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TRAINING MANUAL

RISK MANAGEMENT IN SHRIMP AQUACULTURE: SENSITIZATION PROGRAMME TO OFFICERS OF BANKSAND INSURANCE SECTOR

1-3, March 2023

ICAR-CENTRAL INSTITUTE OF BRACKISHWATER AQUACULTURE
75, Santhome High Road, R. A. Puram, Chennai, 600028, India

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RISK MANAGEMENT IN SHRIMP AQUACULTURE: SENSITIZATION PROGRAMME TO OFFICERS OF BANKS AND INSURANCE SECTOR

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Foreword

Indian shrimp sector is one among the fast growing sub sector in Indian economy. The country is producing about 8.43 lakh tonnes/annum of farmed shrimp from an area of about 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 Feces 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 is organizing a Sensitization Programme for banks and insurance officials from India on risk management in shrimp aquaculture during 1-3rd March 2023. In this programme, the officials will get trained on varied topics of shrimp farming like overview of shrimp aquaculture, institutional and regulatory framework, diversification of species and systems, health management, soil and water quality management, nutrition and feed management and its significance, capital, credit requirements and profitability of shrimp farming, potential of crop insurance in risk mitigation, ICT application for shrimp farm management, innovations, startups and incubation in shrimp sector, scope for diversification with alternate species 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 delegates, farmers and other stakeholders, students etc., I congratulate the course coordinators Dr T Ravisankar Principal Scientist and Scientist-in-Charge Social Sciences Division, Dr.Prasanna Kumar Patil Principal Scientist and Officer in Charge Institute Technology Management Unit and Dr Akshaya Panigrahi Principal Scientist Crustacean Culture Division for organizing this sensitization programme. In addition, I also congratulate all the authors who have assisted to prepare this manual. I wish the programme all success.

कुलदीप कुमार लाल
(KULDEEP KUMAR LAL)
Director, ICAR CIBA Chennai

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Indian aquaculture with special reference to shrimp farming

M.Jayanthi
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Overview of shrimp aquaculture

Shrimp aquaculture has grown very fast in the recent past in many tropical and subtropical countries, however, there have been setbacks resulting from diseases, and the environmental and social impacts of shrimp farming. At the global level, the rapid expansion of coastal aquaculture has resulted in large-scale export earnings in Southeast Asian countries. In India, aquaculture has transformed from a traditional to a commercial activity in the last three decades and the area under shrimp culture has increased manifolds.

The history of shrimp farming in India is almost similar to the other South East Asian countries. In the early 1950s, 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 as a shrimp product known as 'prawn-pulp'. Later at the advent of the frozen shrimp industry in India, the demand for larger shrimps increased considerably, and, therefore it was essential to grow the shrimp in the farm field to meet the demand of the export industry. Thus the paddy field shrimp fishery has 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 a few months, without any feed or aeration. Later, to augment the production, farmers started the practice of stocking the ponds with wild-caught seeds, and thereafter, when commercial hatcheries started, with hatchery-reared seeds.

Shrimp aquaculture has undergone a metamorphosis in the past three decades and has scaled great heights and consequently attained the status of the fastest food-producing sector. Modern scientific aquaculture is a relatively new initiative since the late 1980s in India, and has grown tremendously and contributes 6.3% of global fish production of 66.6 million tons (FAO, 2016) by making use of around 2 lakh ha of land resources.

India by its long coast length of 8118 km, supports a wide diversity of inland and coastal wetland habitats. It has been estimated that 3.9 million ha of estuaries and 3.5 million ha and brackishwater areas in the country. Out of this, 1.2 million ha of coastal area has been stated as suitable before the enactment of CAA guidelines. Out of 1.2 million ha, 17 % and 3.6% has been utilized in East Coast and Westcoast respectively indicating the immense potential remaining for further development.

In spite of export earnings, issues raised over the unplanned aquaculture growth have made the sector under regulatory and licensing mode. The Supreme Court of India has directed the government to set up Coastal Aquaculture Authority. The Coastal Aquaculture Authority Act, 2005 enacted by the Parliament of India, received the assent of the President on 23rd June, 2005. The Coastal Aquaculture Authority has brought out guidelines for the development of sustainable aquaculture (www.caa.gov.in) and brought the sector under licensing mode.

Aquaculture Systems in India

Shrimps are generally cultured in land-based earthen ponds where suitable water and soil environment exists. The farming operations are many types, like intensive, semi-intensive, and extensive by stocking density, location, and environment, species under culture and inputs involved.

Fig 1: Traditional aquaculture farm

Traditional system is low input systems characterized by low stocking densities, with little or no external nutritional inputs, tidal water exchange and shrimp yield of less than 500kg/ha. Improved traditional/extensive system is tide-fed traditional system of culture, selective stocking and feeding with local feed is done to increase the production and productivity. Stocking density varied from 40,000 to 60,000 numbers/ha, fed with high protein diets. The productivity is less than one t/ha.

Under semi-intensive culture, stocking density increased up to 2-3 lakhs/ha. Aerators are used to maintain dissolved oxygen. Shrimps are fed with high protein diets with strict feed management. Improved health management practices and water quality monitoring are followed. The production ranged from 1-1.5 t/ha. Licensing is needed from coastal aquaculture authority of India to carry out the shrimp culture.

Super-intensive/intensive culture is done under fully controlled conditions with high stocking densities. *P. vannamei* culture is carried out with strict regulations, with the permitted stocking density of 60/m^2. Continuous aeration is provided to maintain the dissolved oxygen more than 5mg/l in the pond water. The productivity ranges from 8 to10 t/ha

Brackishwater aquaculture in the country is almost synonymous with Penaeid shrimp namely *P. monodon* initially and then *P. vannamei* since 2009 after its introduction in the country. Early nineties witnessed a phenomenal growth of the sector which was entirely dependent on the tiger shrimp, *P. monodon*.

Fig 2: Black tiger shrimp P. monodon **White shrimp *P. vannamei***

During this period, the shrimp culture was a low-risk, high-profit venture, there were serious problems of viral diseases particularly white spot syndrome virus and environmental safety issues in late 90s. Lack of planning and regulation has made *P. monodon* culture as a high-risk, low-profit venture.

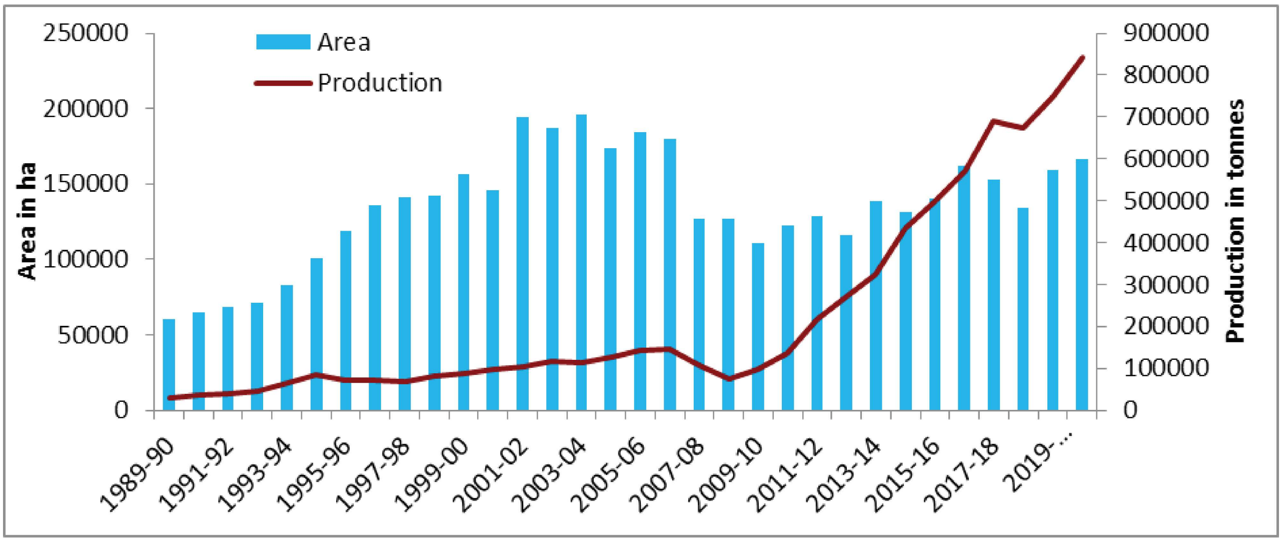

Fig 3: Year wise area and production of shrimp aquaculture

Shrimp aquaculture production (*P. monodon*) showed a phenomenal increase between 1990 to 1995. The area under shrimp culture has been more or less stagnant from 1997 to 2007 at around 140,000 to 150,000 ha due to the White Spot Syndrome Virus disease outbreak. In 2008-2009, the culture area drastically reduced to about 100,000 ha, which is equivalent to the pre-1995 level. After a thorough analysis of pros and cons at various levels and after making the risk assessment on its introduction, the *P. vannamei* has been permitted for culture. The introduction of *P. vannamei* in 2009 led to the recovery of the sector with the production and area of 843633 MT and 166723 ha in 2020-21, respectively.

However, as of now, out of the potential area of 1.2 million ha available for aquaculture, 15% is only utilized and the remaining vast land is still available. In spite of the limited utilization of resources, it has confronted many problems such as environmental issues, quality input, lack of facilities, lack of schemes and sector competition. The aquaculture planning without affecting other coastal resources users, coping up with changing climate is very much needed in the present context.

Guidelines for developing aquaculture

Location of shrimp farms in relation to other land uses and human habitation assumes greater importance in view of the various social and environmental conflicts reported due to shrimp farming. The following aspects should be kept in mind while deciding on a site for shrimp farming. The Coastal Aquaculture Authority (CAA) has formed the guidelines for site selection.

Coastal Aquaculture Authority (CAA) Act was enacted in 2005 and a new Coastal Aquaculture Authority was instituted as per the Gazette Notification No. 1336 dated 22nd December 2005.

The functions of the authority are

- ❖ Under this CAA Act, coastal area for aquaculture includes the land within a distance of two kilometers from the High Tide Line of seas, rivers, creeks and backwaters.
- ❖ The delineating boundaries for coastal aquaculture along rivers, creeks and backwaters shall be governed by the distance unto which the tidal effects are experienced and where salinity concentration is not less than 5 ppt and ii. In the case of ecologically fragile areas, such as Chilka Lake and Pulicat Lake the distance would be up to 2 km from the boundary of the lakes.
- ❖ 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.

Challenges and problems in shrimp aquaculture

Unplanned and uncontrolled development

The shrimp aquaculture sector developed initially without any proper comprehensive spatial planning, however, faced with sudden collapse due to a massive disease outbreak in many shrimp-growing countries. Shrimp pond abandonment has become common in disease-hit areas, but there was not much effort made for the reuse. The imbalance due to fast unregulated growth of the sector on one side and vast abandoned areas available on the other side necessitated spatial planning at the administrable level of the state. The coastal aquaculture authority (CAA) established under the Coastal aquaculture authority act of 2005 has laid down clear-cut regulations for shrimp farming in the country which involves several means of ensuring a sustainable development of the industry. The registration of all coastal shrimp farms which has been a major objective and regulation under the CAA still continues to be a challenge for the authority and the nation. Even today, several farms in coastal areas do not have certificates of registration under CAA and several registered farms do not abide by the regulations made mandatory by the authority. One of the major regulations of CAA, namely the effluent treatment pond (ETP) still continues to be a distant dream for several farms thus seriously affecting the growth and sustainability of the industry

Problems in the seed production

It has been noticed a drastic decline in shrimp productivity. In 2010, productivity per million seeds was 21.4 mt, whereas in 2010 the productivity has reduced to 10.4 mt per million seeds. These worrying downward trends cast doubt about the sustainability of farming this exotic shrimp. Further, seed prices for vannamei in recent years have significantly dropped from 70 to 90 paisa/PL in 2012-14 to 30 paisa/PL. There are even reports that certain hatcheries are willing to supply seed at much lower prices. The high demand for vannamei has resulted in the establishment of a large number of hatcheries. This has resulted in several hatcheries turning to pond-reared brood stock rather than imported SPF brood stocks. The use of pond-reared non-SPF brood stock has resulted in inbreeding of the stocks and farmers currently receive non-SPF seed with poor growth parameters. Larger farms have started to take seeds from several hatcheries and rear them in separate ponds to identify the hatchery which is supplying the best quality seed. Again, in this case, the marginal and small farmers are the worst affected class owing to their reduced buying power.

