBA. The brooders were quarantined and vertical transmission of OIE listed diseases were prevented. The crops were successful with farmers' adherence to bio security measures. Feed sector saw adoption of indigenous feed technology from ICAR-CIBA to an extent of 5-10% of the total area. Indian feed companies started performing well. The growth rates were high. The stocking densities were restricted and many farmers took a harvest of 8-10 tonnes and average national productivity rose to 4 – 5 tonnes. The introduction of SPF-PV helped the aquaculture sector to increase the production by 4.6 times from 1.5 lakh tonnes to 7 lakh tonnes compared to the pre-SPF-PV scenario. An industry estimate puts the total Indian shrimp production currently stands at close to 843,000 metric tons (90% is vannamei) from an area of 167,000 hectares, with average productivity of 5042 kg/ha/crop in 2022.

Fig.1. Growth trend of shrimp farming in the country (2010-2023)

As the brackishwater aquaculture sector has come through the ages of many ups and downs, the resilience needs support with more sustainable technologies from Research and Development, promotion, and policy agencies. ICAR- Central Institute of Brackishwater Aquaculture has always been at the forefront in developing new technologies and supporting the sector in policy meetings with scientific data and other inputs.

Role of CIBA in the sustainable development of the sector

ICAR Central Institute of Brackishwater Aquaculture is the Research and Development arm of ICAR dedicated to the sustainable development of the brackishwater aquaculture sector in the country. The mandate of ICAR-CIBA is as follows:

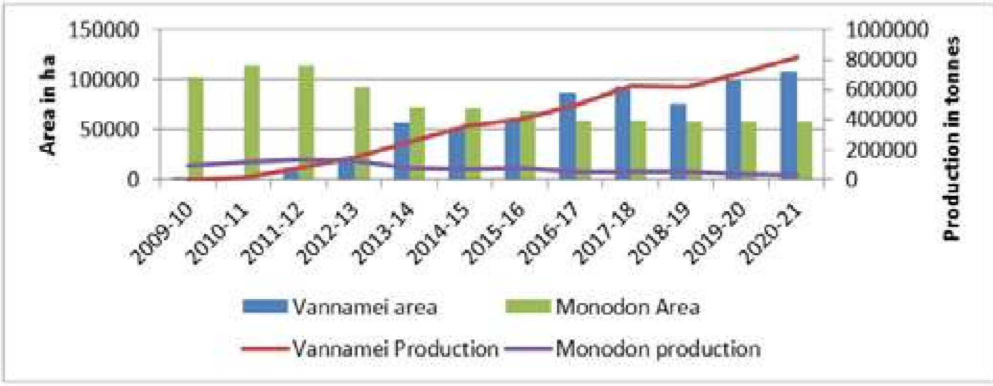

Figure.2. Area and production trends of *P. monodon* **and** *P.vannamei.*

- Basic, strategic, and applied research for techno-economically viable and sustainable culture systems for finfish and shellfish in brackish water.
- Species and systems diversification in Brackishwater aquaculture
- Act as a repository of information on brackishwater fishery resources with a systematic database.
- Human Resource Development, capacity building, and skill development through training, education, and extension

ICAR-CIBA is headquartered in Chennai and has two regional centres in Kakdwip and Navsari, along with a Field experimentation Station at Muttukadu. Sixty-seven scientists belonging to different disciplines are working towards sustainable technology development for shell and finfishes breeding, culture, nutrition, health management, and socio-economic aspects. The vision for the R&D work of the institute is to develop technologies that are technically feasible, economically viable, environmentally stable, and socially acceptable technologies for brackishwater aquaculture.

ICAR considerably contributed to shrimp farming since 1970s. The backyard hatchery, development of breeding techniques like unilateral eye stalk ablation, improved methods of farm made feed preparation and standardization of shellfish and finfish culture technologies. Intense efforts were put on development of human resource and capacity building of state and national level officers in fisheries departments and other line departments like banking and insurance personnel. Many officials from SAARC and ASEAN countries were also trained at ICAR-CIBA facilities. ICAR- CIBA also established close relationship with international agencies like Network of Aquaculture Centres in Asia and Pacific (NACA), Norwegian Agency for Development Cooperation (NORAD) and French Research Institute for the Exploitation of the Sea (INFREMER) which helped in conducting research on topical areas of research.

Thematic Areas of Research

The Seven thematic areas in which ICAR-CIBA focuses the research efforts are:

- Reproduction, breeding, and larval rearing
- Brackishwater production system research
- Brackishwater ornamentals & aquariums
- Nutrition, feed technology, bioprospecting
- Aquatic animal health and environment
- Genetics, genomics, transgenic, and biotechnology and
- Social Sciences and development

Public-Private Partnership

A total number of One hundred and Twenty-eight MoUs have been signed-in the last two decades (1999-2019). As on date, ICAR-CIBA commercialized nineteen technologies. A total amount of around Rs.1.66 crores generated from one-time license fee, revenue share and royalty. On the Intellectual Property Rights side, Eight patents obtained and five patents have been filed. About Forty Start-ups were graduated and trained by ICAR-CIBA.

Policy and Infrastructure support

- Establishment of new hatcheries, nurseries, grow-out farms and feed mills for commercializing new species
- Training and capacity building for nursery and grow-out farmers, hatchery operators, and feed mill owners
- Regular impact assessment studies and corrective actions

- Land lease policies- unfinished agenda for many states
- Water lease policies- Not in place
- Electricity tariffs – Very high compared to Thailand and Vietnam and even among States, the electricity charges vary very widely.
- Diesel prices – one of the highest in the region

Capital requirements for shrimp farming

Capital requirement for shrimp farming per ha varies from state to state due to various ecological parameters right from soil type, water source and prevailing climatic conditions. The farmers adopt different farming practices suiting to their locations and investment and input cot differ accordingly. Cost estimates as approved by financial institutions like NABARD is given in the table.1. Though the values can vary very widely in different areas based on location, climate and system of culture, to have an understanding indicative values are arrived.

Table.1. Averages Costs and Returns of P.vannamei shrimp farming per ha

S. no	Item	Quantity	Approx. Value in Rs
1.1.	Pond preparation, bund repairs and servicing of aerators/generators etc	LS	250000
1.2.	Bio security measures Bird net, farm lighting crab fencing etc	LS	50000
1.3.	Pump sets 5 HP	2 Nos	85000
1.4.	Aerator 2 HP	4 Nos	180000
1.5.	Farm shed, store ,watch, pump housing, feeding canoe & electrical fittings	LS	120000
1.6.	Miscellaneous (Cooking facility, furniture etc)	LS	15000
A	Total Fixed Costs(Capital investment)		700000
2.1.	Pond preparation (bottom scrapping, cleaning and levelling)		10000
2.2.	Bleaching powder, lime & dolomite	LS	25000
2.3.	Probiotics & Soil water health products	As advised	30000

2.4.	Seed	5 lakh per ha	250000
2.5.	PCR Lab charges	LS	4000
2.6.	Feed FCR 1:1.2	8400kg@ Rs.90/kg	756000
2.7.	Fuel & Electricity charges		75000
2.8.	Watch & Ward		25000
2.9.	Harvesting & packing		20000
B	Total Variable Costs (cultivation expenses)		1195000
C	Total costs (B+A/10)		1265000
D	Gross Income		2100000
E	Net Income		835000
	Different Scenarios		Net Income
F	10 % rise in input costs		708500
G	10% fall in shrimp price		625000
H	20% loss in output		415000

NABARD Working Capital for Animal Husbandry and Fisheries

The NABARD Working Capital for Animal Husbandry and Fisheries scheme helps the farmers to meet their working capital requirements. Also, the scheme provides cash for the production requirements and for ready purchase of seeds, fertilizers, pesticides etc. The farmers are benefited by utilizing the system. The new facility provides the short-term credit requirements for the rearing of animals, birds, fish, shrimp and capture of other aquatic organisms.

Features of the Scheme

- A Kisan Credit Card with a passbook is issued for eligible farmers.
- The farmers are enabled with any number both manual and electronic transactions within the limit as rotation of cash credit facility.
- The banks fix and allocate the credit limit as sub-limits to cover the short and medium terms.
- The card validity is for 5 years and can be renewed on its expiry.

- For the extraordinary performance of staff, an incentive with enhanced credit limit is provided to look after their fisheries breed and development.
- In case of any natural disaster or pest attack, the scheme provides the leverage for the conversion and reschedule of the loan.
- The scheme follows the rules and regulations of RBI in terms of security, margin, rate of interest.

Eligibility Criteria

The criteria involved in the selection process of the beneficiaries are as follows. The individual must own or lease any of the fisheries-related activities like:

- Pond, lake or tank
- Open water bodies
- Raceway and hatchery
- Rearing farms

Licensed fishing properties

The beneficiaries should be in any of the following professionals or Associations that are involved in the Inland Fisheries and Aquaculture:

- Individual or association of Fish Farmers
- Self-Help Groups
- Joint Liability Groups
- Women Groups
- The Marine Fisheries who possess
- Leased or registered Vessel or Boat
- License or permission for fishing in bay and sea
- An association with the State Fisheries and their allied activities
- Joint Liability Groups or Self-Help Groups, including tenant farmer

Rate of Interest

Rate of Interest is allied to the Base Rate and is left to the decision of the banks.

Amount of Financial Support

- Every state appoints a District Level Technical Committee (DLTC) that forecasts Capital Limit to extend the financial support based on farmer's land and cattle availability.
- The financial support is evaluated based on the cost incurred in the seed, feed, organic and inorganic fertilisers, harvesting and marketing charges, fuel/ electricity charges, labour and lease rent.
- Working capital includes the cost of fuel, ice, labouring charges, mooring/ landing charges for captured fisheries.
- For animal husbandry, the scale of finance is provided as a recurring cost towards feeding, veterinary aid, labour, water and electricity supply.
- Fisheries and Animal Husbandry experts of the Government are members of the DLTC who give technical inputs for assessing the cash credit requirement.
- Advanced entrepreneurs of livestock/fisheries sector include the DLTC for providing field level inputs while evaluating the working capital requirements.
- The maximum period for assessment of working capital requirement is the completion of one production cycle based on the cash flow statement.
- The Short-term credit limit is fixed for the first year to those who meet with the following conditions,
- The farming and cultivation carried out as per the proposed cropping pattern & scale of finance
- The credit limit is extended for the Post-harvest/household/consumption requirements.
- The limit allows the expenses incurred for the maintenance of farm assets, crop insurance, Personal Accident Insurance Scheme (PAIS) and Asset insurance.
- An additional limit of 10% is extended for the post-harvest requirements with an augmented amount of finance for the crop as per DLTC and the extent of area cultivated.
- The limit is extended up to 20% towards repairs and maintenance expenses of farm assets including the crop insurance, PAIS & asset insurance.

- The credit limit is augmented up to 10 % in every successive year until the fifth year.

Dual Type Smart Card

Under the scheme, a dual-type of Smart card is issued for the beneficiaries to serve the stated purpose. The smart card type that stores all the necessary information regarding the farmer's identity, assets, the land they hold, the amount of credit payable. The debit card that can be swiped for cash at all the ATMs and Hand-held swiping machines.

Required Documents to Claim the Scheme

- A Duly filled in application form
- Any Identity proof that can be a Voter ID card or PAN card or Passport or Aadhaar card or driving license
- Any Address proof that can be a Voter ID card or Passport or Aadhaar card or Driving license
- Additional Rules and Regulations
- According to the sanction terms, the withdrawal amount is based on the monthly cash flow, the value of the available stock and the deliverables.
- The repayment is fixed based on the cash flow or the income generation pattern of the activity undertaken by the beneficiary.
- The monitoring of end-use of funds is done in line with other loans
- Organising the field trip by the branch officials for monitoring the progress of the project.
- With the periodic review, regarding the facility, the banks will decide whether to continue or withdraw/scale down the facility based on the farmers

ICT applications for shrimp farm management

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Introduction

Shrimp farming is technology intensive and high investment food production system. Shrimp is a high value commodity alone contributed 71% of Indian seafood export earnings worth 5 billion USD. Introduction of Specific Pathogen Free (SPF) Pacific White Shrimp (*Penaeus vannamei*) farming in 2010 has quadrupled the Indian shrimp production from 0.15 MMT in 2008-09 to 0.815 MMT in 2020-21 with an enhanced average productivity of 6.0 tonnes/ha (MPEDA, 2021). Though profit is relatively higher in shrimp farming, it is equally susceptible to diseases and other production risks in the form of pond driven stress factors. Therefore, Farm advisory services are important to enhance the technical capacities of the farmers to adopt appropriate farming practices and facilitate them to access quality farm inputs, diagnostic services and premium market. Return to investment on farm advisory services is estimated at 58% and attributed for increased production and household income of farmers to the tune of 18-30%. In India fisheries is the provincial subject, hence, the states have the major responsibility in providing extension advisory services. Though fisheries and aquaculture contribute significantly for food production, employment generation, societal development and national economy, it has not been adequately supported with a formal dedicated extension service at states level.

