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Mariculture Development in India: Status and Way Forward

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Mariculture has immense potential in India in the context of fast-growing demand for seafood, which cannot be met by capture fisheries sector alone. Mariculture can also play an important role in increasing fish production from the coastal and offshore waters by involving local fishers and entrepreneurs to take up the activity. The pioneering attempts for mariculture development in the country by ICAR-Central Marine Fisheries Research Institute (CMFRI) on seed production and farming of finfishes such as cobia, silver pompano, Indian pompano, sea bass, groupers, snappers, breams and ornamental fishes, shell fishes such as molluscs, marine pearl production and seaweed farming, sea-cage farming, Integrated Multitrophic Aquaculture (IMTA). Recirculating Aquaculture System (RAS) and aquatic animal health management are highlighted and suggested strategies for way forward.

Introduction

Globally, aquaculture has emerged as a fastest growing food production sector with an annual growth rate of >6% in the last two decades. Mariculture is the fastest growing subsector of aquaculture and has very high growth potential. In 2020, mariculture contributed around 33.0 million tonnes of food fish, which formed about 27% of the global food fish aquaculture production. The total mariculture production including seaweeds was 68.1 million tonnes, which constituted 55.6% of the total world aquaculture production during 2020. Mariculture has immense potential in India in the context of fast-growing demand for seafood, which cannot be met by capture fisheries sector alone. The National Policy on Marine Fisheries (NPMF, 2017) clearly states that mariculture can play an important role in increasing fish production from the coastal waters and the government will address the Institutional and commercial needs of this emerging sector, which will include leasing rights policies, spatial planning, technological inputs such as husbandry, seed, feed and health management, environmental and social impacts as well as capacity building of local fishers and entrepreneurs to take up mariculture. The pioneering attempts for mariculture development in the country was initiated by ICAR-Central Marine Fisheries Research Institute (CMFRI) in the 1970s in Mandapam and Tuticorin with seaweed and bivalve culture, followed by attempts in induced maturation and breeding of Indian white shrimp in Njarakkal, Kerala and promoting semi-intensive shrimp farming in Kerala. Though India has a projected mariculture production potential of 4 to 8 million tonnes annually, the current mariculture production is less than 0.1 million tonne. However, the lessons learned from the successful expansion of inland and brackishwater aquaculture in India could be capitalized to boost mariculture production in a phased manner. This involves making the best use of available technologies such as seed production and farming of finfishes such as cobia, silver pompano, Indian pompano, sea bass, groupers, snappers, breams and ornamental fishes, shell fishes such as mussels, oysters, clams, green tiger shrimp and blue swimmer crab. Technologies for marine pearl production and seaweed farming are also available in the country.

Recent Developments

In recent times, the Government of India has taken several measures to streamline mariculture development in the country. Recognizing the prospects offered by the sector, the National Fisheries Development Board (NFDB) had constituted a committee with Director, CMFRI as the Chairman to prepare the Draft National Mariculture Policy (NMP). The Policy addresses various aspects such as mariculture area development, leasing and licensing, mariculture systems and species, environmental sustainability, seed and feed development, health management, certification, insurance, market support as well as institutional and legal framework. The Committee submitted its final report in November, 2019 and is presently under the consideration of the Ministry of Fisheries, Animal Husbandry and Dairying.

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Another major initiative to boost mariculture production is the establishment of National Brood-bank Facility for cobia and silver pompano by CMFRI. It is aimed to enhance the availability of quality seeds of cobia and pompano which are the most suitable species for sea-cage farming in Indian waters. CMFRI has established brood bank facilities at its Centres in Mandapam and Vizhinjam with a targeted production of 48 million silver pompano larvae and 30 million cobia larvae per year. The institute has also signed Memorandum of Understandings (MoUs) with seven Private/ State run facilities for technology transfer and seed production of these species. The All India Network Project on Mariculture [AINP (M)] is another major ongoing initiative to address technological constraints in mariculture. It is being headed by CMFRI and has five collaborating partners across the coastline. For development of seed production and farming technologies, ICAR-CMFRI has prioritized 76 species, which include marine finfishes (food and ornamental), shellfishes and invertebrates. Research efforts has so far yielded fully mature technologies for round the year seed production of six marine finfishes (cobia, silver pompano, Indian pompano, orange spotted grouper, pink ear sea bream and John's snapper) and 27 species of expensive marine ornamental species including five cross breds.