Higher cost of shrimp feed

The high cost of shrimp feed has been a major concern for shrimp farmers around the country. Most commercial feed manufacturers levy high rates for shrimp feeds thus seriously affecting the profitability of the venture. As of today, most commercial formulations charge around Rs. 72 to 75/Kg of shrimp feed. The prices of shrimp feed would be greater at distant locations like Haryana, wherein a new industry is shaping up. Shrimp feeds are sold at a higher price of Rs. 80 or more in Haryana. Small and marginal shrimp farmers with small holding sizes or leased land are the worst affected due to the increased shrimp feed prices. Such farmers are dependent on middlemen and have poor bargaining power compared to large farmers who directly source the feed from commercial feed manufacturers. It is estimated that the high cost of shrimp feeds has increased the production cost of farmed shrimp to about Rs. 220/kg.

Poor growth and stunting in vannamei

The stunted growth of vannamei has been a major issue presented in the Indian shrimp farming sector. Most farms in Andhra Pradesh have reported poor growth of vannamei. It has been observed that several farms reported a growth of 10 to 12 grams even after 110 days of culture. The exact reasons of stunting is not known, although researchers point towards the poor quality of seed and emerging diseases to be a major cause of the menace. Studies have shown that most hatcheries currently make use of pond-reared brood stock which has the problem of inbreeding. Such inbred shrimp seeds obviously will present a slower growth. Moreover, farmers are not following basic pond preparation practices in order to earn more money. Since ponds are not dried between the crops and the soil is not given sufficient time to release all accumulated organic matter, subsequent crops face production issues as a result of the reduced carrying capacity of the system.

Emerging diseases

Diseases have been a major cause of setbacks in shrimp farming. Several industry sources are of the opinion that Indian farmed shrimp production is set to decline in 2016 as a result of stunted growth and emerging diseases. White shrimp farmers across the country have faced the issue of new and emerging diseases most of which do not have an identified etiological agent. Some of the most reported diseases in vannamei farms in India for which a definite etiological agent has so far not been identified are Running Mortality Syndrome (RMS), Covert Mortality Disease (CMD), White Muscle Syndrome (WMS), bacterial white spots, White Gut Disease (WGD) and muscle cramping. One of the emerging diseases namely White Faecal Syndrome (WFS) often associated with poor growth of vannamei has been identified to be caused by a microsporidian parasite called Enterocytozoon hepatopenaei (EHP). Additionally, this year there has been a greater incidence of white spot virus (WSSV) and IHHNV outbreaks in several coastal districts of A.P. thereby seriously affecting the production in these areas.

Conclusion

The development of aquaculture provides an opportunity to make use of unproductive resources to grow shrimp. However, the development of aquaculture has certainly not been without problems. The guidelines are framed to ensure environment-friendly, socially acceptable, and sustainable aquaculture. As self-discipline is the secret of sustainability, shrimp farmers and other stakeholders need to follow the regulatory guidelines. A financial support system like insurance is very much needed to support shrimp farming. There is a need for timely action to make all farms registered, and insured and move forward with reduced risk.

Institutional and Regulatory framework for aquaculture in India

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Aquaculture in India is one among the dynamic sector in Indian agricultural economy having higher growth rate. For sustainable growth of aquaculture sector, related research, extension, institutional and regulatory framework needs to have proper synergism. The technologies which are proved to be technically feasible and economically viable under research institutes field and or laboratory conditions, need proper technology transfer mechanism with suitable convergence with the institutional and regulatory bodies for actually up-scaling those technologies among the aqua farmers and fishers. In this background, this Chapter highlights on various institutional and regulatory framework for aquaculture in India.

Research Institutions

National Agricultural Research System (NARS)

The Indian Council of Agricultural Research and 62 State Agricultural Universities (SAUs) {including animal husbandry, dairying and fisheries}, 5 Deemed Universities, 2 Central Agricultural Universities and 4 Central Universities with Agriculture Faculty is the core of National Agricultural Research System (NARS), Department of Agricultural Research and Education, under the Ministry of Agriculture and Farmers Welfare, Government of India. ICAR has a Division of Fisheries, which undertakes the research, extension and education on a national perspective on aquaculture and fisheries through its eight research institutes and one Deemed University. Department of Fisheries and Aquaculture in various SAUs undertakes research, extension and education on their respective State / Agro-Climatic Region perspective on aquaculture and fisheries.

Fisheries and Aquaculture Extension

There are 732 Krishi Vigyan Kendras (Farm Science Centres) in the Country, operated through State Agricultural Universities, ICAR Research Institutes, State Departments of Agriculture and NGOs, and about 30% of them undertake frontline extension programmes through technology assessment and refinement and also 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.

The State Department of Animal Husbandry and Fisheries / State Department of Fisheries in various Indian States implement field extension programmes and implement various welfare schemes for the benefit of the coastal fishermen community and also for aqua farmers and fishers. Major fisheries oriented schemes from Government of India such as Pradhan Mantri Matsya Sampadan Yojana (PMMSY) is being implemented through State Departments.

Institutional agencies

Credit Institutions

Aqua farmers and fishers require adequate capital for implementing the technologies which are being developed through NARS and institutional credit facilities are being provided by the Commercial Banks and Cooperative Banks. They can also avail Kisan Credit Card in which the beneficiaries must own or lease any fisheries related assets such as Ponds, Tanks, Open Water Bodies, Raceways, Hatcheries, Rearing Units, Boats, Nets and such other fishing gear as the case may be and possesses necessary authorization/certification as may be applicable in respective States for fish farming and fishing related activities and for any other States specific fisheries and allied activities.

The National Bank for Agriculture and Rural Development (NABARD) is the nodal organ for providing institutional credit to agriculture including animal husbandry and fisheries sector, through its refinancing system to commercial banks, co-operative banks, Regional Rural Banks etc.

Major features of NABARD schemes

- Providing support by re-financing or funding
- Building infrastructures in rural areas
- Preparing credit plans at the district level
- Guiding the bank sectors in achieving their credit targets
- Supervising Regional Rural Banks and Co-operative Banks
- Designing new projects for rural development
- Implementing the Government Development Schemes
- Training handicraft artisans

Functions of NABARD schemes for fisheries sector

- Providing financial services for the improvement of and development of rural India
- Organizing and managing funding programmes in agriculture and farming activities
- Policy making for rural financial institutions
- Funding services for the development of food parks and food processing units in designated food parks
- Lending services to warehouse and cold chain and cold storage infrastructure
- Short term and Long term re-finance services to its customers providing direct re-finance services to co-operative banks
- Credit facilities to marketing federations
- Long term irrigation and rural infrastructural development funds

Development institutions

National Fisheries Development Board

National Fisheries Development Board (NFDB) located with its headquarters at Hyderabad in Telangana State, is an autonomous body under the administrative control of Department of Fisheries, Ministry of Fisheries Animal Husbandry and Dairying, Government of India. The specific objectives of NFDB are focused attention and professional management of major activities in fisheries and aquaculture, national and state level coordination of various activities of these sectors, improvement of production, processing, storage, transport and marketing of the products of capture and culture fisheries, conservation and sustainable management of natural aquatic resources including the fish stocks, capacity building, employment generation in fisheries and aquaculture, women empowerment etc.

Marine Products Export Development Authority (MPEDA)

The Marine Products Export Development Authority (MPEDA) with its headquarters at Kochi in Kerala is having the major mandate of promotion of marine products in the country with special reference to exports from the country. MPEDA is also empowered to carry out inspection of marine products, its raw material, fixing standards, specifications, and training as well as take all necessary steps for marketing the seafood overseas. It has varied mandate like registration of infrastructural facilities for seafood export trade, collection and dissemination of trade information, promotion of Indian marine products in overseas markets etc.

MPEDA has three societies viz., i) Rajiv Gandhi Centre for Aquaculture (RGCA) located in Sirkazhi in Nagappatinam district of Tamil Nadu which is a society with no profit no loss motto has made breakthroughs not only in culture technologies of Shrimps, but also in diversified species such as Seabass, Cobia, Pompano, Tilapia, Groupers, Mud Crab etc. ii) **Network for Fish Quality Management and Sustainable Fishing (NETFISH)** located at Vallarpadam in Kochi in Kerala, is a registered society under the Travancore–Cochin Literary, Scientific and Charitable Societies Registration Act, 1955. NETFISH, the extension arm of MPEDA, stands for improving the quality of fishery products exported from the country and the sustainability of fishery resources as well. The major objectives is to empower fisheries sector by imparting knowledge to fishermen, fisherwomen, processing workers, technicians, etc. on fish quality management, conservation of fish resources and sustainable fishing and iii) National Centre for Sustainable Aquaculture (NaCSA) is an outreach organization for improving the livelihood status of small and marginal shrimp farmers through technology adoption through group approach.

Non-Government Organizations (NGOs)

In India many Non-Governmental Organizations like M S Swaminatham Research Foundation Chennai, South Indian Federation of Fishermen Society (SIFFS), Society of Aquaculture Professionals (SAP), The Prawn Farmers Federation of India (PFFI), Seafood Exporters Association of India (SEAI) and All India Shrimp Hatcheries Association are well known for their research, extension, education and development activities in aquaculture. They have their operations in major aquaculture production regions and are functional based on varied objectives. They operate based on funds received from international and national sources and have serve for the growth and development of aquaculture sector.

Regulatory bodies

Coastal Aquaculture Authority (CAA)

Located at Chennai, Coastal Aquaculture Authority is a regulatory body for aquaculture and in specific for shrimp production industry in India through its guidelines and regulations. The Authority is empowered to make regulations for the construction and operation of aquaculture farms in coastal areas, inspection of farms to ascertain their environmental impact, registration of aquaculture farms, fixing standards for inputs and effluents, removal or demolition of coastal aquaculture farms, which cause pollution etc. The primary task of CAA is to get registered all the shrimp farms in the country. 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 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. CAA also performs the vital activities such as approving farms, hatcheries, brood stock suppliers and do aquatic quarantine for *Penaeus vannamei* farming.

International Arrangements

India is a member of agencies like World Trade Organization (WTO), South Asian Association for Regional Cooperation (SAARC), Network of Aquaculture Centres in Asia and the Pacific (NACA) etc.,. Hence the fisheries and aquaculture sector need to oblige the international rules and regulations from these agencies also. India is a party to the Convention on Biological Diversity (CBD) and has signed the Biosafety Protocol. India is also a party to the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).

Summary

Aquaculture is one among the rapid growing sectors in Indian economy. The existing institutional and regulatory mechanisms have varied objectives and region of operations in production, processing, marketing and international trade sectors. However lack of focused synergism among them and serving the farming community in isolation making these agencies to have further scope of improving their efficiency. This requires medium to long term vision oriented planning to solve various location specific / regional specific, state specific, water body specific issues through system approach.

Recent Advances in Shrimp Aquaculture for Sustainable Farming

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Introduction

Aquaculture is the fastest growing sector in agriculture over the past 20 years, with an average growth rate of growth at ~6% (FAO, 2020) contributing a major share (82 million tonnes) in the total global fish production of 179 million tonnes (FAO, 2020). In coastal aquaculture sector, there is phenomenal increase in shrimp production contributing about 70% of India's seafood exports on value basis for the worth of 5.96 billion USD (MPEDA 2021). Shrimp farming is widely considered the economic engine of brackishwater aquaculture. The introduction of SPF-*Penaeus vannamei* helped the aquaculture sector to increase production by five times from 1.5 lakh tonnes to nearly 9 lakh tonnes compared to the pre-SPF-*P. vannamei* scenario. Also, recently the revival of *Penaeus monodon* through SPF *P. monodon* introduction in 2020-21 is getting attention. India had its highest-ever value exports of seafood, totaling 1,369,264 MT and $7.76 billion. The fish industry fared admirably in 2021–2022, against significant odds. The amount of seafood exported during the year grew by 19.12% in terms of quantity, 31.71% in terms of rupee value, and 30.26% in terms of USD value. Additionally, from 5.18 to 5.67 USD, the unit value climbed by 9.36% (MPEDA, 2022). For further growth in the sector, new aquaculture avenues like improving genetics and eco-friendly farming approaches are given importance. Again, sustainable intensification was emphasized during the deliberation of the world development report on agricultural productivity when climate change and the population explosion become a daunting challenge. The recent advances in aquaculture need to embrace the theme to produce more with less environmental impact and maximum societal benefit.