The Departments of Fisheries (DoFs) of states due to their limited reach, welfare-centric functions, lack of manpower, extension service orientation and budgetary constraints, could not perform this role efficiently. Many ICT aided projects were undertaken to provide the extension support, but due to their narrow focus and limited geographical attention they could not make an impact. Nevertheless, development of mobile networks that support greater data speeds and connectivity even in remote geographies and affordable prices of mobile handsets across the globe facilitated the exponential rise of mobile applications to bridge this communication gap in a required mode to the end users and facilitate research, extension, farmers, input and market integration. Studies have asserted that mobile phone based information pathway could ameliorate the major impediment, the access to farm advisory, for raising agricultural productivity among smallholders. Further, mobile applications were found to have ensured bidirectional information flow, customised advisories to the farmers, broken information asymmetry and enhanced knowledge level among the farmer segments. Elfeky and Masadeh (2016) and Brize-Ponce (2016) confirmed that the use of mobile learning (e.g., apps) was more effective on end-user's knowledge than the use of traditional teaching approaches, due to the availability of the device without the restrictions of time and place. Shrimp farmers are constant information seekers from online sources and positively receptive towards accessing technology information through mobile applications.

Application of ICT – tools for aquaculture

Globally, ICT tools been widely used in various aspects of fisheries including, research and education. As in any farming enterprises, health management is the key subject in aquaculture too, and aptly, ICT aided tools have been most widely applied in the field of fish disease diagnosis and health management, apart from its application in other areas viz., aquaculture site selection, aquaculture farm management and aquaculture produce marketing. Aquaculture is technology driven farming enterprise and the aqua farmers are looking for quality information in time at an affordable cost. ICT aided tools like e-learning courses, e-publications, compact discs, short films, mobile telephony, Phone in programme, information kiosks, expert systems and decision support systems have developed and implemented in a limited scale as projects or programmes. Apart from these, farm advisories, success stories and important information which are to be informed to the end users immediately are being uploaded as e- publications in the websites of the institutions concerned, and short duration video-film on different aspects of aquaculture are being produced especially in local languages.

Development of Mobile Applications for Smart Shrimp Farming

In the present case, smart shrimp farming refers to facilitating shrimp farmers with specific mobile based applications inclusive of digital technology advisories, input optimizing calculations, bio-mass/stock assessment, on-farm disease diagnosis, farm risk assessment, pond- wise digital record keeping of all the farming operations, graphical display of pond parameters in the dash board, recommendations based on the data given by the farmer/end user for the efficient management of farms. In this context ICAR-CIBA has developed two android mobile applications viz., CIBA ShrimpApp and CIBA ShrimpKrishi both are available in the Google play store for free of coast. The applications developed adopting the Software Development Life Cycle (SLDC) approach which is comprised of eight phases and relevant methodologies as given in Table-1.

CIBA ShrimpApp: This app has eight information modules *viz.*, better management practices of shrimp farming, quantification of inputs, on-farm disease diagnosis, on-farm risk assessment, Frequently Asked Questions (FAQs) in shrimp farming, regulations, advisories and updates and posting queries were integrated in the mobile application. The internal consistency and validity of the modules were evaluated with appropriate reliability tests and judgement validation by domain subject matter specialists. The contents of the modules were translated in to programming language wherein the programme specifications were converted in to software instructions. Android Studio version 3.4.2 Integrated Development Environment was adopted for the development of mobile application with Java language as front end and the data bases were created as back end through Structured Query Language (MySQL). The framework for knowledge representation the mobile application along with the modules is given in Fig. 1.

Table-1: Software Development Life Cycle (SLDC) approach and methodology

Sl.No	SDLC Phase	Subject matter	Methodology
1.	System Analysis	Shrimp aquaculture sector, production systems, exiting information flow, mobile application for bidirectional flow of information, shrimp farmers profile analysis, information need assessment, formats, receptivity and sustainability.	Farm survey, focus group discussions.
2.	Feasibility Analysis	Availability of technical content, subject matter specialists, operational resources, time and budget requirement.	subject matter specialists
3.	Requirement analysis	Availability of mobile networks, connectivity, access to smart phone by end users, technical information requirements, modules, format of delivery, preferred platform and language.	Farm surveys using structured questionnaire and focus group discussions.

4.	System design	Modules and content: static/dynamic; end user access to app, login details, dashboard details, navigation details, module choosing, accessing the content and interacting with modules.	Flow chart analysis
5.	Coding	Translation of module content in to programming language and software instructions. Operating system - Android Studio Integrated Development Environment with Java language as back end score and the data bases were created through MySQL.	Data base creation and linking, Android application file formatting and computer programmes.
6.	Testing	Testing to recognize the gaps, errors and missing necessities *vis-à-vis* the actual requirements. Unit/module wise testing for its functionality, integration testing for connectivity of modules, programme testing for coding and the whole app testing to ensure the user requirements. Each module interface of the app was tested to ensure its proper functioning.	Content validation by domain subject matter specialists. Internal consistencies and validity of the modules evaluation with appropriate reliability tests.
7.	Implementation	Naming the mobile app "CIBA ShrimpApp" and display in the Google play store publisher for publication. Tutorial for end users.	Awareness / sensitization workshops; social media and online communication.
8.	Maintenance	Review of module contents for updation and modification, design and visual improvements.	Content review and updation analysis.

CIBA Shrimp KrishiApp: The farmer end-users preferred that a mobile application in which the farmer or the farm operator could enter his/her data on water quality parameters, feed requirements, feed rationing, feeding behavior and feed management, biomass estimation, animal behavior, pond conditions, average growth, body weight and economics of inputs. The application could include blocks of farmer specific details, farm specific information, crop specific information and day-to-day data entry register.

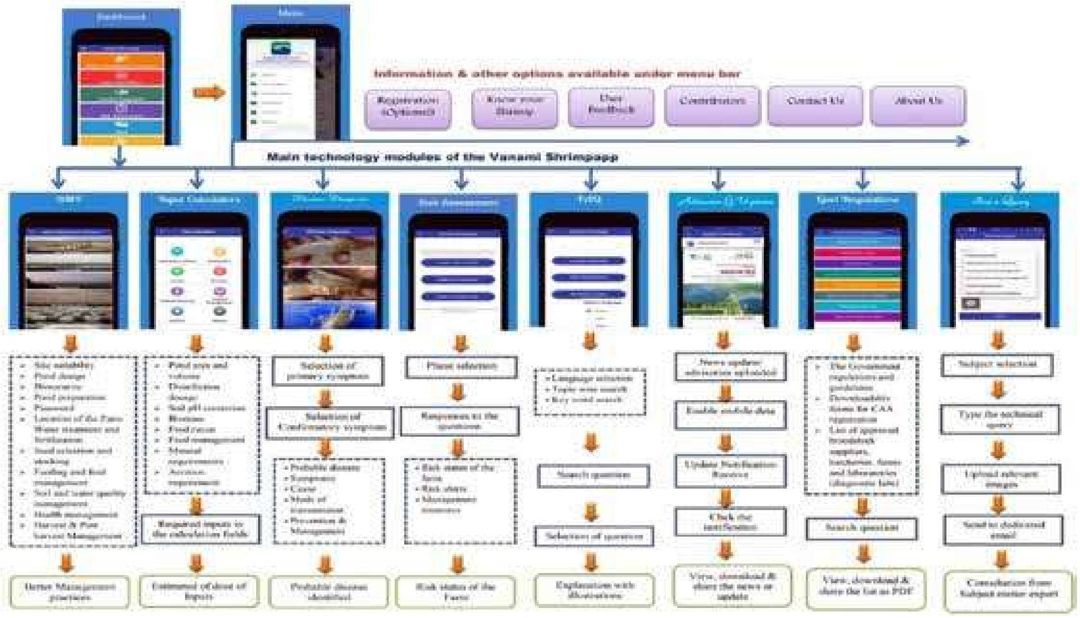

Fig 1: Framework for knowledge representation of CIBA ShrimpApp

The application should integrate the data from these components, process them and show inferences in the form of graphs or data matrices using that the farmer can visualize the status of his farming and might take decisions appropriately. It is intended that by using this application the farmer can forecast his inputs requirements and productivity. Such that we can pool the data from several farms and forecast the requirements and identify the shortfalls in every aspect monitored and alert the farmer to rectify the issue and take an appropriate decision. Therefore the second application CIBA Shrimp Krishi was developed. A frame work for the mobile application is developed for implementing a mobile application for shrimp farm management (Fig-2). The screen shots of the mobile application are presented as figures below.

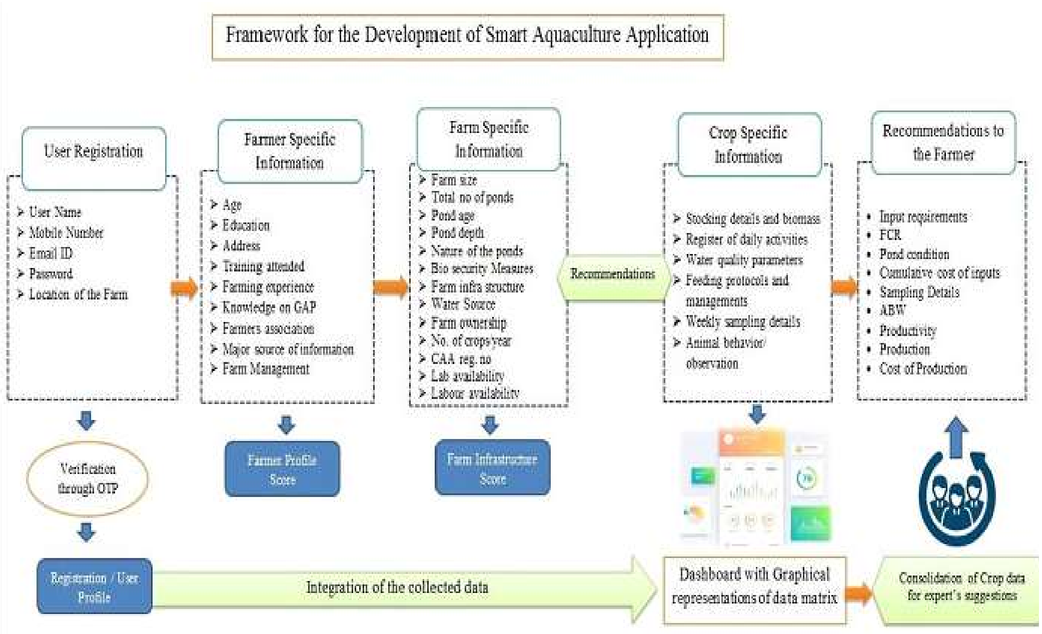

Fig 2: Framework for Mobile application for shrimp farm management

"CIBA Shrimp KrishiApp" was developed for handholding the farmers to make real- time based informed decisions at the farmer level. Front end was developed on Android platform SDK using Java programming language. This technology was used because it is portable to all android devices. Linux, Apache, MySQL and PHP tools were used for designing back-end. These tools are selected as they are open source, robust, and institute has the entire necessary infrastructure to store, manage and update the back-end content. The app size is 8 MB and it will work in Android version 5.0 and above. The app is made available in English, Hindi, Tamil and Telugu languages. Using this interactive mobile application, the farmer can input his farm data on day-to-day farming operations/observations from stocking to harvest. Based on the inputs provided and inbuilt decision-making system, the app will display pond-wise status on shrimp survival, biomass, feed conversion ratio, pond water quality, and the expenditure incurred.