Sea Cage Farming

Sea cage culture has made a beginning for intensive production of commercial finfish in coastal areas in the country. Since inception in 2007, many innovations on designing and fabrication of cages and mooring systems were made. Subsequently, demonstrations of cage farming were undertaken under a participatory mode with the help of local fishermen co-operatives and entrepreneurs. ICAR-CMFRI has developed and standardized guidelines and practises including Good sea cage farming practices for different regions in the country. Two different versions of indigenously fabricated 6 m diameter cages (GI and HDPE) developed by ICAR-CMFRI are presently being adopted by fishers. On an average, 2-3 tonnes of fish can be produced in a 6-meter diameter cage per cycle. The net economic return per crop (8 months/year) ranges from Rs. 1.5-2.5 lakh depending on the species grown. A major scheme on sea cage farming was operational with NFDB support in Maharashtra, Tamil Nadu, Kerala and Karnataka under the Blue Revolution Scheme of the Union Government during 2017-2020 and under Pradhan Mantri Matsya Sampada Yojana (PMMSY) along Bahabalpur coast, Odisha during 2020 - 2022.

Suitable sites are to be demarcated for different mariculture activities such as cage farming, bivalve farming, pen culture, seaweed culture, hatcheries and nurseries based on scientific criteria and considering the socio-cultural attributes and other logistics. The potential zones for mariculture development should be identified based on the criteria developed through scientific evaluation of environmental parameters suitable for the type of farming, negligible impact on environment, avoidance of conflict with other users, protecting livelihoods of local fishing communities and ensuring their access to fishing grounds. Satellite remote sensing data and GIS can be employed to provide essential tools to support. Marine Spatial Planning (MSP) can be employed for data management, analysis, modelling and decision-making taking cognizance of CRZ zoning. The institute has identified and geo-referenced potential cage farming sites along the Indian coastline within 10 km (146 sites; 47384 ha) with a production potential of 2.13 million tonnes/year [based on the estimate that 15 cages (6 M dia.) can be accommodated in 1 ha, multiplied by the production figure of 3 tonnes/cage/year in an area of 47384 ha]. A planned massive programme to commercialize sea-cage farming will go a long way in realising the Blue Economy potential in India.

Integrated Multitrophic Aquaculture (IMTA)

The idea of bio-mitigation of the environment pollution along with increased biomass production integrating commercially important species of different trophic levels is emerging as an innovation in aquaculture. IMTA is the practice which combines appropriate proportions of the cultivation of fed aquaculture species (*e.g.* finfish/ shrimp) with organic extractive aquaculture species (*e.g.* shell fish/herbivorous fish) and inorganic extractive aquaculture species (*e.g.* seaweed) to create balanced systems for environmental stability (bio-mitigation) economic stability (product diversification and risk reduction) and social acceptability (better management practices). This concept is being adopted in cage aquaculture wherein appropriate proportions of finfishes/ shrimp with shell fish/herbivorous fish are integrated with sea weed farming. This system can mitigate the potential negative externalities of sea cage farming with simultaneous enhancement in seaweed yield. This technique (16 rafts of 12ft×12ft size installed around a 6m dia. cage) has proven to enhance sea weed yield by about 122% in one cycle (45 days) of seaweed farming (additional 176 kg per cycle/raft of 12ft×12 ft size) with commensurate income enhancement. The technology is currently adopted by more than 150 farmers in Palk Bay region with the support of CMFRI.

On a global basis the search for additional areas to expand aquaculture to satisfy the growing local and export markets are necessitating an expansion of its activities farther off the coast. Mariculture is considered "offshore" when it is located > 2 km or out of sight from the coast, in water depths > 50 m, with wave heights of 5 m or more, ocean swells, variable winds and strong ocean currents. The economic, technological and sustainability issues of developing offshore mariculture in India needs to be explored.

Recirculating Aquaculture System (RAS)

Recirculating aquaculture systems (RAS) are onshore systems, in which fish can be grown at high density under controlled environmental conditions. Recirculation systems use land-based units to pump water in a closed loop through fish rearing tanks and consist of a series of sub-systems for regular water treatment process. These facilities can be used for both seed production and grow out of fishes in a strictly controlled environment even for exotic temperate species such as Atlantic salmon. CMFRI has successfully developed and adopted cost effective RAS facility for year-round maturation of broodstock and seed production and for nursery rearing of seven species of marine finfishes. Such RAS facility has been popularized among stakeholders in different coastal States.