In the Fisheries and Aquaculture sector, full-time, part-time, occasional, and undefined workers will make up about 58.5 million of the predicted employment totals. Women will also make up 21% of this workforce. Aquaculture and fisheries accounted for 65 and 35 percent of employment in this sector, respectively (FAO, 2020). 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. Intensive farming systems such as IMTA, RAS, integrated aquaponics, and biofloc-based farming models are getting popularity due to better financial returns from these farming practices. 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.

Recent advances

1. Aquaculture production systems and husbandry

- Multi-phase aquaculture system gives more harvests per year.
- Diversification into other shrimp and fish species (*P. indicus/ P. monodon*, Seabass, Sea bream, Mullets etc)
- Super intensive, circular-tank model (to counter low survival; small sizes and biosecurity issues in earthen Ponds, A high growth up to 45-50 grams in 125 days)
- RAS-based system model.
- Nursery rearing system (conventional/BFT) for shrimp/fish is gaining importance
- Offshore technologies- Open Sea cage culture project: Three-tier farming model

2. Reproduction and genetic improvement

- Genetic improvement of farmed species is very much required in aquaculture as the application of genetic principles to increase production is far more lagging here compared to that of animal and plant science.
- Similarly shrimp genetics improvement program have contributed immensely for the revolution in the sector through adoption of SPR/SPT and SPF lines
- Genome-based technologies in aquaculture research, Selective breeding and the production of single sex and sterile populations
- Carp and tilapia culture in Asia is benefiting from genetics research in a number of areas, including genetic sequencing and the development of specific genetic markers. The GIFT project has been instrumental for producing pure-bred lines and the distribution of strains of improved performance to farmers

3. Disease diagnostics and health management

- Surveillance for existing and emerging diseases of coastal farming
- Control of viral and parasitic diseases, improving disease resistance through selection,
- Novel system adoption- The circular tank model is one of the best solutions to control EHP due to its clean bottom and good water quality, microsporidium growth is kept in control
- Functional diets, epidemiological studies and Genetic selection acts as Prophylactic action and prevent the outbreak of diseases.

4. Nutritional advances

- Reducing dependence on Fish meal and animal protein and possible enhancement of inclusion rate of plant protein
- Alternate protein sources (BS Fly / Krill meal)

- More targeted feed and feed systems that meet the needs of the system
- Nutrigenomics approach for better performance
- Usage of SPF live polychaetes as broodstock feed
- Pellet feed is replaced by extruded feed because of its less dust and lesser broken pellets and its more water stability

5. Pond automation and IoT

- 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.

6. Market research, Credit, Insurance, Start-ups

- Development of domestic marketing
- Building a sustainable circular economy
- Crop Rotation and scheduling
- Technologies like Super intensive, Circular-tank systems take less initial investment (than lined ponds), Less risk, and more predictable production.

Innovative Aquaculture Practices For Sustainability

1. Development and dissemination of specific pathogen-free (SPF) penaeids shrimps

The white spot syndrome virus and other diseases took the edge of black tiger shrimp farming in India (Karunasagar et al., 1998; Dash et al., 2017; Otta et al., 2018). Farmers started looking for alternative species or SPF varieties, and the introduction of SPF *P.vannamei* gave a much-needed boost to disease-struck Indian shrimp farming. However, single species-oriented culture resulted in multiple challenges such as the emergence of new diseases, the escalating price of imported brood stock, etc. Recently with an aim to diversify shrimp farming, a selective breeding programme for producing a SPF (specific pathogen-free) fast-growing and disease-resistant variety of *P. monodon* is initiated. It is reported that the growth rate and WSSV resistance has been improved after each generation.

2. BMP/GAqP in shrimp/fish farming

Better Management Practices (BMPs) are designed to standardize on-farm practices and improve the (environmental) performance of shrimp aquaculture, BMPs for shrimp farming are designed to standardize on-farm practices and reduce the economic risk associated with disease and environmental degradation. Similar to third party certification standards, BMPs set out a range of technical indicators that producers can use as targets to improve their production practices (Vandergeest, 2007; Anh et al. 2011; Padiyar et al. 2012). The model is of a self-propagating nature, and most of all, has contributed to the sustainability of shrimp farming in India, and indeed, in the region.

3. 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 (Sundaram, et al., 2017; Panigrahi et al., 2020a). 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.

4. 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.

5. 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.

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.

6. High-density Genetically Improved Farmed Tilapia (GIFT) farming

The GIFT is an important candidate species for tropical aquaculture due to its fast growth rate, short duration, tolerance to water quality variation, disease resistance, and easy culture techniques with better adaptability to wide water quality parameters. Intensive tilapia farming with a nursery rearing at 75/ m^2 and grow-out farming at 3-5/m^2 reported an yield of 10-12 tons per ha in a six-month duration. This allows farmers to take two crops per year (FAO, 2017).

7. Integrated multitrophic aquaculture (IMTA): Shrimp-seaweed-mollusc system

Integrated multitrophic aquaculture is a farming practice where by products from one species are recycled to form input for other species (FAO, 2014). 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 (Chopin et al., 2008). Thus, the benefits of IMTA can be summarised as: 1) bio-mitigation of effluent from the farming; 2) diversification, and reduces the overdependence of single species, resulting in creating risk and financial burden to the farmers. ICAR CIBA-demonstrated open-water Integrated multi-trophic aquaculture (IMTA) in Maharashtra district of Sindhudurg, and its efforts are successful in supporting the livelihoods of west coast coastal farmers.

8. 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.

9 Improved participation and contribution of women in aquaculture intensification

Intensive bivalve farming was successfully adopted by many farmers after the standardized scientific technological improvement, Further, the value-addition in ready-to-cook or ready-to-eat products made marketing more manageable and opened new vistas in the domestic market. Environmental sustainability can be established through synergy development among researchers, financiers, promoters and farmers. This mission was spearheaded by women’s self-help groups, involving around 7000 members and producing 20,000 tons of produce, making India one of Asia’s top producers of these bivalves in 2009**.**

Employment opportunity in Coastal Aquaculture industry

Diversely skilled labour is crucial to the shrimp supply chain. It provides a wide range of employment options, including farm management, technical assistance at hatcheries, farms, and processing facilities, staff for the production and marketing of inputs, wholesale, and retail businesses, and workers for the operation of farm machinery, vehicles, civil engineering projects, plumbing, mechanical, and electrical equipment (Kumaran et al., 2020). A study by ICAR-CIBA estimated that the Indian shrimp sector suffered a 40% loss in each component, for a total loss of 1.50 billion USD by due to Covid-19 on 2020. A significant loss in employment and income was caused by the closure of state and district borders and limits on people's daily travel. International institutions and organizations (Bennett et al., 2020; FAO, 2020b; International Monetary Fund (IMF), 2020; Schmidhuber et al., 2020; Stephens et al., 2020) shared the same opinions. According to some reports, the aquaculture workers need to be more organized and should have better social safeguards).

Most importantly to improve the economic income through PMMSY schemes, the government of India expects the fisheries industry to contribute roughly 9% of agriculture GVA by 2024-25, up from 7.28% in 2018-19. Furthermore, the career possibility may be creating 55 lakh direct and indirect job opportunities throughout the value chain. Doubling the earnings of fishermen and fish growers can be achieved by the PMMSY scheme.

Conclusion

The use of modern technologies and improved management approaches are required to assure the long-term viability of shrimp farming. Numerous new inventive technologies connected to ecologically friendly and sustainable methods have resulted in substantial improvements in shrimp farming systems across the world. PMMSY, MPEDA, and ICAR-CIBA have taken significant steps to strengthen aquaculture companies through different diagnostics. Private investment and entrepreneurship for the shrimp industry and organizing credit and insurance facility can help increasing export earnings from Rs.46,589 crores (2018-19) to Rs.1 lakh crores by 2024-25. Research must examine additional or novel technology to augment coastal aquaculture, including diversification of species and systems, bioremediation, growth augmentation, nutrition, protective responses, immunological enhancement, and other cutting-edge approaches like improved genetics, nutrition, health, genomics, gut microbiome, AMR, one health and eco-friendly technologies can boost the sector increasing per capita domestic fish intake from fulfilling the income generation of coastal aquaculture farmers.

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Health Management in Shrimp Aquaculture System

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Introduction

Aquaculture is one of the fastest growing sectors throughout the world. The fisheries sector has been playing an important and responsible role by providing high profit oriented business to maintain social status and cheap source of protein to maintain good health. As per one of the report, 16.5% of total animal protein source and 6.5% of total protein consumption is supplied through fisheries products. The growth from the aquaculture sector has consistently been in an increasing trend. It is also predicted that by 2030 that the production will almost match with capture fisheries. Similarly, towards 2030 the consumption from aquaculture sector will be about 60% of total production.

This rapid expansion of aquaculture has forced the increase use of several inputs resulting in disturbance to the ecosystem. This has further resulted in the emergence and spread of several diseases. Disease outbreaks virtually wiped out marine shrimp farming production in Mozambique in 2011. Thailand's production fell to 1.2 million tonnes in 2011 and 2012 owing to flood damage and shrimp disease. In 2013, Thailand experienced a decline in its exports (to US$7.0 billion, down more than13 percent on 2012), as disease problems reduced farmed shrimp production. Current estimates predict that up to 40% of tropical shrimp production (>$3bn) is lost annually, mainly due to viral pathogens. World farmed shrimp production volumes decreased in 2012 and particularly in 2013, primarily due to the disease-related problems, such as early mortality syndrome in Asia and Latin America, reducing their production by 35 percent in 2013. As Asia accounts for 90 percent of global shrimp aquaculture, global supply would contract by 15 percent in 2015.

Disease always brings anxious moments in the mind of farmers and therefore they can never become sure for a successful harvest. The industry has witnessed several emerging diseases and many of the existing diseases have re-emerged bringing heavy loss. The aquaculture practice should be a sustainability one and therefore knowledge on aquatic animal health and effective management practices are inevitable to achieve this goal.

Prevailing 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 viral diseases started emerging. So far more than 20 viral pathogens have been reported from shrimp and new pathogens are constantly being added up.

Some of the important and virulent viral pathogens are listed below

1. White spot syndrome virus (WSSV)- Double stranded DNA virus, WOAH listed
2. Infectious hypodermal hemotopoetic Necrosis virus (IHHNV)- Single stranded DNA virus, WOAH listed
3. Taura syndrome virus (TSV) – Single stranded RNA virus, WOAH listed
4. Yellow head virus (YHV): Single stranded RNA virus, OIE listed
5. Infectious myonecrosis virus (IMNV)- Double stranded RNA virus, WOAH listed
6. Covert Mortality Noda Virus (CMNV)- Single stranded RNA virus, not listed by WOAH
7. Decapod Iridescent Virus 1 (DIV I) – Double stranded RNA virus, Listed by WOAH

However, in India, only WSSV and IHHNV have been reported to be wide spread and prevalent throughout the year. Starting from 2017, IMNV was also reported to be present in India. Other virulent viral pathogens are till now exotic. WSSV is a highly virulent shrimp virus which has been responsible for huge economic loss throughout the world. Even after more than two decades of its prevalence the virus still continues to threat the shrimp aquaculture industry.