Fig 3: CIBA ShrimpKrishi Mobile Application

Three expert systems viz., Shrimp feed management, water quality management and shrimp disease management are inbuilt in to the app. Based on the data fed in to the app, it Shrimp Krishi alerts the end-user farmer with technical advisories whenever any deviations are noted in the pond operational and critical day-to-day parameters such as water quality, feeding and shrimp health. The app can store the entire crop data in it, and the farmer can retrieve the data for their own long-term decision-making purposes or share it with their resource person for technical advice. Moreover, it paves the way for accessing real-time bulk data from the remotely located shrimp farms to monitor and extend customized technical advisories.

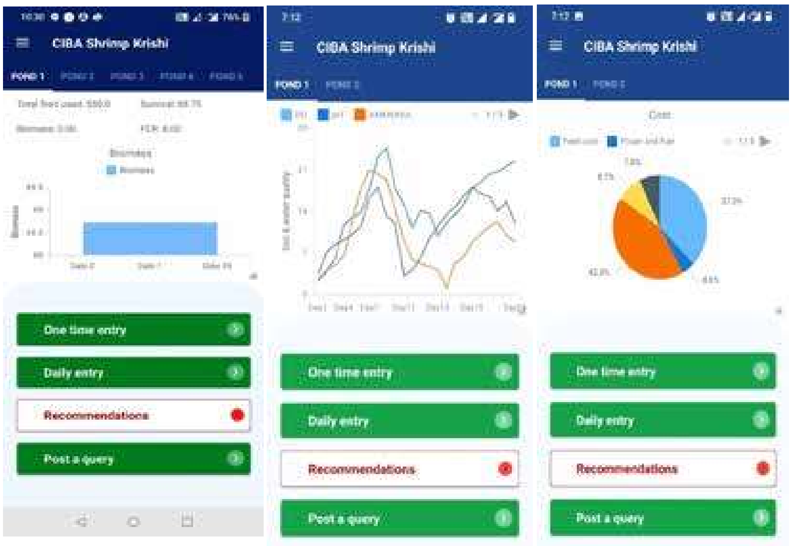

Fig 4: Graphical recommendations of shrimp pond parameters in the App

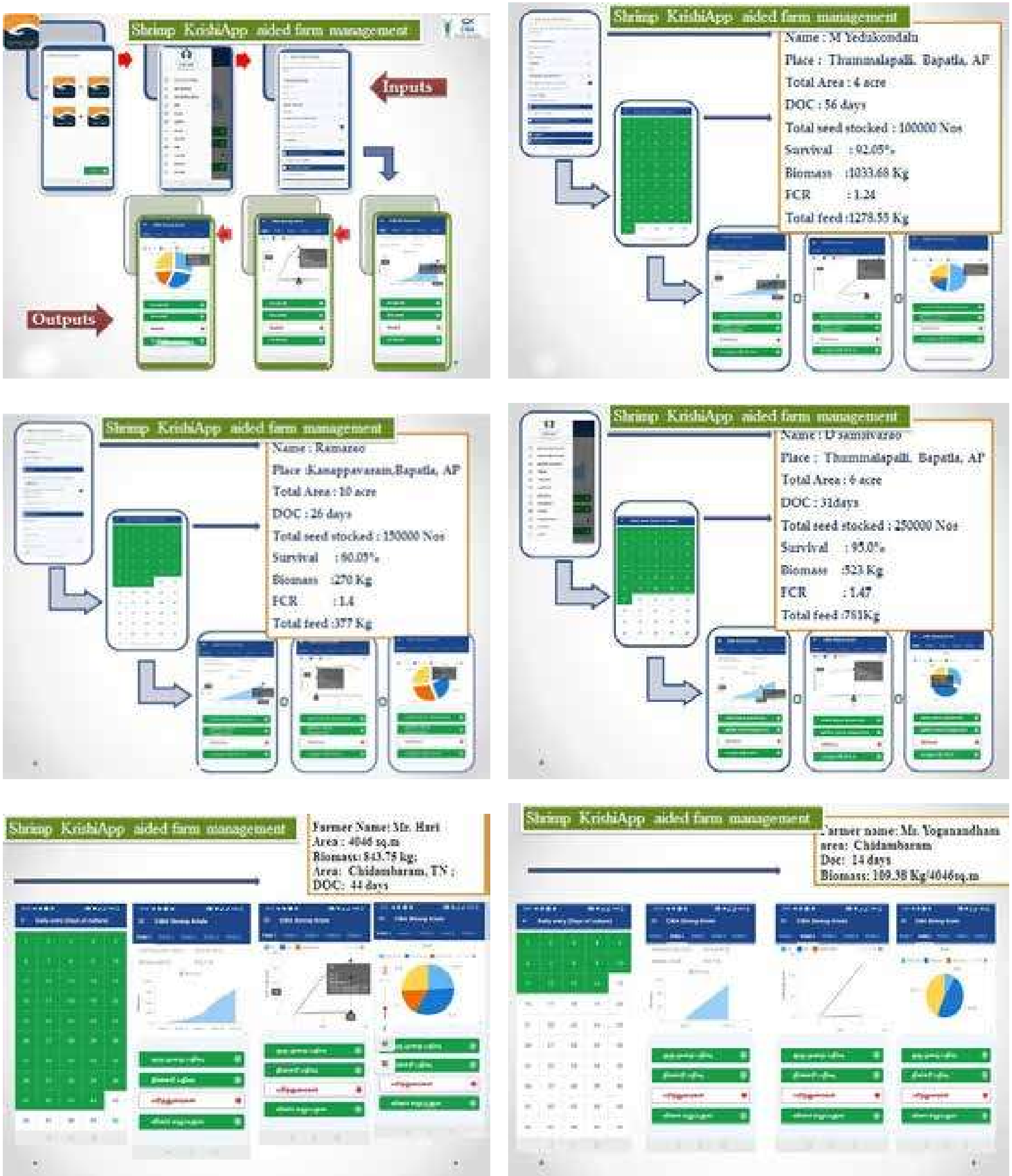

Fig 5: Successful adoption of CIBA Shrimp Krishi by the farmers

Impact of the mobile applications

The CIBA ShrimpApp has more than 27500 cumulative downloads across the world (Fig-5) and rated as 4.5 out of 5.0. The application was found to have improved the knowledge level of end users to the tune of 20-37%. The Google firebase application data showed that 98.4% of users of CIBA ShrimpApp were free from errors and crashes. Through post your Query option more than 5000 queries received and advisories were given the end-users (Fig-6). An evaluation study conducted among sample regular users indicated that the app aided in farm decision making and its design functionality and extension service function were perceived to be efficient. Considering pervading mobile connectivity and affordability of mobile phones, smart phone based mobile applications and data analytics would play a significant role in shrimp farm advisory services and its sustainability.

Fig 6. CIBA ShrimpApp users across countries

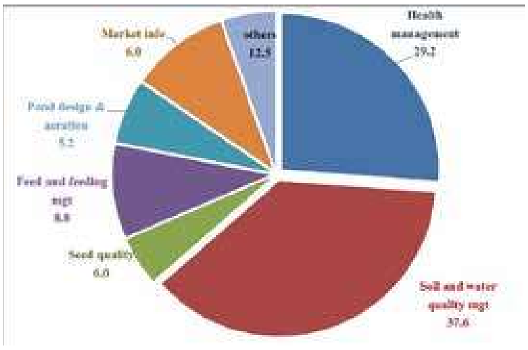

Fig 7: Subject matter wise queries ceived and answered through the app

Likewise the initial feedback from the end-user farmers on Shrimp Krishi indicated that the app is highly useful for efficient shrimp farm management by acquiring, storing and sharing the data, helped in inputs optimization, tool for farm traceability & certification, very handy as the app is in regional languages, facilitated the farmer in crop planning and helped efficient decision making based on real-time data. There are suggestions like convert the app in windows platform, wider sensitization and training to the end users for effective use of the tool by the farming community. An evaluation study conducted among sample regular users indicated that the app aided in farm decision making and its design functionality and extension service function were perceived to be efficient.

Conclusion

ICT aided tools are one of the means to enhance the capacity of the end users and have the potential to bridge the research- extension-farmer-inputs - market linkage gap. Evaluations and field feedback have shown that CIBA mobile applications are an important contribution to the shrimp farming sector and found effective in disseminating the technology information to the end users. The farmers and extension workers perceived mobile application as a potential tool for knowledge improvement and real-time data based shrimp farm management. Apps enabled the bidirectional flow of information between the research institution and end users in getting field feedback through receiving and answering queries. Considering the all-pervading mobile connectivity, mobile application based technology advisories play a major role in minimizing the information communication gap in shrimp aquaculture and it may speed up and enhance the quality of the farm extension services. However, the efficiency of mobile application for extension services would depend on constant updating of the modules based on field requirements and translation of the modules in vernacular languages. These mobile applications can be a tool to monitor shrimp farming operations by the institutions for traceability and adoption of better management practices by the farmers.

Scope for diversification with alternate species

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Introduction

Brackishwater aquaculture has been an age old practice in the traditional culture systems of India in the form of traditional prawn filtration systems *Pokkali fields* of Kerala, the *bheris* of West-Bengal, *Gheris* of Orissa, *Khar* lands of Karnataka and *Ghazni* fields of Goa. As early as 1911 James Hornell suggested the development of salt water fish farming in Madras Presidency which led to establishment of marine fish farm near Tuticorin by utilising few lagoons in the area and stocking mullets and sand whiting (*Mugil spp.* and *Sillago sp.*).. The prime brackishwater finfish species having high consumer preference and market demand in India include Asian seabass *Lates calcarifer* (Bloch, 1790), grey mullet *Mugil cephalus* (Linnaeus, 1758), milkfish *Chanos chanos* (Forsskal, 1775), pearlspot *Etroplus suratensis* (Bloch 1790), and red snapper *Lutjanus argentimuaculatus*. In the year 1997, a significant milestone achieved with respect to brackishwater finfish aquaculture in our country with the successful breeding of Asian seabass in captivity, at the Central Institute of Brackishwater Aquaculture. The R&D in seabass breeding thus led to the establishment of the first brackishwater/ marine finfish hatchery of our country located at MES, CIBA, Chennai.

Subsequently seabass hatching and rearing technology, developed by CIBA was transferred to Rajiv Gandhi Centre for Aquaculture (RGCA) during 1999-2000 (CIBA Annual Report 2000-01). The hatchery produced seeds are being produced and supplied to farmers, which is further spreading the seabass farming in country. Today private entrepreneurs are taking interest in the farming of seabass, and the demand for hatchery produced seeds of finfish species is on the rise, reflecting the increasing interest of brackishwater farmers in adopting seabass nursery rearing and farming technology. The year 2015 will go down in the history of Indian brackishwater aquaculture for another significant milestone achieved- the first successful captive breeding of the marine herbivorous fish species, the milkfish *Chanos chanos* by ICAR-CIBA. The herbivorous species forms the mainstay of brackishwater finfish aquaculture of many south- east Asian countries such as Indonesia and Philippines. Captive breeding followed by successful larval rearing and fry/fingerling production helped to conduct scientific milkfish farming in India. Successful results came from the efforts for transporting the batches of fertilized eggs of milkfish to private entrepreneur and the subsequent rearing of milkfish larvae to fry stage and its sale to growout farmers. CIBA has been successful in breeding and successfully developing farming models of the catfish *Mystus gulio* which commands good market value in the states such as Bengal.

The declaration of pearlspot, "Karimeen" as the state fish of Kerala in 2010 came as a boon to this indigenous cichlid which has been an important brackishwater food fish of Kerala, with great local demand with a market price in the range of Rs. 300 to 600/kg. The policy helped to lay a new focus on the species leading to the revival the aquaculture for improving the overall pearlspot production in the state. Grey mullet *Mugil cephalus* by virtue of occupying lower trophic levels of the food chain and at the same time having a high market value is a species of significance for sustainable aquaculture systems like the IMTA (Integrated Multi- trophic Aquaculture) and finfish polyculture. We are still reliant on wild seed resources for its aquaculture the availability of which is today getting limited due to deteriorating nursing grounds and emerging regulations on wild seed collection by states like Kerala. Hence ICAR-CIBA has laid high impetus on developing a technology for grey mullet captive seed production. Brackishwater ornamental aquariculture is also given a special focus and being developed as new area on account of its potential to play a significant role in providing livelihood to small scale farmers and Self Help Group's, by adopting the homestead rearing model. CIBA has bred spotted scat, *Scatophagus argus*, Moon fish *Monodactylus argenteus* for the first time in the country. Species such as orange chromide, crescent perch, pearlspot are also being developed as ornamental fish production models, suitable to get regular monthly incomes to farmers.

Brackishwater finfish species

1.1 Asian seabass, *Lates calcarifer*

Asian seabass is an important food fish in Indo-pacific region, most sought after candidate species for aquaculture in recent years and it has expanded as candidate species for cage culture and in the recirculating systems globally. Asian seabass *Lates calcarifer* is an euryhaline fish belongs to the family Centropomidae widely distributed in the Indo-West Pacific region, Arabian Gulf to China, Taiwan Province of China, Papua New Guinea and northern

Australia It is found throughout the northern part of Asia Southward, Queensland (Australia) West ward to East Africa ((Copland and Grey1987).

Taxonomy

Class : Actinopterygii

Order : Perciformes

Family : Latidae

Genus : *Lates*

Lates calcarifer is known as seabass in Asia and Barramundi in Australia and it has also been variously called as 'bhetki' in India.. For the first time in India, seabass was bred in captivity and successful larval rearing was done in 1997 which paved way for the large scale seed production and culture of seabass in India followed by year-round seed production by establishing recirculation aquaculture system. Hatchery production of seabass involves breeding of captive broodstock fish, rear fish larvae up to fingerling size with weaning feed. The hatchery technology includes, broodstock development, management, maturation, breeding, larval rearing, live feed culture and nursery rearing. Asian seabass is catadromous fish, grows in coastal low saline area migrate to sea for spawning, in the Sea many influential factor induces maturation and spawning process naturally. In captive broodstock, many times marine conditions may not prevail hence we have to induce maturation and spawning. The exogenous hormones are used to induce maturation and spawning, In CIBA, Luteinizing Hormone Releasing Hormone – analogue (LHRH-a) being used for maturation and spawning. For induction of maturation in the broodstock fishes reared for more than two years in the case of males and 3 years in females if found not matured, the hormonal pellet prepared with LHRH-a @50-100µg/kg implanted to prolong the gamete formation.

1.2 Milkfish, *Chanos chanos*

Milkfish *Chanos chanos*) is one of the most popular cultivable brackishwater finfishes in the south east Asian countries and widely distributed in the Indo-Pacific region. The maximum weight and age of this fish were reported as 14kg and 15 years respectively. In India, it is named as *Paal Meen* in Tamil, *Pala Bontha and Tulli Chepa* in Telugu, *Poomeen* in Malayalam, *Hoomeenu* in Kannada, *Golsi* in Goa and *Seba khainga* in Oriya. Being herbivore, milkfish feeds on plankton, benthic algae, detritus matter in the natural condition and easily accepts the pellet feed under culture condition. It can tolerate and live in extreme salinity ranging from 0-100 ppt but growth is optimal between 0.5-40 ppt. Milkfish can attain the table size weight from 400 to 500 gm in 5-6 months under culture condition. Milkfish having tiny bones resemble with Hilsa and can be considered as a '*Decan Hilsa*'. Milkfish can be produced in the farm with the production cost of Rs.80-90/kg by feeding with low protein pellet feed.

Kingdom	– Animalia
Phylum	– Chordata
Order	– Gonorynchiformes
Family	– Chanidae
Genus	– *Chanos*
Species	– *Chanos chanos*

ICAR-CIBA has made major breakthrough on captive breeding of milkfish for the first time in India during June 2015 and developed comprehensive technology package for seed production of milkfish. Captive breeding of milkfish involves development of land based captive broodstocks (6+ years old) and application of calculated dose of slow release hormone (LHRH- A) pellet. Hatchery produced seeds were distributed among farmers for promotion and demonstration of milkfish farming in coastal states. To educate the farmer community about this technology, routine trainings are being organized by ICAR-CIBA on need-based.

1.3 Grey mullet, *Mugil cephalus*

Mugil cephalus L. is cosmopolitan and contribute significantly to the economy of countries of Southeast Asia, Mediteranean region, Taiwan, Japan and Hawaii. This species is euryhaline and capable of surviving in wide variety of marine, estuarine and freshwater environments of varying turbidity, salinity and dissolved oxygen levels.

Taxonomy

Kingdom	: Animalia
Phylum	: Chordata
Class	: Teleostei
Order	: Mugiliformes
Family	: Mugilidae
Genus	: Mugil
Species	: Mugil cephalus
Common Name	: Striped Mullet, Grey Mullet

The species is recognized economically as an important food fish. The roe of the species is used to prepare “Bortaga cavier” a delicacy in Taiwan and Japan and hence referred to as “Grey gold”. In India grey mullet has good market in all the coastal states fetching between Rs 300-400 per kg. Grey mullet is situated at the base of the food chain and feeds on detritus and benthic micro-algae thus playing its significant ecological role as a converter of primary productivity, particulate organic matter and detritus into quality fish protein. The significant market demand, tolerance to wide salinity ranges and ability to utilize the herbivorous and detrital food chain qualifies it as an excellent candidate species for aquaculture. A quality broodstock forms the foundation stone of a breeding programme. Being a high value herbivorous species, grey mullet has high potential to contribute to the brackishwater aquaculture production. Considering the economic significance of the grey mullet, the major constraints affecting its development has to be addressed scientifically, especially with respect to seed production. ICAR-CIBA has also initiated captive seed production of grey mullet seeds are being produced at the fish hatchery of CIBA experimentally for the past three years during the annual breeding period. Few interested farmers were supplied with seeds for farming. Males of grey mullets mature between 250- 300 mm standard length while females mature at slightly larger size, 270- 350 mm. Males are reported to mature at approximately 2-3 years of size while females mature at 3-4 years. The stage of maturity in female fish is assessed by biosying the oocytes. This helps in judging the right stage of maturity and giving the appropriate hormonal treatment. Captive grey mullets found to possess an oocyte size about 80-90 µm were found to be in the primary oocyte stage, 110-120 µm in the slightly advanced stage of the primary oocyte, the perinuclear stage. Oocytes in the size range of 140- 150 µm were found to be in the cortical alveoli stage. Further, oocytes above 180 µm were seen to be vitellogenic. This stage is good for administering LHRHa implants for supporting oocyte development to functional maturity. In grey mullets, an ova diameter of 600 micro-m is reported to be optimum for successful induced spawning.

1.4 Mangrove red snapper, *Lutjanus argentimaculatus*

Mangrove Red Snapper *Lutjanus argentimaculatus* is an Indo-Pacific species that inhabits riverine, coastal and offshore reef habits. Juveniles and young adults found in mangrove estuaries and in the lower reaches of freshwater streams. They migrate offshore to deeper reef areas, sometimes penetrating to depths in excess of 100 m. The fish has greenish-brown to reddish body. Fishes that are found in deeper water have reddish body colour. Young fishes have eight whitish bars on the sides and 1-2 blue lines across the cheek. *L. argentimaculatus* has a slightly concave caudal fin and the scale rows on the back are roughly parallel to the lateral line. Habitat frequently consists of areas of abundant shelter in the form of caves or overhanging ledges. It feeds mainly on fishes and crustaceans. *L. argentimaculatus* is an important food and sport fish throughout the Indo-Pacific region, but never found in large quantities. They caught mainly with hand lines, bottom longlines and trawls. Aquaculture importance of this species has been well documented due to high demand in the international market.

Taxonomy

Phylum	- Chordata
Sub-phylum	- Vertebrata
Class	- Pisces
Sub-class	- Actinopterygii
Order	- Teleostei
Family	- Lutjanidae
Genus	- Lutjanus (Bloch 1790)

L. argentimaculatus can attain the maturity under pond/tank/cage based captive conditions when they maintained in the salinity regime of above 30 ppt. The fish can be induced to spawn through hormone (hCG) treatment. Lutjanus are broadcast spawner. Batch fecundity of this species estimated was around 5.0 lakh eggs/kg body weight. The size at first maturity for male and females reported were 2.5 and 3.9 kg respectively. The fertilized eggs size would be around 750µm and the newly hatched larvae size were between 1.6-1.75 mm. The larvae can reach to 2.0 cm fry size at 40 day post hatch by feeding with live feed such as rotifer Artemia nauplii followed by the artificial feed.

1.5 Pearlspot, *Etroplus suratensis*

Pearlspot, *Etroplus suratensis*, is a high value food fish popular in different coastal states of India; it is also finding market as an ornamental fish. Pearlspot is distributed in peninsular India and Sri Lanka. Its tolerance to wide range of salinities makes aquaculture of the species possible in both freshwaters and brackishwater bodies.

Taxonomy

Class	- Actinopterygii
Order	- Perciformes
Family	- Cichlidae
Genus	- Etroplus
Species	- suratensis

Being omnivorous in nature, aquaculture of pearlspot is relatively simple, economical and especially suitable for small scale aquaculture for supporting livelihood of fish-farmers. Pearlspot is extensively farmed in brackishwaters of Kerala has shown productions upto 1t/ha when cultured with milkfish and mullets. Traditionally pearlspot has been cultured in pokkali fields of Kerala along with other brackishwater fishes. Pearlspot has chiefly been cultured by farmers as a component of polyculture in brackishwater systems. Small scale cage based aquaculture experiments showed that stocking pearlspot @ 200 nos m^3 in 2 m net cages can give a production of 26 kg m^3 in 200-260 days using commercial feed (crude protein-20%). More recently with the support of the state fisheries department many farmers and Self-Help Groups (SHG's) in Kerala are involved in culture of pearlspot in small cage (2-3 m^3) and pond systems. However, one of the major limiting factors for expansion of pearlspot aquaculture is inadequate availability of seed for stocking in different culture systems. Pearlspot exhibits a high degree of parental care and has very low fecundity as compared to other brackishwater fishes. These are the main reasons which makes mass scale seed production of the fish challenging. Hence development of technologies which allow seed production at multiple locations in the form of backyard hatcheries or small scale seed production systems is important. However, the fish is easier to breed compared to many other brackishwater fish and today different models in a range of systems are available or being tested, so that seed production can be conducted by entrepreneurs, Self- Help Groups or farmers themselves depending on their local resources.

1.6 Long whisker catfish, *Mystus gulio*

The long whiskers catfish, *Mystus gulio*, belongs to the family Bagridae is a euryhaline fish, which is commonly called as nona tengra in Bengali. *M. gulio* is commercially important estuarine catfish of Sunderban delta of Bangladesh and India. It has also market value in state of Andhra Pradesh and Odisha. It is a small indigenous fish species (SIS), having high nutritional value. The domestic market price of *M. gulio* is very high and ranges from 200-700 Kg-1. The important attributes such as high nutritional value, consumer demand, high market price, hardy nature and faster growth make this species a desirable candidate species for aquaculture in Southeast Asia. Due to euryhaline nature this fish can be breed and farmed in both fresh and brackishwater environments. This species is suitable for co-cultured with other brackishwater fishes in paddy fields and bheris of the Sunderban. This fish can also be farmed at high densities in cage and Recirculatory Aquaculture System (RAS). Expansion of *M. gulio* is stumbled because of the unavailability large quantity of hatchery produced seeds. In this connection, Kakdwip Research Centre of ICAR-Central Institute of Brackishwater Aquaculture, West Bengal, India has developed and popularized a cost effective, farmers-friendly seed production and farming technology of *M. gulio*.

Taxonomy

Class	: Actinopterygii
Order	: Siluriformes
Family	: Bagridae
Genus	: *Mystus*
Species	: *M. gulio*

During the spawning season, mature *M. gulio* are collected from the broodstock ponds. An ovarian biopsy of the female is performed to assess maturity. However, without ovarian biopsy, maturity can be judged through morphological observation of vent; a swollen belly and swollen reddish vent indicates maturity. Mature males can be identified by the presence of elongated papillae with a pinkish tip. Generally, females and males in the size range of 60-120 g and 25-75 g, respectively, are selected for breeding. The operational sex ratio of males and females is 2:1. A single intramuscular injection of either human chorionic gonadotropin (HCG), leutinizing releasing hormone (LHRHa) can be used to induce the fish to spawn.