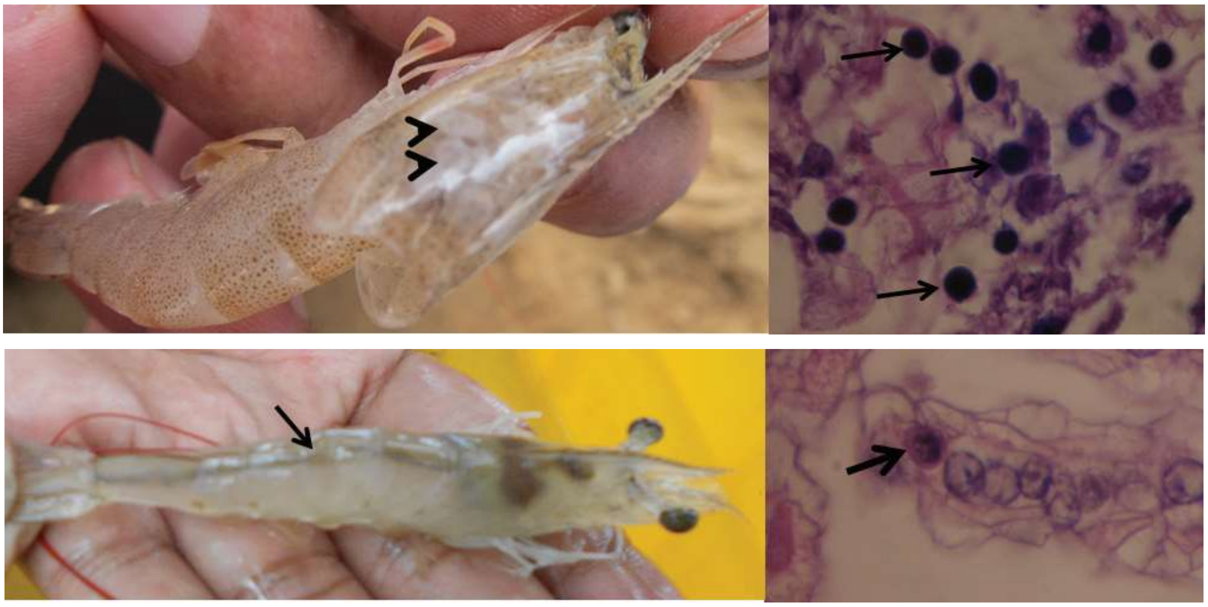

Fig 1: WSSV infection (left) and IHHNV infection (right) in cultured *L.vannamei*

Many times bacterial pathogens are not considered that serious as these are well tolerated through proper management practices. However, at larval stage these are more prone to vibriosis. Similarly, some of the bacterial pathogens acquire virulence through gene transfer and can create havoc.

Two of the disease caused by bacteria is mentioned below.

1. Luminiscent vibriosis (caused by *Vibrio harveyi*): Important at hatchery level
2. Early Mortality Syndrome (EMS)/Acute Hepatopancreatic Necrosis Disease (AHPND) – caused by *Vibrio parahaemolyticus*: Important during early stocking period

Luminiscent vibriosis can bring mass mortality in shrimp hatcheries. This can also be a problem to shrimps during juvenile stage. During the recent times, AHPND has created havoc in many of the South East Asian counties. Farmers have been facing continuous loss due to this.

Fig 2: Vibrio infection in cultured *L.vannamei*

Diseases of unknown aetiology

Some of the diseases with unknown aetiology are also wide prevalent in shrimp aquaculture system and bring loss in the form of low mortality, high FCR or growth retardation. In spite of considerable effort through research, it has not been possible to find out the causative agent. In many of the cases either bacterial pathogens or environmental parameters are suspected to be the cause.

Listed are some of the currently prevailing diseases with unknown aetiology

1. Running Mortality Syndrome (RMS)/consistent mortality syndrome – In cultured shrimp where partial mortality is noticed after 40-50 DOC
2. White Faeces Syndrome (WFS) – In cultured shrimp. Suspected due to parasite or vibriosis
3. Zoea syndrome – In hatchery. Suspected due to vibriosis

Fig 3: Running mortality syndrome (Top) and White Faeces Syndrome (Bottom) in cultured *L.vannnamei*

Parasitic diseases

Many of the external parasitic infection caused by *Zoothamnium* sp. or *Epistylis* sp. etc can be avoided through management practices. However, some of the parasites that infect the internal organs (ex. Hepatopancreas) are reported to bring loss in the form of growth retardation. *Enterocytozoon hepatopenaei* (EHP) has been reported to be responsible for growth retardation and size variation. CIBA has reported this disease to be prevalent in India for the first time. Since then this disease has wide spread to all the shrimp culture practices in India. At present EHP is one of the major threats that farmers suffer from.

Management Practices

Proper management practices become difficult to implement due to lack of sufficient knowledge on the host species, delay in identification of causative agent/pathogen, lack of knowledge on origin and nature of pathogen, lack of knowledge on host and geographic range of the pathogen, lack of knowledge on virulence mechanism of the pathogen and lack of proper regulation processes. Therefore, prior information on these aspects will greatly help to bring effective management practices and avoid disease occurrence.

A wide number of management practices are necessary for proper health management both at farm and hatchery levels. However, proper regulatory bodies both at national and internal levels are necessary to guide supervise and finally implement those management practices.

Suggestive management practices at farm level

1. Adoption of BMP
2. Adoption of good aquaculture practice certification
3. Use of SPF/SPR stocks
4. Regular monitoring
5. Avoid the indiscriminate use of inputs

Conclusion

Disease is the primary constraint for any aquaculture practices. Shrimp farmers worldwide have continuously been suffering from disease outbreak and related crop loss, Effective management protocols are needed to be in place to avoid many of the disease related issues. Prevention is always better than cure and care should be taken to prevent the entry of pathogens into the system. A proper cooperation between farmers, stake holders and regulatory bodies is highly essential for an effective disease management outcome. This will pave the way for a sustainable aquaculture practice.

Water and soil quality management in shrimp farming under varying weather scenarios

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1. Introduction

A pond with good soil and water quality will produce healthier animals than a pond with poor quality. Poor environmental conditions in ponds bring in a state of stress that is unfavourable for the cultured animals but favourable for the disease-causing agents. Soil and water quality can be maintained within the optimal range by giving importance starting from site selection, suitable pond preparation and culture period. Understanding pond water and soil characteristics, and optimum requirements help to decide the better management practices (BMPs) to be followed in terms of liming, manuring, fertilization, water management, etc., for increasing nutrients use efficiency and productivity of the ponds in general and thereby augmenting aquaculture production by reducing the risk of health problems, 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. Day-to-day management of ponds requires only an estimation of the topping-up rate of the water supply to combat evaporation and seepage losses. An annual water budget should be calculated for a potential farm site so that the supply is adequate for existing and future needs. The optimum ranges of water parameters required for aquaculture are given in Table 1.

A detailed sub-soil survey is essential to ascertain the suitability of the site for pond construction. The sub-surface soils should be tested for compaction and seepage properties, as well as surveying contours. Soil samples from different depths at random points within the site should be analysed for important parameters (Table 1) and heavy metals content. Some soils may have undesirable properties like potential acid sulphate acidity, high organic matter content or excessive porosity. The soil pH ranging between 6.5 and 7.5 is best suited for a brackishwater environment for mineralization of organic matter, maximum availability of nutrients and bacterial activities. Soil organic matter is an important index of soil fertility and also helps in the prevention of seepage loss, increases the aerability of pond soil bottom and supplies nutrients. The soil rich in $CaCO_3$ content promotes biological productivity as it enhances the breakdown of organic substances by bacteria creating more favourable oxygen and carbon reserves.

Even if the site is good with optimum soil and water characteristics, problems may still crop up by the large number of inputs like feed and fertilizers, which lead to excessive phytoplankton production, low dissolved oxygen, high ammonia, poor bottom soil condition and other problems. 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)	0.10-0.20
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 (%)	>5.0
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. Pond preparation is generally dealt with in two categories viz., newly constructed ponds and existing culture ponds. 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. For example, if the soil in a new pond is acidic, it should be limed before the initiation of aquaculture. 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 of the pond bottom.

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 (%)	>5.0
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

3.1 Drying

The pond bottom should be dried for at least 7-10 days for the mineralization of organic matter and the release of nutrients. Exposure of the pond bottom to sunlight until it dries and cracks, enhances aeration and favours microbial decomposition of soil organic matter. The optimum moisture content for drying is 20%, but it might vary among soils from different ponds. Pond drying certainly enhances the mineralization of organic phosphorous but mineralized phosphorus is subjected to available water column as well as to pond mud.

3.2 Tilling

Tilling bottom soils can enhance drying to increase aeration and accelerate organic matter decomposition and oxidation of reduced compounds. The pond bottom should not be tilled when they are too wet to support tillage machinery. The depth of tillage usually should be 5 to 10 cm, mouldboard plow often called the turning plow, can be used to turn the soil over.

3.3 Liming

The reason for liming aquaculture ponds is to neutralize soil acidity and increase total alkalinity and total hardness concentrations in water. This can enhance the availability of nutrients in the pond water and improve the conditions for the productivity of food organisms and increase aquatic animal production. 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. In ponds with highly acidic soil (pH < 6) liming can increase phosphorus availability by increasing the soil pH. Soil amendments such as agricultural limestone or burnt lime can be mixed into soil by tilling. Agricultural limestone will not react with dry soil, so when applied over the bottom of empty ponds, it should be applied while soils are still visibly moist but dry enough to walk on. In soils with chronically low pH, it may be beneficial to apply half the total dosage before slight tilling to neutralize underlying soil layers. The amount of different lime materials required to raise the pH to 7 is given in Table 2.

Table 2. Amount of lime (tons/ha) to raise the soil pH to 7.0.

Soil pH	Quantity of lime material (tons/ha)		
	Dolomite	Agricultural lime	Quick lime
6 to 6.5	5.7 to 2.8	5.5 to 2.8	4.6 to 2.3
5.5 to 6.0	8.5 to 5.7	8.3 to 5.5	6.9 to 4.6
5.0 to 5.5	11.3 to 8.5	11.1 to 8.3	9.2 to 6.9
4.5 to 5.0	14.2 to 11.3	13.9 to 11.1	11.5 to 9.2
4.0 to 4.5	17.0 to 14.2	16.6 to 13.9	13.8 to 11.5

3.4 Fertilization

The rate of application of inorganic fertilizers ranges from 25 to 100 kg/ha as a basal dose during pond preparation with a minimum water depth of 10 to 15 cm. When the culture progresses, 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 at short intervals for sustained plankton production.

3.5 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 be 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

All aquaculture ponds' soil bottom become covered with sediment, and this sediment can be considered as 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.

4.1 Understanding of sediment-water interface

For better management of the pond bottom, the aquaculture pond soil profile needs to be understood. 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 oxidized layer prevents the diffusion of toxic metabolites into pond water as they get oxidized to non-toxic forms by chemical and biological activity while passing through the aerobic surface layer. Loss of this oxidized layer can result when soils accumulate large amounts of organic matter, and dissolved oxygen is used up within the flocculent layer before it can penetrate the soil surface. 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.

4.2 Monitoring of soil parameters during the culture period

During culture, the carbonaceous matter, suspended solids, faecal matter and dead plankton, etc. also settle at the pond bottom. The pond bottom soil has to be monitored regularly for pH, organic matter and redox potential. Pond managers should still strive to prevent severe soil quality problems from developing. These materials have a combined effect on the environment of the pond bottom. To characterize the soils based on soil type, a pond core sampler fabricated by the Environment Section of CIBA can be used for the depth-wise collection of cores.

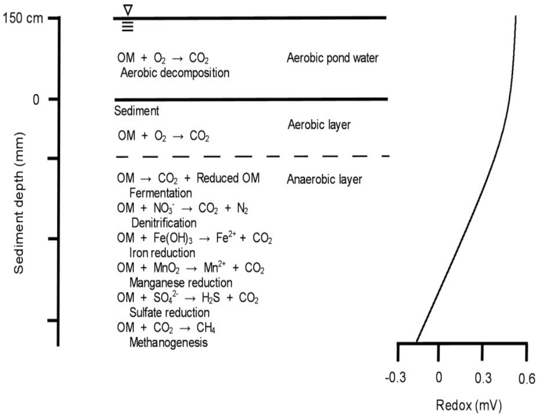

Fig 1: Reactions at the pond bottom soil during aerobic and anaerobic conditions

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. The anaerobic condition can be developed in a pond when the input of organic matter exceeds the supply of oxygen needed for the decomposition of organic matter. This reducing condition can be measured as the redox potential (E_h). $E_{h,}$ indicates whether the water or soil is in reduced (E_h with `-ve' value) or oxidized ($E_h$ with `+' ve value) condition. In anaerobic sediment, some microorganisms decompose organic matter by fermentation reactions that produce alcohols, ketones, aldehydes, and other organic compounds as metabolites. Other anaerobic microorganisms can use oxygen from nitrate, nitrite, iron and manganese oxides, sulfate, and carbon dioxide to decompose organic matter, but they release nitrogen gas, ammonia, ferrous iron, manganous manganese, hydrogen sulphide, and methane as metabolites (Fig.1). Some of these metabolites hydrogen sulfide, ammonia and nitrite can enter the water and be potentially toxic to shrimp. The redox potential (E_h) of mud should not exceed -200 mV. The oxidized layer at the sediment surface is highly beneficial and should be maintained throughout the culture period. Ponds should be managed to prevent large accumulations of fresh organic matter at the soil surface, or in the upper few millimeters of soil. Hence, it is extremely important to maintain the oxidized layer at the sediment surface in culture ponds.