Brackishwater Finfish aquaculture- The Present Scenario

Asian seabass has been mooted as a prime candidate for diversification to finfishes on account of its high market demand (Rs.400-600 per kg), and availability of hatchery produced seed and formulated extruded feeds. Globally seabass is cultured in different culture systems like cage, ponds, pens and tanks showing the adaptability of the fish to the different culture methods. In India seabass is primarily cultured in brackishwater pond systems where it exhibits growth rates ranging from 800g-1.0 kg in a period of

6-8 months Partial harvesting of larger fish is carried out periodically in this extensive farming practice. Monoculture of seabass is practiced at stocking densities of 4000 to 5000 nos/ha^{-1} (initial wt.-60-80 g) and a production of 3.5 to 4.0 t ha^{-1} can be achieved. The cost of production is around Rs. 175-225/kg at a fish sale price of Rs 350-400. To develop a holistic model of seabass culture, a formulated seabass feed, 'Seabass Plus' has been developed by CIBA for nursery and growout culture which gives an FCR of around 1.5. Presently, seabass is considered as one of the most potential finfish aquaculture candidates for those looking for diversification from shrimp culture.

Herbivorous species form the backbone of sustainable fish farming models due to the lower cost of production- milkfish, grey mullets and pearlspot have been traditionally cultured by enhancing the ponds natural productivity and through low cost supplementary feeding using agro-by-products. CIBA's effort on the seed production of these fish species bore fruit with the captive breeding of milkfish at its Muttukadu Experimental Station (MES). Today hatchery produced milkfish seeds distributed to brackishwater farmers across the country are being cultured using growout formulated feeds specially developed for milkfish. Interventions in parental care of pearlspot has assured enhanced seed production and given rise to a modular tank based system for seed production for adoption by small scale farmers.

Novel finfish farming technologies being given key focus by CIBA

In keeping with its slogan "Brackishwater aquaculture for food employment and prosperity", icar-CIBA recognizes that brackishwater aquaculture is a powerful tool to bolster livelihood and nutritional security. Hence, focus has been placed by CIBA to develop location specific need based models for different stakeholders.

i) **Satellite based nursery rearing of seabass -** One of the interesting innovative approaches adopted by CIBA for developing seabass as a separate livelihood activity is the hapa based nursery rearing model where hatchery reared fry are cultured for a duration of about 60-75 days to fingerlings size. This model is being mooted both as a livelihood activity for farmers for giving returns in a short duration and also for developing satellite seabass seed rearing centres to facilitate widespread adoption of seabass aquaculture. This helps in saving space and time during the grow-out culture of seabass and helps farmers to tide over the phase which requires physical labour for frequent size grading of the fry. Adoption of nursery rearing of seabass fry by farmers involved in low volume cage culture of Asian seabass *Lates calcarifer* is encouraged by ICAR-CIBA. The activity helps farmers get a better control over the initial size used for stocking in cages, a factor critical for getting optimum survival rates and fish production.

ii) **Low volume cage culture -** The access of small scale farmers to diverse opportunities offered by different aquaculture initiatives is often limited by ownership or access to water resources, access to simple and adoptable technology and high investment costs. Production of high value fish using low volume cages set in brackishwater bodies can thus be a potential livelihood option to the poor. Low volume cages can be fabricated by the farmers themselves. Species like seabass stocked at rates of 25 advanced fingerlings/r cubic-m has shown to yield a production upto $20kgm^{-3}$. For example, in a demonstration using 3 cage units of 8 m^3 each, a production between 450-500 kg of seabass was obtained partial harvest of the fish from the cages can thus provide the family with sustained monthly income of Rs 10,000-15,000 by sale of the fish at Rs 400/kg. Construction and setting up of these low volume cages is also being mooted as a skill development activity for small farmers.

iii) **Integrated Multi-Trophic Aquaculture (IMTA) -** IMTA is the farming of aquaculture species from different trophic levels and with complimentary ecosystem function. For laying a roadmap for sustainable aquaculture, CIBA is developing economical polyculture models and adopting IMTA (Integrated Multi-Trophic Aquaculture) approach. These models have been successfully demonstrated at Kakwdip, West Bengal and Sindhudurg, Maharastra with farmers participation. The benefit cost ratio of pond based IMTA was worked out to be 1.5 as compared to 1.4 in monoculture of shrimps at the culture demonstrated at Sindhudurg district of Maharastra. Culture demonstrations at Kakwdip centre of ICAR-CIBA has shown the environmental and economical benefits of IMTA over conventional culture practices.

iv) **Finfish seed production from egg stage –** Realising the need for elaborate investment and infrastructure for maintenance of broodstocks of finfishes, private entrepreneurs are encouraged to transport fertilized eggs for hatching and subsequent larval rearing in their hatcheries. This model has been successfully adopted in case of candidate species like seabass and milkfish by private entrepreneurs.

v) **Ornamental fish seed rearing as a household activity -** CIBA is mooting the adoption of nursery rearing of ornamental fish like silver moony, spotted scat orange chromide and pearlspot as an activity to be adopted at household levels for getting regular monthly income. As a part of the Mera Gaon Mera Gaurav program of CIBA, pearlspot nursery rearing as a livelihood activity is being successfully adopted by tribal women groups.

Way forward for brackishwater finfish aquaculture development and CIBA's interventions CIBA has placed a major thrust on developing economically viable seed production technologies of the prime brackishwater candidate species. The development of hatchery technologies are also being followed by partnership with entrepreneurs for facilitating technology adoption in different states in PPP mode, this is witnessed in the partnerships both for shrimp and finfish species. There is a need of private sector hatcheries for scaling up of seed production for catering to the increasing demand of fish seed among brackishwater fish farmers. For the development of large scale economical finfish aquaculture practices, development of efficient, eco-friendly and low cost feeds is perceived as the next major challenge. CIBA has developed feeds for Asian seabass and other major species are being tested. By entering into partnerships CIBA is also facilitating the development of feed mills and developing feeds for different brackishwater food fish and ornamental species. Considering the significance of aquaculture as a tool to alleviate poverty, provide livelihood and nutritional security, CIBA lays a major thrust on developing family farming models for widespread adoption in different states.

Thrust is also being laid for developing suitable marketing models for getting the best price for the farmer.

The aquaculture industry in the inland saline waters needs an ecological mapping of salt affected areas (including salinity, composition) for development of region-specific aquaculture practices. Introduction of low-cost, low-risk species for sustainable development of inland saline water aquaculture, with special reference to small and poorer farmers is need of the hour. Establishment of a National Aquaculture Network and

Public Private Partnerships (PPP) to ensure the supply of inputs like seed, feed and others, and support for marketing, processing and exports to non-coastal states. Development of production skills and farming clusters, promoting support groups, cooperatives and contractual farming under strict biosecurity monitoring and regulatory governance for the development of brackishwater finfish aquaculture in the inland saline areas. CIBA visualizes and strives for a holistic sustainable development of the brackishwater aquaculture sector of India with an underlying thrust on sustainability, economic viability and livelihood provision. For this CIBA reaches out for active partnerships with the state government, the private sector, other research organisations and Self-Help-Groups to develop and advance the brackishwater aquaculture technologies for the betterment of the farming sector. Species diversification in aquaculture and developing need based location specific technologies is the best roadmap for sustainable aquaculture sector for our country.

Economic impact of diseases in Indian shrimp production and role of insurance

P.K.Patil and R.Geetha

Indian shrimp trade in the international market accounts for almost 25% and India is the leading supplier of shrimp to the US and second largest to the European Union. Shrimp farming contributes to the economic growth and provides significant employment opportunities. Introduction of specific pathogen free (SPF) Pacific white shrimp, *Penaeus vannamei* in 2009, establishment of Aquaculture Quarantine Facility (AQF) and screening imported broodstock for OIE listed diseases have led to substantial improvement in shrimp health and production. Strict adherence to the biosecurity measures and implementation of better management practices have helped to achieve economic sustainability of the sector.

However, a recent report on global aquaculture developments over the past two decades identified diseases, suboptimal feed efficiency and climate change as major challenges to the sector's sustainable growth. Diseases are expected to influence the future of global aquaculture production and supply, which will affect nutritional security and livelihood. Indian shrimp farming face major diseases threats due to microsporidial infection, *Enterocytozoon hepatopenaei* (EHP), viral infection, white spot diseases and bacterial infection vibriosis. In EHP, affected shrimps suffer significant growth retardation and low level mortality during the culture period, since most of the times farmers fail to notice the disease, continue to feed and provide inputs as usual, leading to substantial economic loss. Similarly, in White spot syndrome virus (WSSV) outbreaks, widespread mortality leads to complete loss of crop in 7 to 9 days. However, in case of vibriosis, the low levels of under current mortality and reduction in growth leads to losses to the farmers. At the farm level, the economic cost of disease could be direct due to loss of stock and expenditures on control and management of infection. However at industry level the indirect cost leading to loss of employment in upstream (hatcheries, feed mills, etc.) and downstream (processing exports, etc.) enterprises and the consequent loss to the exchequer.

Generally the economic loss due to diseases in aquaculture farms is calculated based on the difference between expected and actual production. Studies have observed occurrence of diseases like, EHP, WSSV and vibriosis in major shrimp farming areas of

India, Tamil Nadu, Andhra Pradesh and Gujarat. However, in the state of West Bengal WSSV was the most common diseases due to the general practice of low level biosecurity as the farmers in these regions are following traditional farming. Since, the farmers continued to feed the ponds affected by EHP and in the absence of evident mortality, shrimp consumed feed poorly and suffered stunted growth. Whereas significant costs of feed are saved with WSD since mortalities are rapid, farmers are aware and terminate crops by emergency harvest. Hence the loss of productivity (t ha^{-1} $crop^{-1}$) is always higher in WSSV affected farms while the total loss of revenue is high in EHP affected farms.

Due to the farm intensification and the area under cultivation stressing carrying capacity of the water bodies the economic loss to the farmers of Andhra Pradesh was higher compared to other states. It has been observed that generally farms in the west coast practice lower stocking density and longer culture period compared to rest of the country. Though economic loss was found to be inversely proportional to stocking density, scientific pond preparation, testing seeds before stocking could help overcome losses due to diseases in the farming.

In one of our recent studies, we have estimated annual production loss due to shrimp diseases as 0.21 lakh tons worth US$ 1.02 billion in addition to the employment loss of 1.65 million man-days. Outbreaks of diseases in the surrounding area was the major factor determining the intensity of the disease while bulk of the financial burden was attributed to expenditure incurred on account of steps taken to contain the infectious agents from spreading. Further, cessation of farming activity due to disease outbreaks leading to emergency harvest causes loss of employment.

In our study the estimated economic loss mainly comprised of direct loss as management measure to control EHP and WSSV was mainly the implementation of BMPs which is mandatory in India in *P. vannamei* farming. The observation suggested that the regular occurrence of EHP and WSD led to the severe reduction in production followed by reduced stocking densities in future crops. Steps taken to reduce the severity and spread of diseases through application of disinfectants and other antimicrobial agents could further add to the cost of production. Distress harvest during the disease outbreaks leading the discharge of large quantities of pond water containing the pathogen loads further enhances the chances of spread of WSSV. While EHP spores are highly resistant to harsh environmental exposures; introduction of the pathogen into the farm would result in continuous build-up in the system.

The economic impact assessment of diseases in shrimp farming is vital for appropriate investment in disease control programs. EHP and WSSV are the major diseases in Indian shrimp farming causing substantial economic losses and the consequent loss of employment. Revenue loss by EHP alone was more than two times than that of WSSV contributing more than half of the national economic loss due to diseases. While disease surveillance should be continuous program, implementation of better management practices would help in reducing the loss of production and minimize the economic losses. Reduction in economic loss could be achieved through region specific increase in stocking density and culture period and targeting for higher average body weight at harvest. Prioritizing the research especially application of artificial intelligence in disease forecasting and implementation of required policy interventions are warranted for the economic viability of the sector.

The direct cost of disease includes loss of stock and expenditure towards prophylactic and therapeutic measures, while indirect cost may include employment lost in upper (hatcheries, nursery, feed mills, chemical and healthcare manufacture, etc.) and lower (processing, marketing, exports) production lines, contributing significant loss to the exchequer.

Diseases impose yield-limiting effects and continue to be the primary cause of production and economic loss, adversely impacting the income of the producers and supply chain operators. Disease outbreaks have significant economic impacts on the aquaculture industry. Outbreaks led to direct losses from mortality and reduced productivity, as well as indirect losses due to trade restrictions and increased production costs.

We have observed in our recent survey that the loss due to disease are under control due to the effective management of disease through increased awareness among the farmers, amendments in farming practices (improved pond preparation, reduced stocking density, feed and harvest management) in addition to the availability of improved diagnostic services and commercial healthcare formulations containing phytochemicals, probiotics and other microbial products which offered considerable success.

In general, the occurrence of diseases could be controlled through the implementation of comprehensive disease control activities, including better management practices, stocking quality (PCR-tested negative seeds (especially in shrimp), reducing the stress by adjusting stocking densities and maintaining the farm environmental parameters within optimum ranges, and use of quality feed. The exponential growth of aquaculture could partially attribute to application of veterinary medicinal products and other chemicals for managing the health of cultured animals and the farm environment. We have observed that the application of chemicals, in-feed administration of immunostimulants, natural antimicrobial agents, and nutritional supplements effectively reduced the disease incidence despite significant variations in their efficacy. The beneficial effects of probiotics in improving overall fish health and immunity have been documented. Earlier, we have noticed the higher use of chemicals for maintaining optimal environmental quality and in-feed administration of probiotics, disinfectants, and nutritional supplements in Indian shrimp farming operations. Additionally, stocking density, survival, and productivity play an important role in the occurrence of diseases. These suggested guidelines help farmers in making decisions regarding production strategies, resource allocation, and market planning. Also, accurate predictions and prediction-based guidelines enhance farm efficiency, financial management on the use of inputs, risk assessment on disease loss and biological loss, increasing the profitability of farming.

Role of shrimp crop insurance

In view of these losses due to infectious diseases, the policy of crop insurance to the Indian shrimp farmers is a great opportunity. The policy is expected to cover the major infectious diseases mentioned here in addition to the abiotic stress due to environment issues. The economic sustainability of the sector can be ensured through these insurance policies. Additionally, the step also bring confidence among the bankers for credit services to the shrimp farmers. Since the shrimp is an internationally traded commodity, it is imperative to support the farmers through required risk covering and the credit supply.This helps the farmers to adopt the global standards in production and processing generating confidence among the international traders and consumer in the destination countries.

Conclusion

Diseases like, EHP, WSD and vibriosis are the major economic constraints, while expenses on prophylactics, therapeutics, and biological loss of crop were the key components of economic burden to the Indian aquaculture. Based on predictions, reorienting the expenditure on prophylactic and therapeutic agents, awareness programs, quality diagnostic services, developing guidelines for the scientific use of healthcare products, and implementing targeted disease control programs could help reduce the losses. Further efforts are necessary to address the identified determinants of the diseases to improve production, revenue, and profit from aquaculture, thereby strengthening food security. Covering the risk through proper insurance policies will help the sector for its economic stability and to maintain international trade dominance.

Survey and loss assessment for shrimp crop insurance

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Indian shrimp farming scenario

Indian shrimp farming is in vogue since last three centuries. The low input low output style of closed economic activity within small regions grew as major export activity since 1990s after concerted efforts by the Government of India through its various agencies like ICAR, MPEDA, State Fisheries Departments, EIA and host of many other organizations and line departments. Species wise three major species viz., white shrimp (*Penaeus vannamei*), tiger shrimp (Penaeus monodon), and freshwater prawn (*Macrobrachium .rosenbergii*) form the major portion of production and exports from India. Very little quantity of shrimps of other species from capture and traditional culture are also available for domestic consumption and exports.

Indian shrimp aquaculture produces more than eight lakh tons shrimp valued at Rs. 40000 crores in the last couple of years. Shrimp is large foreign exchange earner after basmati rice exports. More than 1.7 lakh ha is under shrimp culture in remote coastal rural areas. More than a million people are employed in areas of limited entrepreneurial avenues. Though export market performance is based on trade relations and trade balances, USA(42%), China (25%), Europe and Middle East along with Vietnam are our important export destinations. Our domestic market also consume 70,000 to 100000 tons per year, mostly sold by farmers who do multiple harvest from 100 counts and distress harvests on incidence of diseases.

The top six countries of shrimp production by volume wise are Ecuador, India, China, Vietnam, Indonesia and Thailand. Major shrimp exporting countries are Ecuador, India, Vietnam, Indonesia, China, and Thailand. Major shrimp consumption centres are the United States, Europe- Spain and France, China and Japan. The present production and consumption pattern makes the south and east parts of globe producing shrimp for meeting the demand of affluent western countries

Scope for shrimp crop insurance

Shrimp aquaculture is labelled as “risky venture” by the finance professionals and due to this, credit and insurance institutions are cautious to take up business in shrimp crop sector. Contrary to this prejudice, India has earned Rs. 42,706 crores in 2021-22 from shrimp exports, which was only Rs. 9912 crores in 2009-10 – 430% growth in 12 years - which explains the overall profitability, growth and stability of shrimp culture. Advances in the scientific technology coupled with stringent regulations imposed on aquaculture have made this giant leap possible.

Advantage of SPF vannamei culture

Though India is one among the major shrimp producer and exporter for the last few decades, introduction of exotic SPF vannamei has put indian shrimp farmers in an advantageous position due to the following:

- Provision of SPF (Specific pathogen free) Seeds
- Development of Better Management Practices and Bio security protocols
- High volume of production of vannamei shrimp
- Easy marketability of vannamei shrimp
- Apart from the above farmers venture into nursery farming, bio floc based farming and lined ponds for better control and management of shrimp production.

Total Shrimp (Tiger, *L.vannamei* & Scampi) Production

Both these shrimps together constitute the bulk of Indian shrimp and Marine products export. The state of Andhra Pradesh is the largest shrimp producing state from aquaculture.

Table.1. Total Shrimp (Tiger, *L.vannamei* & Scampi) Production in 2020-21

S.No	State	Area Utilized	Production (Mt)	Productivity t/ha
1	Andhra Pradesh	74512	639896	8588
2	Gujarat	9021	50526	5601
3	Tamil Nadu	8630	44816	5193
4	West Bengal	50844	54582	1074
5	Orissa	11200	44555	3978
6	Maharashtra	1183	4204	3554
7	Karnataka & Goa	3145	3185	1013

8	Kerala	2971	1868	629
	Total	166722	843633	5060

Majority of the aquaculture farmers are small farmers, own 2-3 ponds and face huge obstacles to raise working capital for the crop, due to lack of access to institutional credit and insurance. The loss of one crop due to natural calamities or viral diseases make the farmers fall into deep debts as they are to repay the loans taken for the crop and also raise money for next crop season.

Insurance operation across the shrimp value chain

The insurance and government support across the shrimp value chain is depicted in the table.1. we can see right from input supply systems to shrimp consumers all are given different options for availing insurance cover and government or institutional support system. Only shrimp farmers lack crop insurance or any direct government support .

Table.2. Insurance operation across the shrimp value chain

	Input system	Farmers	Markets	Processing	Exporters	Consumers
Items/Actors	Seed, Feed Other inputs Brooders & Fish meal	Land Ponds Infrastructure Labour Credit	Aggregator; wholesaler ; Commission agents Retailers Vendors	HACCP Food Safety	Trade issues SPS/ Non SPS rejections; International relations; Exchange rate	Quality Hygiene Value for money
Insurables	Hatchery Indigenous feed mills Aerators/ motor/ Genset producers	Shrimp Nursery Farm	Fish cold chain Marketing infrastructure (yards, vehicles)	HACCP for hygiene Antibiotics free products Anti dumping		

Govt. Support & Insurance	Fire/ factory Insurance & other Nat cat cover Fisherman Insurance (with State subsidy)	1.Flood/Fire/ Motor /Bund insurance – rarely taken 2. No Crop Insurance	1.Business insurance 2.Govt. support	Freight insurance Merchandise Exports from India Scheme MEIS (Budger Rs. 2000 crores)- replaced w.e.f. 1.1.2021. Remission of Duties and Taxes on Exported Products (RoDTEP) - refund the embedded duties	1.Mediclaim 2.Health cover support from employers

The NFDB has proposed to subsidize the insurance premium to certain extent, and the scheme is yet to reach the farmers in practice. Though a couple of insurance companies have aquaculture crop insurance schemes in their kitty of insurance products, the extent of actual farm coverage is negligible. They are to go a long way to make an impact in risk coverage as desired by the aquaculture farmers due to many practical issues. However, though insurance coverage is essential for small farmers and bankers are willing to finance the aquaculture sector in India.

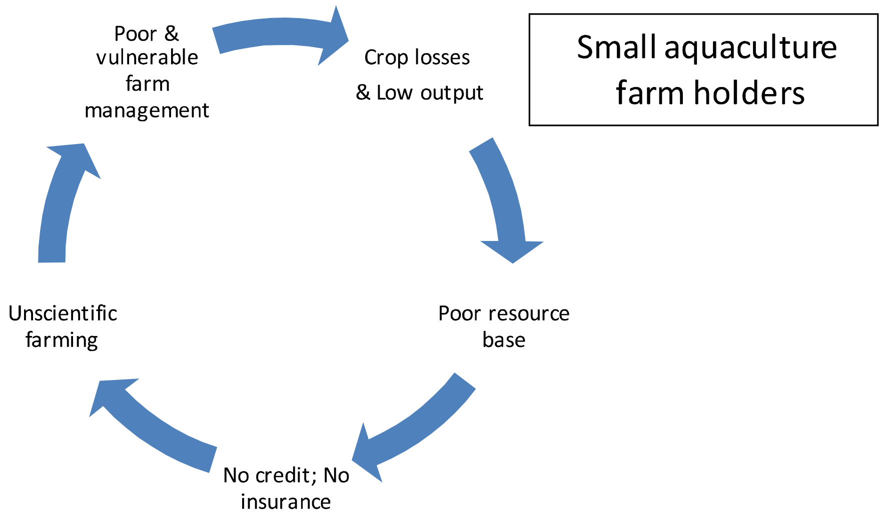

Fig. 1. Vicious cycle of inefficient small farm aquaculture

Market estimates for shrimp crop insurance

As evidenced from Table 1 on area and production of shrimps in India, we can draw the following inferences:

- AP, Gujarat & TN produce 88% of Indian vannamei shrimps.
- Insurance market size= Premium rate (Average input costs *Crop area (ha))/100
- Range of insurance market size estimate for 1% to 4% of total input costs
- 150 to 601 crores in INR p.a. (20 to 40 Million USD)

Table.3. Market size of shrimp crop insurance premium

Farming area	ha	1,00,206
Average Input costs	in INR	15,00,000
Total turn over	in INR	1,50,30,90,00,000
Premium rate	1%	150,30,90,000
	2%	300,61,80,000
	3%	450,92,70,000
	4%	601,23,60,000

Based on the statistics of shrimp production in 2020-21 (MPEDA, 2022) it is estimated Rs 750 crores per year as the business potential of shrimp crop insurance premium. Micro credit requirement is also estimated over Rs. 13,000 crores per annum, which is now being serviced by informal creditors at higher interest rates. A paradoxical situation exists with loss of profitable business to banks and insurance companies on one side, hardships of farmers with minimal access to credit and insurance on the other side. Bringing back access to insurance and institutional credit will help the in Doubling Farmers' Income in much faster time frame.