5. Water quality management during the culture period

Test indicators to ensure that the pond is ready for stocking are 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.

5.1 Water quality maintenance

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. The acclimatization rate should not exceed 1 or 2 ppt per hour. Due to the high evaporation rate in summer salinity may increase beyond 40 ppt, which can affect the growth of shrimp. Sudden fluctuations in the salinity associated with heavy rains result in heavy mortality. Water should be exchanged frequently either by pumps or through the tidal exchange to reduce the salinity variations. Maintenance of salinity of 18 to 35 ppt with variations not exceeding 5 ppt will help in reducing stress on the shrimp. Water pH can fluctuate between 7.5-9.5 with the accumulation of residual feed, dead algae and excreta over 24 hours with the lowest pH occurring near dawn and the highest pH occurring in the afternoon. 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. On account of unequal distribution of temperature with a higher temperature near the surface layer and decreasing temperature with depth, thermal stratification can occur resulting in degradation of water quality. The planting of trees on pond dikes to give shade will reduce stratification but at the same time reduce the beneficial effects of wind mixing and restricts solar energy for photosynthesis. The operation of aerators during warm and calm afternoons helps to break thermal stratification by mixing warm surface water with cool sub-surface water. 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.

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. The concentration of a toxic substance such as unionized/reduced form (NH_3), sulphur (H_2S) and carbon metabolites (methane) increases when a low DO level exists. However, in the presence of an optimum level of oxygen, the toxic substances are converted into their oxidized and less harmful forms. The use of aerators results in the mixing of water at surface and bottom and breakdowns DO stratification and also can eliminate black mud formed at the interface of pond water and bottom mud. Water exchange is the best solution to prevent low DO problems in the pond where aeration is not practiced. However, daily water exchange usually does not improve water quality, because routine water exchange can discharge carbon, nitrogen and phosphorous substances from ponds before they can be assimilated. Thus water exchange should only be used when necessary. The number of aerators required is about 1 HP per every 300 kg of biomass. The location of the aerators should be adjusted in such a way the sedimentation occurs at the center of the pond which will aid in its easy removal.

5.2 Metabolites load

The toxicity of ammonia nitrogen is attributed primarily to the un-ionized form and should be less than 0.1 ppm. Un-ionized hydrogen sulphide is toxic to aquatic organisms and the ionic forms have no appreciable toxicity. Any detectable concentration of hydrogen sulphide is considered undesirable. The toxic effect of metabolites can be minimized in several ways. Maintaining a sufficient level of DO facilitates the oxidation of ammonia to harmless nitrate by nitrifying bacteria. 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.

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.

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 as 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.

7. Shrimp farms discharge water management

The waste from culture ponds contain mainly suspended solids, comprising of unconsumed feed, faecal matter and plankton, dissolved nutrients phosphorus and nitrogen and metabolites such as ammonia and nitrite. The overcrowding of farms in certain areas and the limited carrying capacity of the creeks/ estuaries serving such farms have been a matter of concern. The Ministry of Agriculture in its guidelines for sustainable development and management of brackishwater aquaculture has prescribed standards for the water discharged from the aquaculture farms (Table 3).

Table 3. Standards for discharge water from coastal aquaculture farms in India

Parameters	Final Discharge Point	
	Coastal Marine Waters	Creeks/ Estuaries
pH	6.0-8.5	6.0-8.5
Suspended Solids mg/l	100	100
Dissolved Oxygen mg/l	Not < 3.0	0.5
Free Ammonia (as NH_3 – N) mg/l	1.0	0.5
Biochemical Oxygen Demand (BOD_5) mg/l	50	20
Chemical Oxygen Demand (COD) mg/l	100	75
Dissolved Phosphate (as P) mg/l	0.4	0.2
Total Nitrogen (as N) mg/l	2.0	2.0

8. Conclusion

The key to successful aquaculture is the identification of the issue and intervention at the right time through appropriate management practices. Many of the practices no doubt improve production efficiency in the long run, but a poor cost-benefit ratio may deter farmers from adopting some of them. 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. Government regulations are an important component of management in supporting aquaculture development, maintaining environmental quality, reducing negative environmental impacts, allocating natural resources between competing users and integrating aquaculture into coastal zone management.

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 (BMPs)

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.

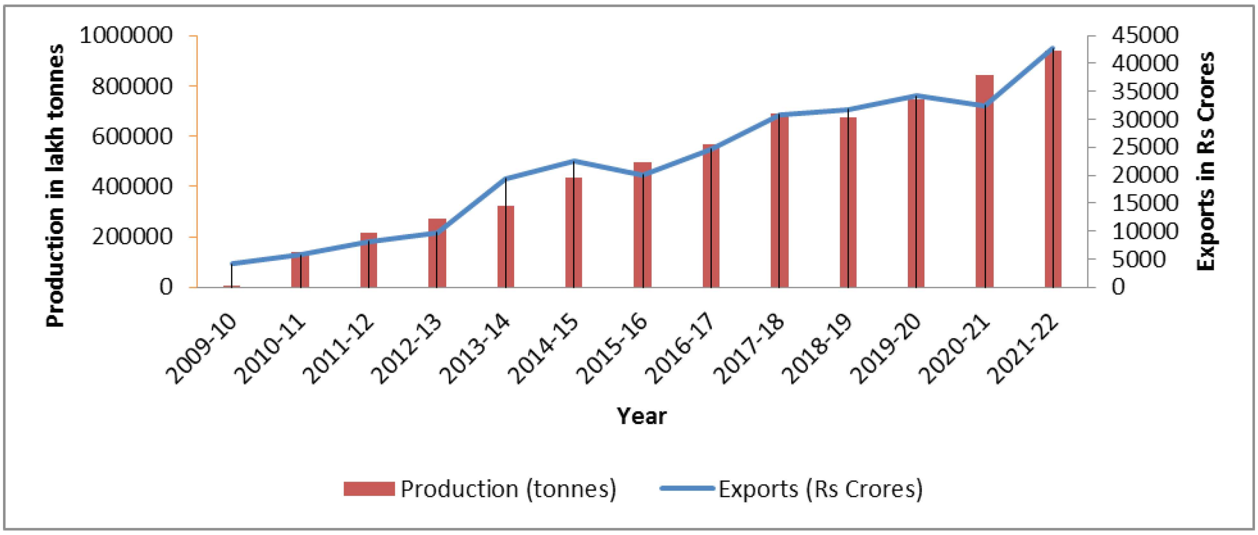

Fig.1. Growth trend of shrimp farming in the country (2009-2022)

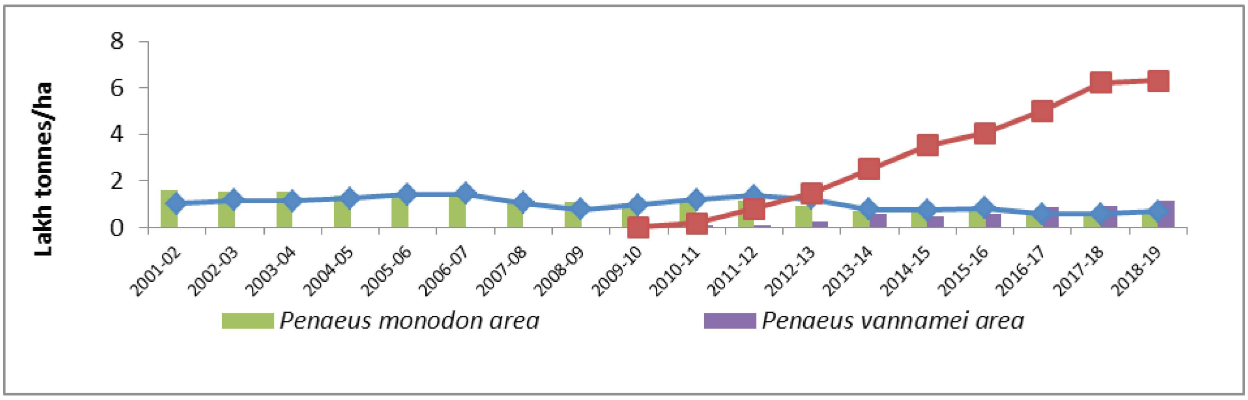

Figure.2. Area and production trends of *P. monodon* and *P. vannamei*

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:

- ❖ 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 Science 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.

Potential of Crop Insurance in risk mitigation

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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.

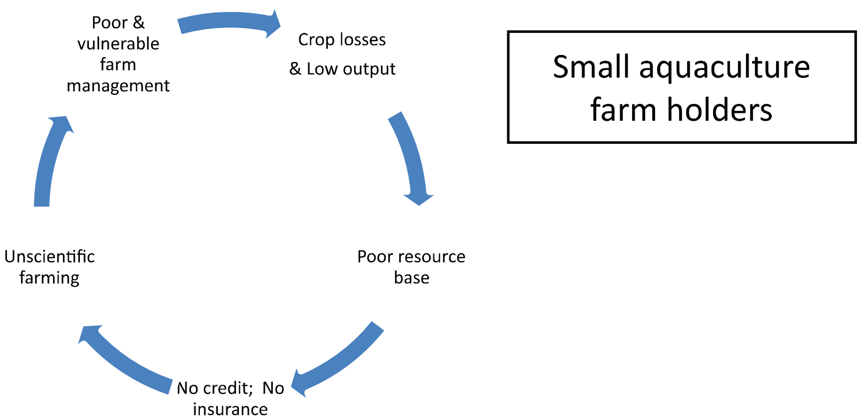

Fig. 1. Vicious cycle of inefficient small farm aquaculture

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

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
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.

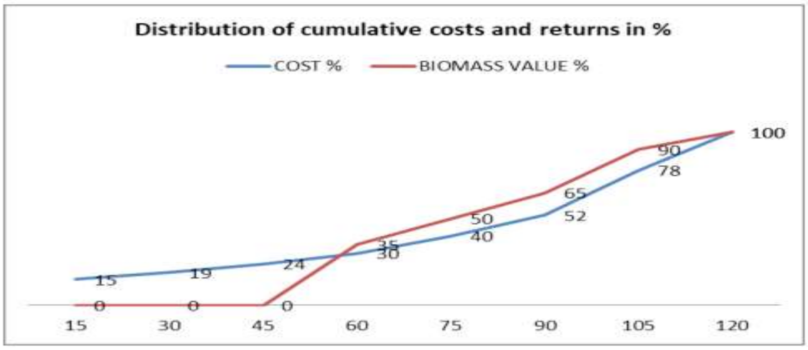

Fig 2: Distribution of cumulative costs and returns in %

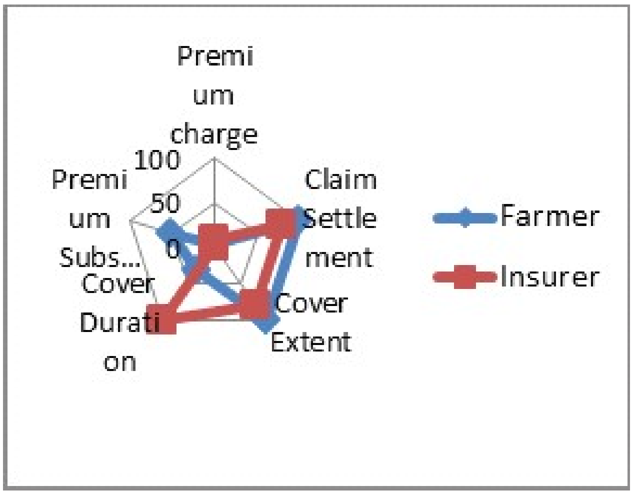

Fig 3: Progressive costs and returns of shrimp farming

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

Application of ICT tools for communication of aquaculture advisory services

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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.