Table.4. Estimate of insurance premium and micro credit market of shrimp farming in India

S. No	State	Area ha (A)	Production MT (P)	Productivity kg/ha (Y)	Cost of production per ha @230 /kg vannamei	Value of Premium market segment @2% Rs. Crores	Value of Premium value market segment @4 Rs. Crores	State requirement of micro credit @ 70% scale of finance on input cost Rs. Crores
Vannamei shrimp ; Cost of production is Rs. 230/kg								
1	Andhra Pradesh	71921	634672	8.82	2029651	291.95	583.90	10,218.22
2	Tamil Nadu	8600	44735	5.20	1196401	20.58	41.16	720.23
3	Gujarat	8986	50410	5.61	1290263	23.19	46.38	811.60
4	Others	8600	44735	5.20	1196401	20.58	41.16	720.23
5	Total	108526	815745	7.52	1728815	375.24	750.49	13,133.49
Tiger shrimp; Cost of production Rs.250/kg								
1	West Bengal	50000	19190	0.38	95950	9.60	19.19	335.83
2	Kerala	2813.85	1128.98	0.40	100306	0.56	1.13	19.76
3	Andhra Pradesh	2591	5222	2.02	503860	2.61	5.22	91.39
4	Karnataka	2175	1000	0.46	114943	0.50	1.00	17.50
5	Others	616.15	1075.02	1.74	436184	0.54	1.08	18.81
	Total	58196	27616	0.47	118634	13.81	27.62	483.28

Base data: MPEDA,2022. www.mpeda.gov.in

There are several constraints, as detailed below both to farmers and insurance companies in taking up and providing insurance schemes for aquaculture in India.

Problems faced by aquafarmers as insured policy holders

The farmers in general are of the sentiment the government should provide insurance cover free of cost as they contribute to national income in a significant manner. The pain points enumerated by farmers are:

1. Expensive premium rates (6-10%) demanded by insurance companies.
2. The unilateral discontinuance of insurance cover after a crop failure by the insurance companies as happened after the golden period of growth (1990-1994).
3. The cumbersome documentation and 'small print' of terms and conditions and a massive list of exclusions "named perils".
4. Practical difficulties of notifying insurance companies on emergency harvest situations.

General concerns of Insurers

Insurance companies still are unable to come out of barrage of indemnity claims received from shrimp farmers during 1995-97, which led to exit of insurance companies from shrimp crop insurance segment. The other technical issues of them are the following:

1. Scarcity of fisheries professionals in insurance companies and poor understanding of modern aquaculture systems and practices by generalists.
2. Worries about falsified claims.
3. Fear of huge losses in an epidemic/ new disease attack.
4. Workforce requirement and expenses burden of premium collection from a large number of farmers across the country.

Important target risks/perils in Indian shrimp farming-Farmer's interest

ICAR-CIBA has been conducting several farmers interactions and focus group discussions with shrimp farmers on risk under different project activities for the last 20 years. The essence of farmer's interest on shrimp farming risks are as follows:

1. Risks and score in the rank of 1-10

- Viral diseases (9) -Complete loss
- Parasitic infection like EHP/ Running Mortality Syndrom (RMS)-(9) Partial loss
- Price (8)
- Policy (6)

2. Uncertainities

- Adverse weather (7)
- Floods, cyclones other Natural calamities(7)
- Geo political conditions (6)
- Pandemic (4)
- Progressive costs and returns of shrimp farming

The progressive costs and returns, increase from day one upwards and the breakeven between cumulative progressive costs and salvage (saleable value) is attained at 60 days of culture on an average. Hence farmers' loss will be total if crop fails due to viral disease earlier than 60 DOC. After 60 DOC, farmer gets some salvage value to offset the loss at least to the extent of costs spent on inputs till date.

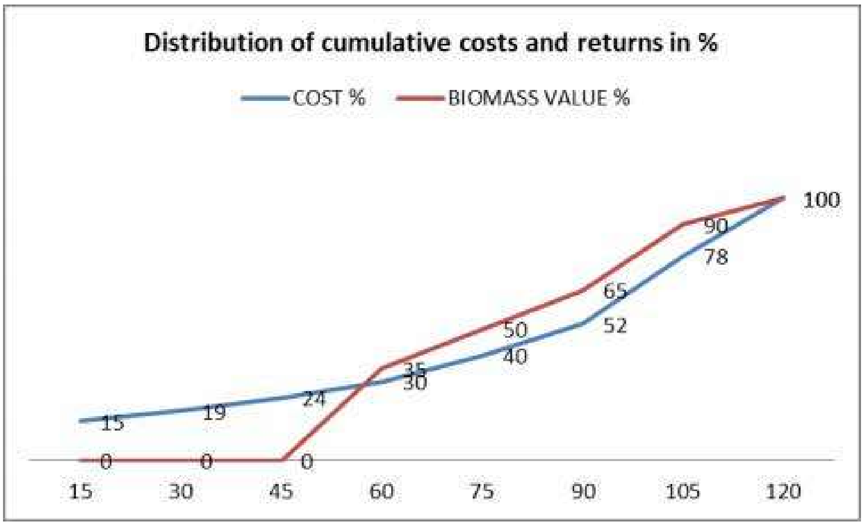

Fig 2: Distribution of cumulative costs and returns in %

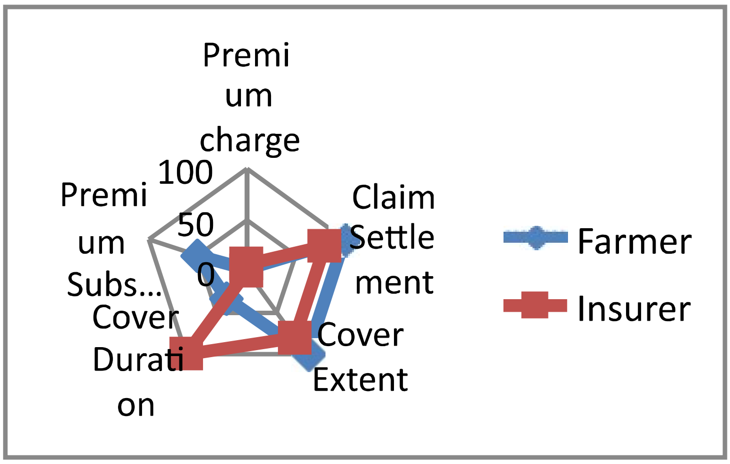

Fig 3: Progressive costs and returns of shrimp farming

Farmers perspective on Insurance

- Coverage for lesser period (40 to 75 days Max);
- Full cover
- Full claim
- At least 50% government subsidy from Govt

Main Contradicting points

- Cover duration (45 to 60 Vs Full crop)
- Premium rate (>2%).
- Indemnity 80% vs 100%

Capital formation is >Rs.15,000 lakh crores in Ponds, aerators, generators and other items. Shrimp aquaculture needs minimum of Rs.10,000 to 25,000 crores credit per annum. Internal Rate of Return is very high (>65%) in aquaculture projects. Recovery is easy compared to other sector loans.

Suggested Credit policy: Rs. 3-5 lakh soft loan per ha with collateral free /collateral standing crop/ Joint Liability Group for Small farmers.

"All these will happen only if there is insurance cover"

Product gap analysis

For a better and robust insurance scheme, there is a need to mitigate the fears and difficulties from both the side of insurers and insured. A product gap analysis of offers of insurers and demand of farmers is given in the following table:

Table.5. Product gap analysis of shrimp crop insurance

Parameter	Current State-Insurance companies' offers	Desired State-Shrimp farmers requirement	Gap	Remedies suggested
Premium on sum insured (input cost)	2.7 to 4 %	1-2 %	1.7 to 2 %	Farmers awareness of insurance need to be increased; Government support, if materializes for 50% premium, will fill the gap
Coverage	80% of input cost	100% of input cost	20%	Government support on premium may offset this gap
Type of insurance	Parametric-weather based	Comprehensive including Disease cover	Unless disease loss is covered farmers not interested	Insurance companies need to engage qualified surveyors for aquaculture insurance
Type of loss	Total loss	Partial losses also to be covered	20 to 80%	Unless insurance companies have full-fledged aqua field staff, partial losses cannot be covered due to few delinquent/negligent claim cases

Duration	Full crop	45 to 60 days	40 to 60 days	Insurance companies should be made aware of insurance requirement from farmers' point of view

Source: Stakeholder meeting held at ICAR CIBA in August 2021 and March 2022.

The discussions with farmers' elucidated their willingness to take up shrimp crop insurance. But farmers' are expecting support from government on premium subsidy. The other expectations of farmers are full coverage, comprehensive insurance including disease cover, and for about two month period. The analysis of this desired state with current state of offer brings out the necessity of government support at least during kick start period. Government agencies need to conduct nationwide awareness campaigns to insurers and farmers to make the gaps to be bridged.

The government can support the aquaculture crop insurance in the following ways:

1. Providing insurance as a central sector scheme by engaging state fisheries departments.
2. Providing 50% or more subsidy on insurance premium paid by the farmers as Direct Benefit Transfer.
3. Providing reinsurance to insurance firms at a reasonable and subsidized cost.
4. Ensuring sustenance of insurance scheme with an insurance stabilization fund as being done by some developed countries for different enterprises.

The first option however, is not workable on many counts, known to all, due to inherent issues in various state fishery department administrative setups. The second option is the NFDB scheme. This scheme allows insurance companies to make and break their fortunes in light and dark periods of aquaculture. While increased business profits may be lucrative in the short term, in the long term, when claims are to be settled, insurers may feel bitter when the size of the total claims may be large in the event of large-scale disease occurrence. Though reinsurance schemes are available to the insurance firms from the global level players, special terms and conditions are needed for aquaculture insurance. Government of India can establish an "Insurance stabilization fund" with a corpus of Rs 100 crores (or more) to be operated by a consortium of stakeholders' viz., representatives of insurers, and insured along with official side nominees under the control of the ministry. Though only an area of 1.5 lakh ha is officially reported under P. vannamei farming expert estimates of area under culture are almost double, if freshwater vannamei farming is also included. But only a fraction of these farms could get the license from CAA due to real-world issues. Hence an insurance coverage scheme may be run on a pilot scale in few clusters of registered farms with the involvement of a couple of willing insurance companies. Insurance companies can be allowed to reinsure with reinsurers if required on their own.

Credit in the aquaculture sector

Aquaculture is a big business opportunity for banks as well. The capital required for shrimp aquaculture is estimated to be more than Rs. 7.5 to Rs. 10 lakhs per ha of farming in India and Rs. 15,000 lakh crores for the Indian Aquaculture sector on the whole on assets such as ponds, aerators, generators, and other valuable items. Apart from this, modern aquaculture segment also requires a minimum of Rs.10, 000 to 15,000 crores credit for each crop period, and the role of credit is vital for the sustenance of the sector. As the supply chain is fully interconnected and transparent in the shrimp value chain, the loan recovery process is easy for credit institutions, when compared to many agricultural, industrial, and other sectors. The Indian government could ease the credit policy and the formal credit sector to sanction collateral-free loans or credit with lower collateral for aquaculture with an increase in productivity. The importance of credit and insurance support required for farmers cannot be undermined, irrespective of technological advancements and commercial viability of shrimp farming. Organizations such as the National Fisheries Development Board (NFDB) should step up its efforts to streamline aquaculture crop insurance to farmers, as already sufficient efforts have been put up in this regard. The National Bank for Agriculture and Rural Development (NABARD) should devise methods of access to credit without collateral. Joint Liability Group (JLG) should be promoted in the aquaculture sector also and other systems of collective protection may be designed to safeguard farmers as well as banks. These efforts will ease the problems of small and marginal shrimp farmers who are the backbone of the sector.

Conclusion

Despite bio-security and all precautions, curable and incurable diseases do occur in ponds (probability- 0.27), leading to losses to farmers. Insurance can help small farmers to tide over such crop losses. The risk to insurance companies is limited as the crop is only for duration of 100 to 110 days and after 60 days, salvage value will help to reclaim breakeven costs to farmers and reduce the liability to insurers. When a farmer harvests a good crop, the insurance company will transfer the surplus to the insurance stabilization fund after deducting their administrative expenses and claims paid, if any. When large scale claims are received due to disease occurrence or any other reason, the insurance stabilization fund will compensate the loss to the extent as agreed upon. Insurance companies will have the freedom to reinsure with reinsurers as per their choice, which will be out of this scheme to protect their financial interests. As farmers essentially need insurance only for 60 days of the crop, the scheme can be operational for specific culture duration. After 60 days, farmers can breakeven most of the cost of expenses with the harvest of the standing crop and its sale. The pilot scheme can be extended phase wise after a minimum of four crops to more, by including more farmers, other aqua-crops, more insurance firms, and increased corpus of Insurance stabilization funds.

CIBA involvement - efforts & Publications

"Focus Group Discussion with Insurance Companies for Re-introduction of Shrimp Crop Insurance in India" organized in 12th March, 2021

International Webinar on "Scope of Reintroduction of Shrimp Crop Insurance in India" organized in Sep 2021

https://agrospectrumindia.com/2021/08/11/icar-willis-towers-watson-organise-webinar-on- shrimp-crop-insurance-in-india.html

ICAR-CIBA organizes Consultation Meeting on developing a Pragmatic Crop Insurance Product for Shrimp Aquaculture

ICAR-CIBA, Chennai inks MoU with Alliance Insurance, Mumbaihttps://www.newindianexpress.com/states/tamil-nadu/2021/feb/17/now-crop-insurance- for-shrimp-farmers-2265067.html

ICAR-CIBA, Shrimp insurance https://www.facebook.com/aquaexindia/photos/a.931156740381497/1858836894280139/?type=3&_rdr

T.Ravisankar, M.Kumaran , M.Muralidhar and C.V.Sairam 2021 Consultancy report for development of viable insurance product for shrimp crop insurance , ICAR –CIBA, Chennai p1- 48.

ICAR-CIBA has signed an MoU M/s Alliance Insurance Brokers, Mumbai in 2021-22 and paid for contract research service extension for two more years 2022 & 23.

Ravisankar T, Why shrimp crop insurance in India is failing to forward? Paper presented in 12th IFAF, May 2022, Chennai

Ravisankar T, Prospects of Shrimp crop insurance , Chola aqua 2022, TNJFU, Thainayaru, 7th Oct 2022

Insurance basics and principles

C.A.Srinivasan

Allience Insurance Brokers

The Principles of Insurance can be studied under the following 3 heads:

(1) General Principles

(2) Basic Principles

(3) Specific Principles

GENERAL PRINCIPLES

- Offer & Acceptance
- Lawful Consideration
- Competency to enter into a Contract
- Free Consent
- Lawful Object
- Certainty and Possibility of Performance

BASIC PRINCIPLES

Principle of Co-operation---- Insurance is a co-operative device to spread loss caused by a particular risk over a large number of persons who are exposed to a similar risk and who have agreed to insure themselves against unforeseen losses.

Principle of Probability----- Probability indicate the chances and amount of loss; Occurrence of risk in each type of insurance can be estimated with the help of theory of probability.

SPECIFIC PRINCIPLES

- UTMOST GOOD FAITH
- INSURABLE INTEREST
- INDEMNITY
- SUBROGATION

- PROXIMATE CAUSE
- MITIGATION OF LOSS

A: Utmost Good Faith ---- Let the buyer beware; Declaration of all material Information about the subject matter of insurance.

The Doctrine of Utmost Good Faith also known by its Latin Term **''Uberrimae Fidei" ,** is a minimum standard, legally obliging all parties entering a contract, to act honestly and not mislead or withhold critical information from one another.

- Material Information is that information which enables the insurer to decide whether he will accept the risk and if so, at what rate of premium and on what terms and Conditions.

Genesis of Utmost Good Faith:

CARTER VS BOEHM (1766)

- The reason of the rule which obliges one party to disclose is to prevent fraud and encourage good faith.
- One party knows all the facts (INSURED), the other party needs to know all the facts (INSURER)

THE RULE

- The parties to the fiduciary contract must disclose all material facts , else

  The contract is voidable at the option of the aggrieved party, that is,

  It never existed.
- To distinguish between fraudulent and innocent misrepresentation.

WHAT TO DISCLOSE?

- All material facts.
- The definition of material fact in various jurisdiction ranges from the
- Reasonable Insured to Reasonable Insurer Test.
- Reasonable insured is what a Reasonable Proposer would reveal.
- Reasonable Insurer is what a Reasonable Underwriter needs to underwrite the risk.

B: INSURABLE INTEREST: It is the legally recognised financial relationship with the subject matter of insurance.

Essential Elements

(i) Subject Matter in Existence.

(ii) There should be a subsisting Economic/Legal/Financial relationship.

(iii) It should not be illegal, unenforceable or opposed to public policy.

Purpose of Insurable Interest

(a) **To reduce Moral Hazard.**

(b) **To discourage wagering.**

INSURABLE INTEREST DEFINED

According to Justice Patterson,**" Insurable Interest is a relation between the insured and the event insured against, such that the event will cause substantial loss or injury of some kind to the insured."**

It is an interest or right which the law will recognize In the preservation of the thing or the continuance of the life Which has been insured.

NATURE OF INSURABLE INTEREST

- Insurable Interest maybe defined as an interest of such a nature

  That the occurrence of the event insured against would cause Financial loss to the Insured.

- In Lucerna vs Crawford (1806) it was pointed out by Lord Eldon

  That expectation though founded on highest probability is not

  ''INTEREST'' and that the Interest must be enforceable at law.

TIME WHEN INSURABLE INTEREST SHOULD BE PRESENT

(1) The time when insurable interest must be present varies with the nature of the insurance contract.

(2) In Life Insurance Insurable Interest must exist at the time of formation of the Contract.

(3) In Property Insurance Insurable Interest must exist both at the time of formation of the contract and at the time of loss.

(4) In Marine Insurance Insurable Interest should be proved at the time of loss.

C: PROXIMATE CAUSE

- The term Proximate Cause is derived from Latin'' meaning the nearest or immediate cause.''
- In case of loss occurring due to more than one cause, then the nearest or the direct cause is to be considered as the actual cause of loss.
- In Pawsey vs Scottish Union and National (1907) it was held that **''the active and efficient cause that sets in motion a train of events which brings about a result, without the intervention of any force starting and working actively from a new and independent source.''** The Proximate Cause is always the dominant cause ; there must be a direct link between the Proximate Cause and the loss; It need not always be the first cause.

D: INDEMNITY

- The Principle of Indemnity states that under the policy of Insurance , the insured has to placed, after the loss, in the same financial position in which he was before the loss.
- Only Actual Loss should be paid.

Liability of Insurer for Indemnity

- Sum assured or value of the policy whichever is less
- Excess/Franchise

Excess clause

If less than limit - no compensation

If more than limit - only excess is paid

Franchise Clause - Total loss is compensated

Life Insurance - Principle of Indemnity does not apply.

Fire Insurance: $\text{Indemnity} = \dfrac{\text{Actual loss} \times \text{amount of policy}}{\text{value of goods insured}}$

Marine Insurance : Value of indemnity is decided at the time of taking policy irrespective of the consideration of depreciation and other relevant factors.

Subrogation

- Transfer of rights and remedies from the insured to the insurer who has indemnified the insured in respect of the loss.

- Corollary to the principle of indemnity.
- Insurer is substituted in place of insured for rights and claims.
- Subrogation only up to the amount of payment.
- Subrogation does not apply to personal insurance.

F: CONTRIBUTION

Survey and loss assessment methods and principles

It is public knowledge that there are two main kinds of Insurance, one is Life and the other deals with Property Insurance.

The Life Insurance Policy claims do not need an assessment of Loss as the sum Insured is fixed and the only peril it insures against is death. It is therefore apparent that the Life Insurance does not require an assessment of Loss. On the contrary, Property Insurance can have different causes for a loss to occur. Fire, Breakdown of Machinery , Loss of Stocks , Theft , burglary ,etc can all erode into the value of the Property or even cause total destruction . In this context assessment of Loss as envisaged in the Policy held, by the Policy holder, becomes a necessity.

It is a well-known fact the Policy is the evidence of a contract that exists between the Policy Holder and the Insurer. In other words they are two parties to the contract. Quantum of fair and reasonable settlement is the ultimate objective, subject to the ambit and constraints of the Policy (The Contract in this case).At this juncture we have to ponder whether one party to the contract such as the Insurer themselves can sit in judgment over the issue. Although the obvious answer is a firm " No" , as a matter of convenience smaller losses are dispensed without a Third party intermediary. Yes. I have used the term third party intermediary.

Now who are these third party intermediaries ? In India they are called "SURVEYORS " or Loss Assessors , but in many countries they are called 'Loss Adjusters" . Mark my words, the word Surveyor is also used for Personnel, who survey and measure land and earmark boundaries. But for some unknown reason the term has come to stay. It would be more appropriate to call them Loss Adjustors for Insurance as in some parts of the world.

Now that begs the question, who is a Insurance Surveyor?

The Insurance Regulatory Development Authority of India defines surveyors as under:

"A Surveyor and Loss Assessor is an intermediary licensed by the IRDAI to investigate, manage, quantify, validate and deal with losses (whether Insured or not) arising from a contingency, on behalf of the Insurer or Insured and Report thereon and carry out work with competence, objectivity and professional integrity by strictly adhering to the Code of Conduct stipulated under the Law / Regulation.

Attention is drawn to the fact that the wordings merely states “contingency “ .

In effect the interpretation of the above would be as follows:

A Surveyor should possess investigative ability, ascertain the extent of damage, quantify the damage in pecuniary terms.

Sounds Utopian and bombastic .However we shall look at the ground realities.

Qualification for obtaining a Surveyor License

The prospective applicant should be a degree holder, Engineer or a Chartered Accountant. It is not out of place to mention here that prior to nationalization of the General Insurance, no minimum qualification was prescribed. In the early 1970’s , after Nationalization the qualification stated above was prescribed. The alternative was to write the Licentiate and Associate ship exams conducted by the Insurance Institute. This was considered sufficient to obtain a license. The Author of this paper being only a Physics graduate, had to utilize this route. However it is to be stated that the courses touched, physics , chemistry, Accountancy besides basics of Mechanical and Electrical Engineering It is needless to add that the Principles and practice of general Insurance was part of the course The exams were conducted in two levels namely Licentiate and Associate The first had three papers and the second had six papers Every candidate had the option to specialize on a particular branch of Insurance such Fire, Marine , Miscellaneous, Engineering or Motor This option could be exercised only in the second level

Post Reforms in the early 2000 it was made mandatory that even despite the candidate being a Engineer or Chartered Accountant, they have to undergo a one year training under a Senior Surveyor for each branch of Insurance stated above. This is a welcome move in the positive direction as Engineers do not touch the subject of Insurance during their regular academic course and Chartered Accountants have a very minor chapter just skirting the boundaries. It would be no exaggeration that the Chartered Accountant aspirants do not attach to much importance to the concerned chapter

Herein I would emphasize that apart from the prescribed qualification in my personal opinion the following attributes is a must

1) A pleasant disposition.

2) Patience to sift through several records.

3) Analytical ability to comprehend the particular nature of the industry. Surveyors cannot be masters of all subjects despite their qualification.

4) Tact is an important aspect as the relationship between the Insurer and the Insured should not be jeopardized

5) Some comprehension of legal terminology and ability to interpret words of the contract of Insurance .

6) Sound Knowledge of Insurance Principles.

7) Last but not the least willingness to apply common sense.

It is emphasized and reiterated that the Surveyor is certifying public money for payment to a particular Industry / Individual/ Firm / or Trader. Therefore the underlying implication is unquestionable integrity.

Let us take the example of Loss in a consumer product Industry, which went up in flames and the surveyor is entrusted to an individual. How is the job going to be accomplished?.

It is imperative that the first visit to the affected premises is as immediate as possible after receiving instruction to assess the loss. Delay would hamper the investigation of cause of loss, cause deterioration of such affected subject matter, besides causing some anxiety in the minds of the Insured.

Digressing a little, I have been in the Insurance industry for 42 years. On several occasions I have had to face comments from not so knowledgeable, that the Surveyors profession revels on other people's loss and misery. Agreed, our income is dependent on losses to the Insured but, we are the ones, who afford solace to the Insured that the financial setback of the Insured can be compensated at least to some extent. Policy conditions and other imagined losses preclude the feeling that settlement is not entirely satisfactory to the Insured. This is where tact helps in assuaging the feelings of the Insured who has lost money

What needs to be done in the first visit

1) Photograph all damage , be it for Fixed Assets or Stocks.

2) Try and establish the cause of loss . In this context lab analysis, expert opinion and the principle of "Reductio ad absurdum" should be used. Elaborating further we should eliminate all the impossible causes and arrive at the most probable cause

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