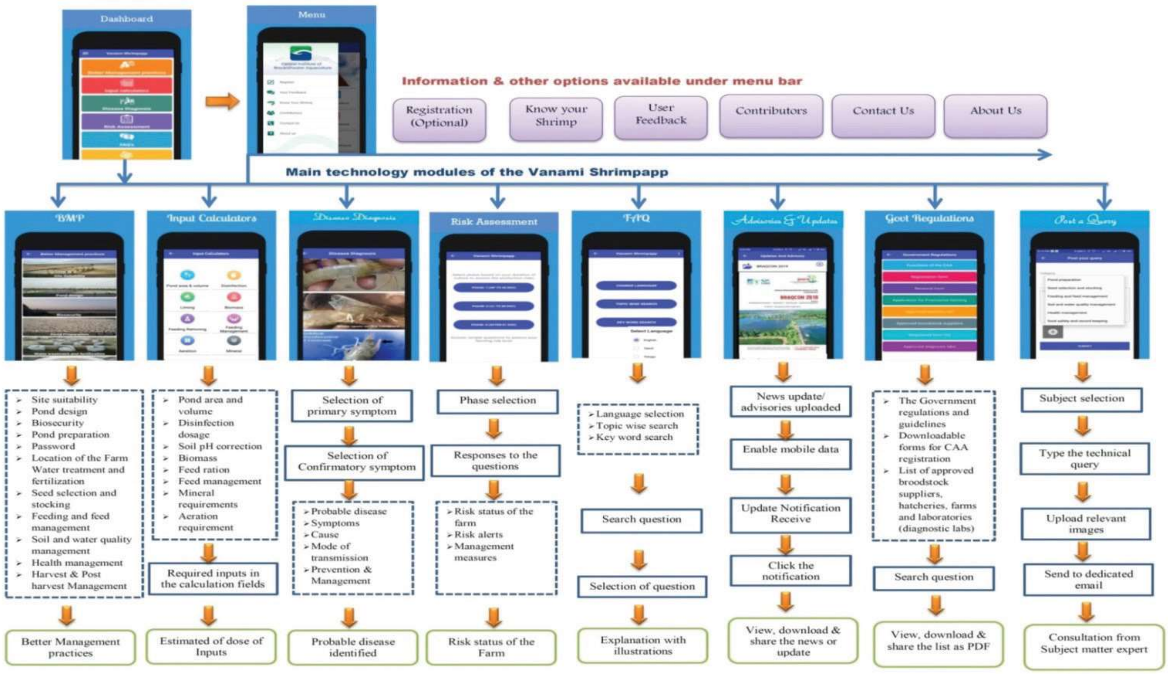


Fig 1: Framework for knowledge representation of CIBA ShrimpApp

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.

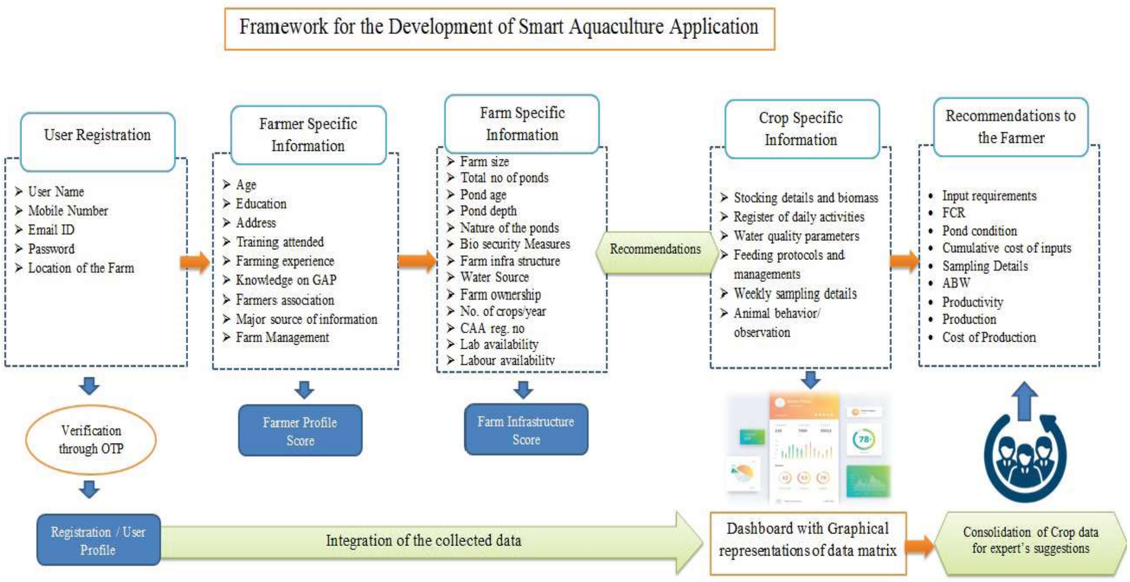


Fig 2: Framework for Mobile application for shrimp farm management

"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.

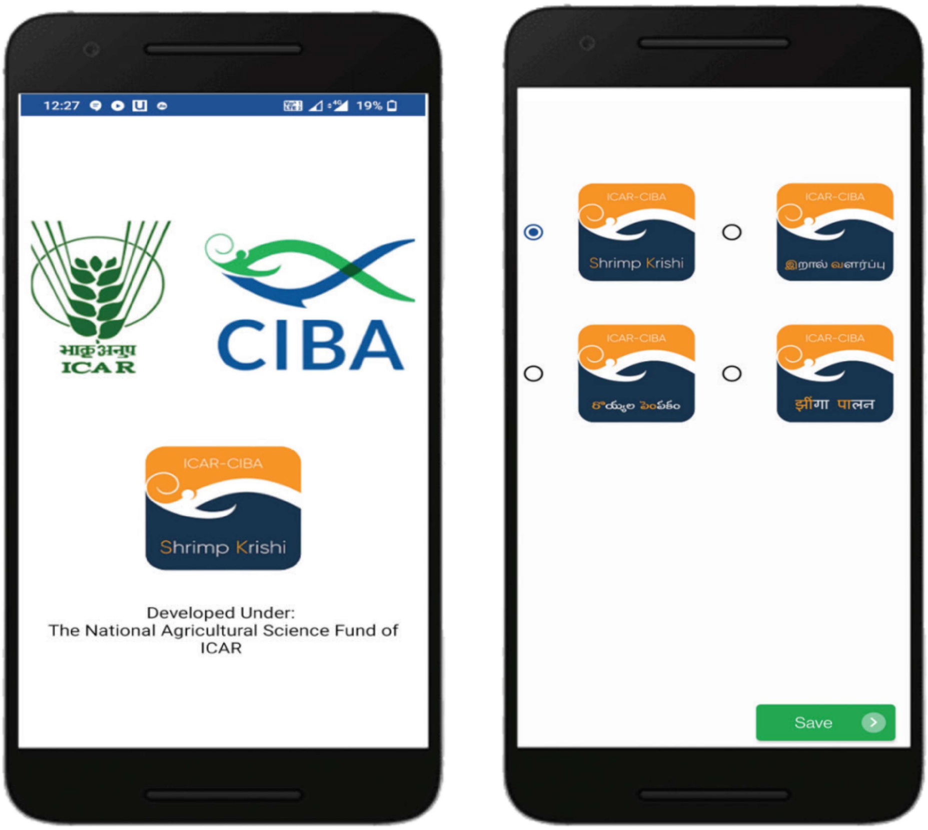


Fig 3: CIBA ShrimpKrishi Mobile Application

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.

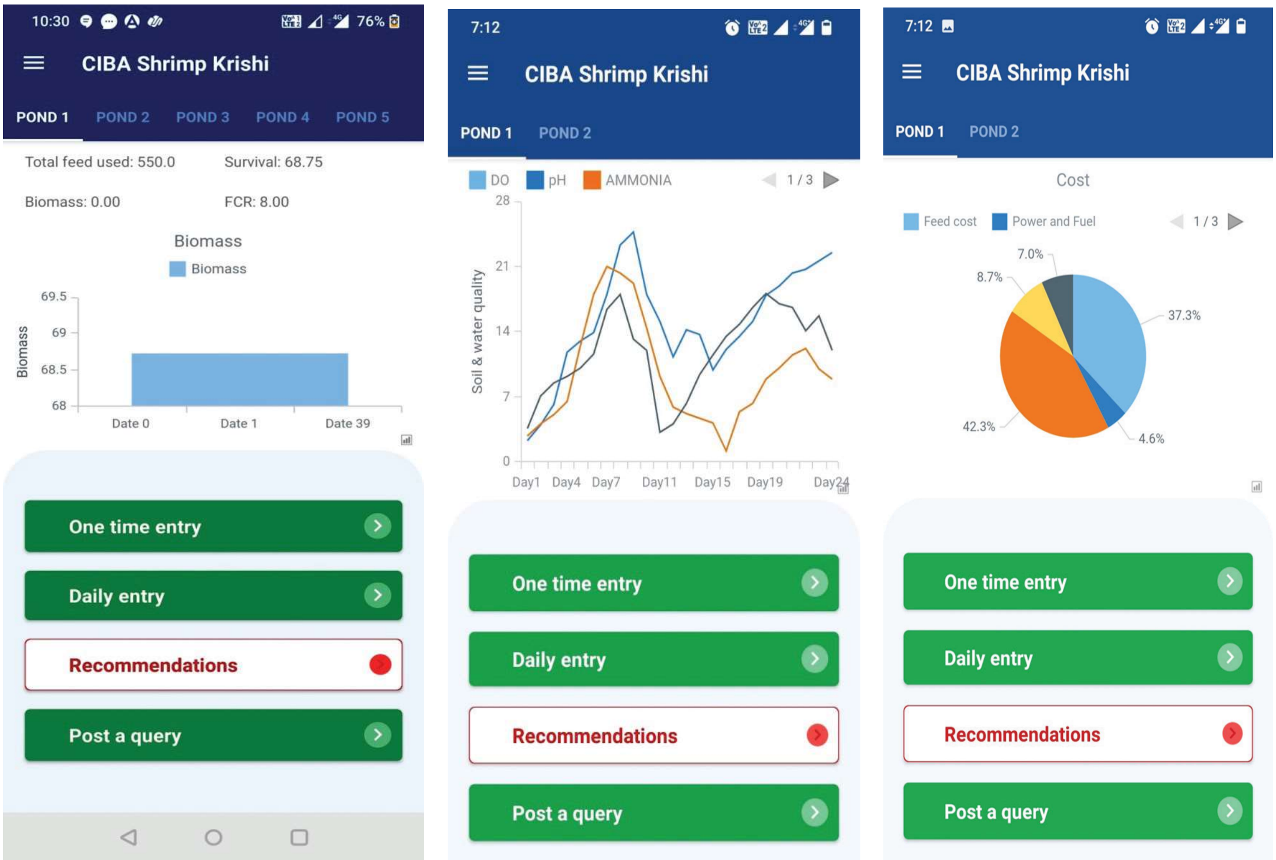
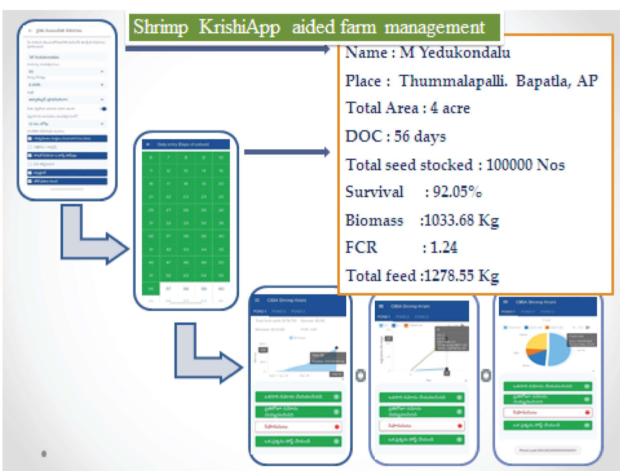


Fig 4: Graphical recommendations of shrimp pond parameters in the App



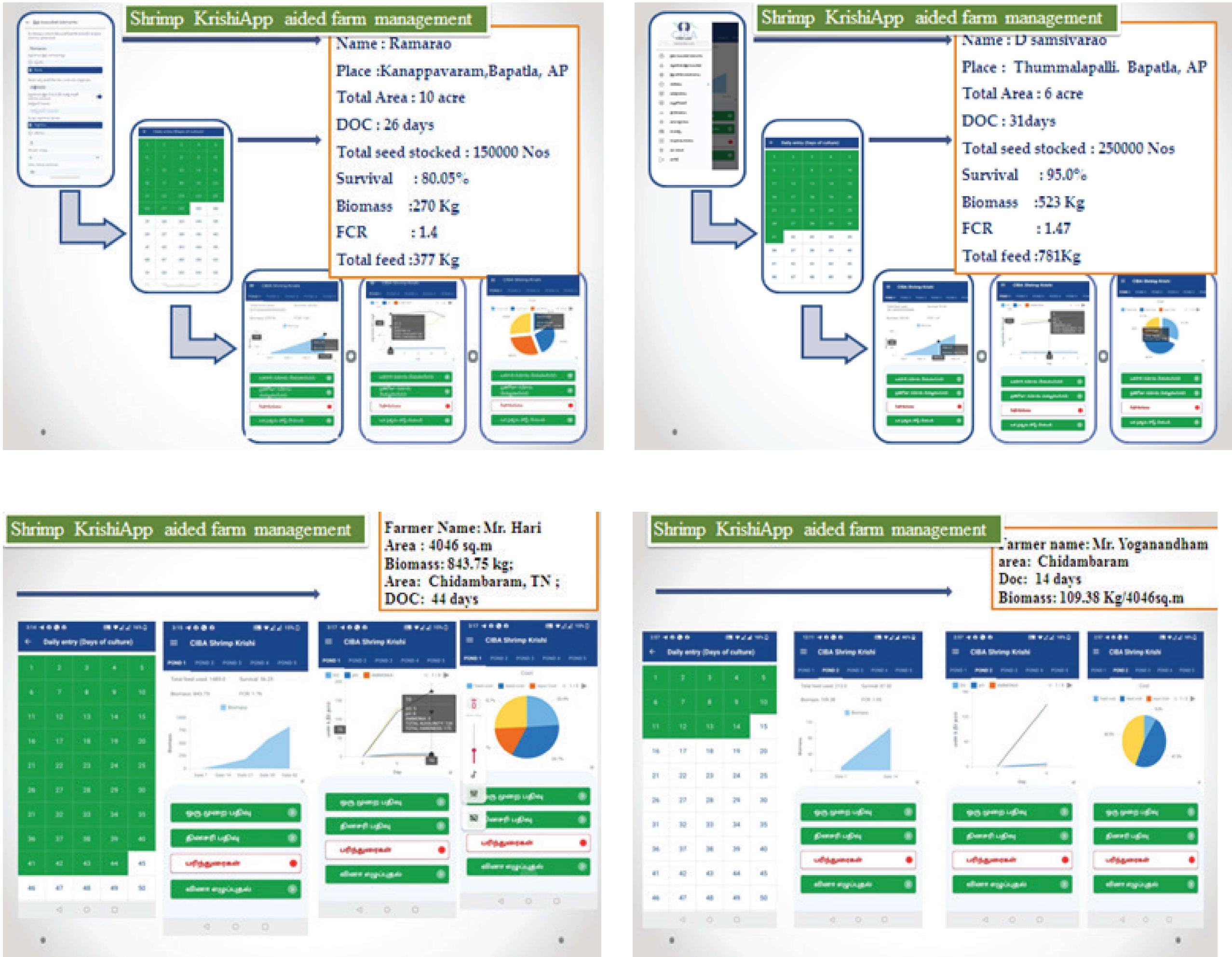


Fig 5: Successful adoption of CIBA Shrimp Krishi by the farmers

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.

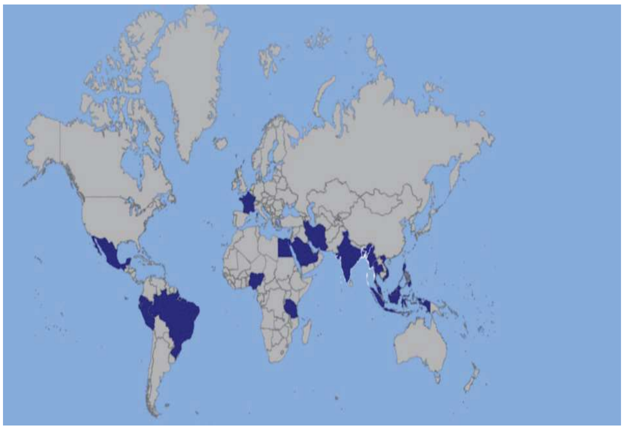


Fig 6: CIBA ShrimpApp users across countries

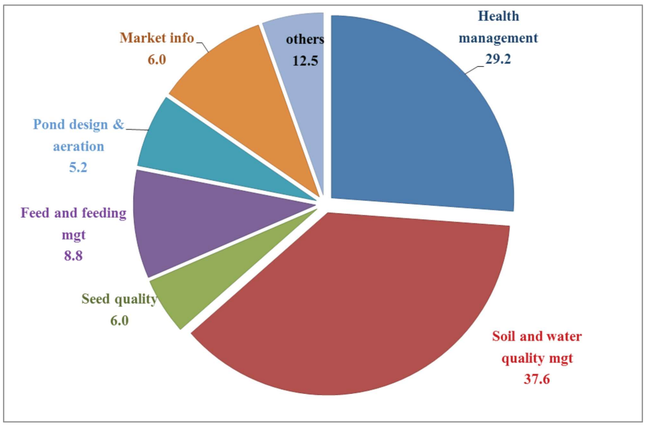


Fig 7: Subject matter wise queries received and answered through the app

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.

Developing innovative technologies for Indian shrimp farming

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Innovation and technology are the main drivers of societal development since ancient times. Similar to other areas food animal production systems especially aquaculture is highly technology driven. Technological interventions are required at all stages of aquaculture practices in shrimp production value chain. Major areas of shrimp production from seed production in hatchery to processing and supply to both domestic and international markets are highly technologically challenging. Academic and research organizations under national agriculture research system and private entities are investing heavily on innovation and technology development in the country. Among the food production systems, shrimp farming is one of the most organized, regulated and technologically backed operation.

Major technological areas of shrimp production value chain include, seed production and farming, nutrition and feeding and animal health and environmental management. Under Indian Council of Agriculture Research (ICAR), Central Institute of Brackishwater Aquaculture (CIBA), Chennai is involved in development of technologies for improving the economic and environmental sustainability of the sector. In addition to the technologies developed in India, farmers continue to adopt the technologies developed in other south East Asian countries for improving the production and productivity. This chapter highlights the technologies developed at ICAR-CIBA and their benefits to the farming community. It is expected that more number of technologies are being practiced by the Indian shrimp farmers.

Technology profiling

1. **Seed production and farming technologies**
    a. Domestication of Indian White Shrimp, *P. indicus*
    b. Biofloc technology for shrimp nursery
    c. Hatchery seed production
        i. Asian seabass (*Lates calcarifer)*
        ii. Milkfish (*Chanos chanos*)
        iii. Pearlspot (*Etroplus suratensis*)
        iv. Long whisker catfish (*Mystus gulio)*
        v. Silver moony fish (*Monodactylus argenteus)*
    d. Nursery and pre-growout seed rearing methods
    e. Cage culture for nursery, pre-growout and grow-out
    f. Polyculture technology for brackishwater finfishes
    g. Hatchery for Mudcrab, *Scylla serrate*
    h. Production of marine polychaete, *Marphysa gravelyi*

- i. Integrated Multitrophic Aquaculture
- j. Hatchery seed production of
    - i. Spotted scat (*Scatophagus argus*)
    - ii. Mangrove red snapper (*Lutjanus argentimaculatus*)

2. Nutrition and feed management technologies

- a. Indigenous shrimp feed processing
- b. Green Shrimp BT feed for organic shrimp
- c. Shrimp Larvi^{Plus} Vanami^{Plus} for grow out *P. vannamei*
- d. Seebass Larvi^{Plus} Nursery^{Plus}, Seebass^{Plus}
- e. EtroBrood^{Plus}
- f. Milkfish Brood^{Plus} , Nurserry ^{Plus} Growout ^{Plus}
- g. Poly^{Plus} for polyculture of fish and shrimp
- h. Kalor Fish^{Plus} for ornamental fish
- i. Cylla^{Plus} Mud crab grow out feed
- j. Functional Feed for different species
- k. Plankton^{Plus} Plankton booster from fish waste

3. Aquatic environment management technologies

- a. Multi-parameter water quality analysis kit
- b. Online Web Tool for Carrying capacity estimation of source waters for optimization of shrimp aquaculture development
- c. Oxygen releasing compound (ORC) for enhancement of dissolved oxygen
- d. Modified Bentonite material for controlling eutrophication (Phosphate)
- e. Biochar product from pond sediment
- f. Collection of GHGs flux from aqua ponds
- g. Soil probiotic

4. Disease diagnostic and therapeutic technologies

- a. CIBASTIM- immune stimulant
- b. CIBAMOX- water probiotic
- c. Nested & RT PCR kit for WSSV
- d. Nested & RT PCR for EHP
- e. Nested & RT PCR VNN
- f. Lumi^{Phage} bacteriophage- vibrio
- g. Para^{cide} - anti-parasitic agent
- h. Vaccine for VNN

CIBA Plankton ^{Plus} - a novel technology for recycling fishwaste

- CIBA-Plankton ^{plus}" is a unique technology developed by CIBA in which fish waste has been converted to two value-added products CIBA-Plankton^{Plus} and CIBA-Horti^{Plus}
- The products are developed under the concept "waste to wealth" in Swachh Bharat initiatives of Govt. of India.
- The technology addresses three major issues in the fisheries and aquaculture sector
    - The fish waste/trimmings generated in landing centres and markets create serous environmental issues if not recycled or disposed.
    - The shrimp farmers often face low productivity due to the crash or low plankton bloom in the culture ponds. A healthy plankton bloom is a critical necessity for good shrimp crop.
    - The livelihood security of underprivileged coastal people who are involved in marine catch and may not be having regular income.
- CIBA-Plankton^{Plus} ensure healthy bloom of phytoplankton and increase the density of zooplankton in aquaculture ponds and in turn enhance the productivity.
- The present technology of producing value added products from fish waste ensures the opportunities for livelihood security to the coastal communities.
- Conversion of waste to Plankton^{Plus} solved sanitary issues due to piling up of fish waste in adjoining area of fish market
- CIBA-Plankton^{Plus} is a nnutrient rich soup with high protein (45-55%), lipid (15-20%), amino acids (Histidine, Cysteine, Lysine and glutamic acid), essential fatty acids (EPA & DHA) and minerals.
- The CIBA-Plankton^{Plus} is effective under wide range of salinity (0 to 47 ppt) and it enhances the abundance and diversity of phytoplankton and zooplankton for aquaculture.
- It reduces the requirement of formulated feed to the tune of 20-30 % for shrimp and fish without affecting growth and production performance.
- It improves the survival of shrimp and fish to the tune of 10.00 -15.00%.
- It enhances average body weight of shrimp and fish to the tune of 9.00-19.00%.
- CIBA-Plankton^{Plus} helps to enhance the production to the tune of 1.2 to 1.7 t/ha of shrimp.

Seed Production Technology of Asian seabass *Lates calcarifer*

Institute developed technology for hatchery seed production of Asian seabass for the first time in 1997. Over years the technology has been refined to achieve year round seed production using hormonal manipulation in RAS based systems to make sure the seed availability to the farmers throughout the year. CIBA is distributing 1.0 to 2.0 million seabass seed annually to farmers in coastal states of Kerala, Tamil

Nadu, West Bengal, Andhra Pradesh, Maharashtra, Karnataka, Odisha, Gujarat etc for farming, which has resulted in boosting seabass production in country.

- Seabass farming has vast potential areas for farming in marine, brackish and freshwater bodies due to its euryhaline nature (salinity tolerance 0 to 40 ppt). As high valued species, seabass has huge demand due to consumer preference for unique taste, texture and white meat.
- Hatchery and culture technology can be easily adopted by small scale farmers to entrepreneurs and corporates.
- Small farmers, SHG and societies can take up production of fingerlings from fry stage by adopting scientific nursery farming technology (Cage/Pen) to meet stockable size seed demand
- Culture of seabass from nursery rearing ensures profit percentage of 90-100% from fry to fingerlings production.
- Grow out culture system results in pond productivity of 3.5 t/ha with production cost of Rs.250/- per kg fish fetches Rs.400 to 500/- per kg on farm site.

Seed Production Technology for Milkfish *Chanos chanos*

The institute has developed captive maturation and induced breeding technology of milkfish (*Chanos chanos*) during 2015 and paved the way for farming of fast growing herbivorous fish species. The technology has been refined over the years for extended seed production of milkfish for eight months (March-October) in captivity with hormone pellete implantation. Milkfish (weight 5.5 to 8.2 kg/ total length 93 to 104 cm) can be induced breed multiple time in a season with average fecundity of 0.3-1 million eggs/kg in tank based system. In the hatchery milkfish fry (around 1 inch) can be produced in one month after larval rearing in 30-33 ppt salinity. Fry can be stocked in ponds for nursery rearing in varied salinities. Hatchery produced seed has been distributed to farmers from Kerala, Tamil Nadu, West Bengal, Odisha, Gujarat, Andhra Pradesh, Goa, Uttar Pradesh for popularization.

- Milkfish is an important candidate species suitable for brackishwater aquaculture. It is an herbivore fish, disease resistant, tolerate wide range of salinities and accept low protein pellet feed under culture conditions.
- Private entrepreneurship can collect fertilized eggs of milkfish from CIBA to develop satellite nursery rearing unit to jumpstart seed production.
- Small farmers, SHG and societies can take up grow out farming in form of monoculture, polyculture (with grey mullet, pearl spot etc.) and mix farming with shrimp (green water farming, enhances shrimp immunity).
- Average productivity of milkfish farming is 4.0-4.5 t/ha (monoculture) with production cost of Rs. 110-115/kg with benefit cost ratio (BCR) of 1.63- 1.75. Milkfish can be sold at Rs.180-200/ kg.

umi[phage]: Biocontrol of vibrios in shrimp hatcheries using bacteriophages

- Luminescent vibriosis causes significant economic loss to shrimp farms
- Biocontrol using bacteriophages is an important therapeutic measure.
- Bacteriophages are viruses that selectively infect and kill bacteria
- Highly specific to the pathogen strain and safe to host and non-targeted microbes
- Controls pathogenic vibrios
- Applicable to use in shrimp hatchery, nursery, and grow-out
- Used as water application or oral administration
- Can be used as an alternative to antibiotics
- Compatible to use along with probiotics
- Works both as prophylactic and therapeutic
- Effective in low doses

CIBAMOX: Water probiotics for controlling nitrogenous metabolites

- Innovative combination of autotrophic ammonia, and nitrite oxidizing bacterial consortia from brackishwater environments.
- Microbes have been selected based on their fast growth, and high oxidation efficiency.
- Mass production protocols were economised and standardised
- Bulk production protocol is simplified for easy and high quality
- Low capital investment and operating cost
- Water application for efficient performance
- Effectively removes nitrogenous wastes form aquaculture ponds
- Works at wide range of salinity 2-45 ppt
- Reduces environmental stress
- Natural remedy for removal for toxic ammonia and nitrite
- Easy water application
- Weekly dose of 5L/ha/week
- Safe to user, culture animal and environment
- Applicable to shrimp and fish farms

Recombinant viral nervous necrosis vaccine for finfish

Viral nervous necrosis (VNN) is a lethal viral disease of marine, brackishwater and freshwater species caused by Nervous necrosis virus (NNV) resulting in up to 100% mortality in larval and early juvenile stages. The disease is transmitted both horizontally and vertically. Adult infected fish remain as carrier and transmit the disease to offspring. CIBA-Nodavacc-R is a recombinant monovalent VNN vaccine for Asian seabass. The vaccine contains recombinant capsid protein of NNV emulsified in commercial adjuvants. The vaccine can be administered intraperitoneally to broodstock and fingerlings.

The injectable vaccine when administered to Asian seabass broodstock can prevent vertical transmission of the virus and result in transfer of maternal antibodies to offspring which can prevent mortality in early larval stages. The vaccine can be used in Asian seabass fingerlings to reduce the loss due to VNN. The vaccine can also be used in other brackishwater and marine species for preventing outbreak of VNN and reduce loss due to the disease.

Vanami ^{Plus}: Cost effective indigenous shrimp feed

ICAR-CIBA's focused research on nutrient requirements of shrimp, expertise in scientific feed formulation, feed processing, database on price and seasonality of locally available ingredients led to a cost-effective shrimp feed using indigenous feed processing technology. Highly palatable feed with good FCR helps in reducing the cost of production and performing on par with best brands of commercial feeds with 20% reduction in the cost of feed.

Feed cost to produce 1 kg of shrimp can be restricted to Rs. 110 to 120 by using indigenous shrimp feed, it goes up to Rs.150 with branded commercial feeds. The feed showed impressive performance and the farmers could reduce the cost of production of shrimp (*P. vannamei*) from Rs.250- 260 per kg to 190-200 per kg. The technology is suitable for medium and small scale entrepreneurs. A big farmer / group of farmer in a cluster can establish a small scale feed mill in each shrimp farming cluster of 300-400 hectares

Water Analysis Kits

- Multi parameter water analysis kit can be used for the analysis of dissolved oxygen, pH, ammonia (0.1 to 2 ppm), nitrite (0.05 to 1 ppm), calcium, magnesium, total hardness, carbonate, bicarbonate and total alkalinity in different source and pond waters
- Results based on the colour chart and no. of drops
- Requires less amount of water sample
- Sensitive and accurate (± 5 % error compared to laboratory analysis).
- Minimal chemicals usage for maximum samples analysis
- The multiparameter water analysis kit is useful for the estimation of key water parameters by aquaculture farmers, hatchery operators and consultants, which helps in maintaining the critical water quality parameters within the optimum levels.
- Regular monitoring of water parameters using these kits can save the time and money of the farmer and will help in taking up immediate measures for preventing the loss.
- Wider range of detection and can be used in freshwater, brackishwater and coastal waters.
- Cost effective and User-friendly and easy to use in the field and laboratories.

- These kits have good market potential as most of the farmers and even aqua laboratories are using the kits for the analysis of water parameters.

Successful public private collaborations in Indian shrimp aquaculture sector

- Establishment of shrimp hatchery
- Import and sale of shrimp broodstock feed
- Shrimp farming technologies- biofloc, RAS, Cage
- Consultancy services-farming, manufacturing, policy
- Manufacturing- feed, health care products, chemicals, equipments, diagnostic kits etc.
- Marketing and sales
- Processing and value addition
- Export of fish and fishery products

Agencies supporting the sector

1. Department of Fisheries, Animal Husbandry and Dairying , GoI
2. Department of Fisheries in all the states
3. Coastal Aquaculture Authority (CAA)
4. Central Institute of Brackishwater Aquaculture (CIBA)
5. Central Institute of Freshwater Aquaculture (CIFA)
6. Marine Products Export Development Authority (MPEDA)
7. Export Inspection Agency (EIA)
8. Seafood exporters Association of India (SEAI)
9. Farmers organizations like NACSA
10. All India Shrimp Hatchery Association (AISHA)
11. Society of Aquaculture Professionals (SAP)
12. Many more such organizations

Scope for diversification of brackishwater aquaculture 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)
Species - argentimaculatus (Forskaal 1775)

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.

PROGRAMME SCHEDULE

ICAR-CIBA TRAINING PROGRAMME ON RISK MANAGEMENT IN SHRIMP AQUACULTURE : SENSITIZATION PROGRAMME FOR OFFICERS OF BANKS AND INSURANCE SECTOR

Day 1	**Date : 01.03.2023**		
9.00 to 9.30 hrs	Registration		
9.30 to 10.30 hrs	Inauguration programme		
10.30 to 11.00hrs	Global Fisheries and Aquaculture Scenario - Dr.Kuldeep K. Lal, Director, ICAR-CIBA, Chennai		
Time (hrs)	**Session**	**Coordinators**	
		Research	**Industry**
11.00 to 12.15	Overview of shrimp aquaculture in India	Dr. M. Jayanthi, Principal Scientist & Scientist In-charge, Crustacean Culture Division, ICAR-CIBA, Chennai	Dr. S. Santhanakrishnan, CEO, Maritech, Pvt. Ltd., Chennai
12.15 to 13.30	Institutional and Regulatory framework for shrimp aquaculture in India	Dr.C.V.Sairam, Principal Scientist & Scientist In-charge, Social Sciences Division, ICAR-CIBA, Chennai	Dr.V.Kripa, Member Secretary, Coastal Aquaculture Authority (CAA) Dr (Smt.) Suvarna Chandrappagari, IFS, Chief Executive Smt. Usha P. T. General Manager, NABARD, RO, Chennai
13.30 to 14.15	**LUNCH BREAK**		
14.15 to 15.30	Diversification of species / systems in shrimp farming	Dr.A.Panigrahi, Principal Scientist, Crustacean Culture Division, ICAR-CIBA, Chennai	Dr. P. Ravichandran Ex-Director (CIBA) & Ex-Member Secretary, CAA
15.30 to 15.45	TEA BREAK		
15.45 to 17.00	Health management in shrimp farming	Dr.S. K. Otta, Principal Scientist, Aquatic Animal Health and Environment Division, ICAR-CIBA, Chennai	Mr. D. Ramraj, Managing Director, Padmanabha Labs Pvt. Ltd, & HiBreeds Aquatics
17.00 to 18.00	Visit to laboratories at HQ		
19.30	**DINNER** Hosted by **Alliance Insurance** Venue: **IMAGE Guest House**		

Day 2	**Date : 02.03.2023**	**Coordinators :** Dr. A. Panigrahi / Dr. P. K. Patil	
8.00 to 12.00	Visit to shrimp hatchery		
12.00 to 13.30	Visit to shrimp grow-out farms		
13.30 to 14.00	**LUNCH BREAK**		
14.00 to 17.00	Visit to Muttukadu and Kelambakkam Experimental Stations		
19.30 PM	**DINNER** Hosted by **Dr. S. Santhana Krishnan, Maritech, Chennai** Venue: **Restaurant ECR Road**		
Day 3	**Date : 03.03.2023**		
9.00 to 10.00	Soil and water quality management in shrimp farming under varying weather scenarios	Dr. M.Muralidhar, Principal Scientist, Aquatic Animal Health and Environment Division, ICAR-CIBA, Chennai	Dr.P.Ram Mohan Rao, Deputy Director of Fisheries (Rtd). Chief Consultant, M/s. Sunrise Aqua Labs, Kakinada, AP
10.00 to 11.00	Significance of nutrition and feed in shrimp farming	Dr.K.Ambasankar, Principal Scientist& Acting Head, Nutrition, Genetics and Biotechnology Division ICAR-CIBA, Chennai	Dr.V.Rajaram, Nutritionist, Grobest Feeds Corporation India Pvt Ltd, Chennai
11.00 to 11.15	**TEA BREAK**		
11.15 to 12.15	Capital, credit requirements and profitability of shrimp farming	Dr.T.Ravisankar, Principal Scientist, Social Science Division, ICAR-CIBA, Chennai	Dr. V. Balasubramaniam, Prawn Farmers Federation of India, Tamil Nadu
12.15 to 13.00	Potential of crop insurance in risk mitigation	Dr.T.Ravisankar, Principal Scientist Social Science Division, ICAR-CIBA, Chennai	Mr. C. A. Srinivasan Alliance Insurance, Chennai Ms. Anupam Bansal Chief Actuary, AIC New Delhi
13.00 to 13.45	**LUNCH BREAK**		
13.45 to 14.45	ICT applications for shrimp farm management	Dr. M.Kumaran, Principal Scientist Social Science Division, ICAR-CIBA, Chennai	Dr. P. E. Cheran, Shrimp Farm & Hatchery Consultant
14.45 to 15.45	Innovations, startups and incubation in shrimp farming	Dr.P.K.Patil, Principal Scientist and Officer In Charge, Institute Technology Management Unit (ITMU), ICAR-CIBA, Chennai	Dr. A. Ravikumar, Alpha Biologicals, Nellore
15.45 to 16.45	Scope for diversification with alternate species	Dr. M. Kailasam, Principal Scientist Fish Culture Division, ICAR-CIBA, Chennai	Mr. Jaideep Kumar, Editor, Aquaculture Spectrum
16.45 to 17.30	Panel discussion & Valedictory Function	Director, ICAR-CIBA, faculties and trainees	