Culture of Seaweeds

Seaweed farming offers immense scope as a livelihood opportunity and for developing a large number of by-products with several applications. Seaweed farming has the advantage of low capital input, as it is a primary producer requiring no inputs. Sea weed farming has picked up as an economically viable farming practice over the past decade on the shores of Palk Bay, Tamil Nadu in India. A floating system of 3.7×3.7 m rafts with a 45-day farming cycle for a total of 270 production days per year is being practiced by the self-help groups (SHG) in the region. Considered as one among the most environmentally benign activity, it has considerable potential to augment the livelihoods of coastal dwellers in the country. A recent feasibility study conducted in the sea water inundated areas in South Andamans has revealed that these regions have huge potential for the enterprise. Similar studies need to be conducted in other suitable areas for enabling further spread of this promising livelihood activity. CMFRI has identified and geo-referenced potential seaweed farming sites along the Indian coastline within 10 kms (342 sites; 24167 Ha) with a production potential of 9.7 million tonnes (wet weight)/year [based on the estimate that 400 rafts (12ft×12ft) can be accommodated in 1 ha, multiplied by the production figure of 1 tonnes wet weight/raft/year in an area of 24167 ha]. Additionally, in future years, seaweed farming can earn carbon credits to the farmers. Farmed and wild collected seaweeds do not meet the current industrial demand for raw material. Large scale production of seaweed planting material through micropropagation and development of processing and marketing are highly essential for future expansion of seaweed farming in India.

Bivalve Farming

Mussel and oyster culture have gradually spread across the backwater belts of Kerala, Karnataka, Goa and Maharashtra owing to their high profitability. A number of methods such as stake culture, on-bottom culture, long-line culture, raft culture, rack culture, etc. are followed for mussel and oyster farming. Over 2000 farmers are practicing rack culture of green mussel in North Kerala, especially in Padanna estuary areas in Kasaragod, which is contributing to three forth of green mussel production in India. CMFRI has established commercial farming of green mussels and edible oysters in coastal areas along the west coast of India with an annual production of over 10,000 tonnes benefitting nearly 6000 women self-help groups (production cost of Rs 90/kg versus with a farm-gate price of Rs 200/kg for green mussel; production cost of Rs 5/- per oyster versus with a farm-gate price of Rs 15/oyster). Though technology for mussel and oyster farming is fairly well available, what is lacking is adequate marketing and processing infrastructure. More number of entrepreneurs may be encouraged to take up these ventures by providing technological, financial, marketing as well as logistical support. Currently Indian bivalves are not exported to Europe, as the produce does not meet the monitoring protocols set by the EU. The focus here has to be on classification of bivalve growing water bodies following the regulations of the European Union (EU Directive 2006/113/EC). It is also necessary to make a prospective (5 years) plan to improve hygiene in farming areas using international guidelines as a criterion and to conduct awareness campaigns for improving bivalve consumption in India. Although ICAR-CMFRI has developed the technology for cultured spherical and *Mabe* pearl production and pearl oyster seed production (hatchery technology), the high investment costs for these has been the limiting factor in the commercialization of these technologies. The gestation period (2½ to 3 years) in the attainment of appropriate size of the pearl oysters (suitable for surgery) is the major impediment in the commercialization process. Selective breeding of native stocks for faster growth and larger size and or production of triploid oysters – which can hold larger nucleus are the options.

Seed and Feed

To meet the additional requirement for seed of cultivable species in future, innovative measures need to be taken for establishing hatcheries, seed banks, rearing units and SPF/SPR/genetically improved brood banks. A system of seed certification can be developed by agencies concerned in order to ensure supply of quality seed. Financial and technical backstopping needs to be provided to establish hatcheries. Establishment of a few marine finfish brood banks is needed to provide fertilized eggs/newly hatched larvae to the hatcheries where further rearing and seed production can be carried out. Centres for the supply of fresh stock of fragments and import of germplasm of seaweeds after necessary quarantine also need to be set up.

The fish meal is the major protein component and determines the cost effectiveness of the feed. The increasing demand for the fish meal in poultry and shrimp farming sector results in steady increase of feed prices threatening economic viability of mariculture operations. Besides, global concern on use of fish meal produced from low value fishes which are consumed by people also force us to look for an alternative. Hence, replacement of fish meal with other protein sources of plant and animal origin needs to be explored without compromising the nutritional requirements of fishes grown in mariculture system. To ensure alternate protein sources for fish feed which is more sustainable, efforts are being made to develop feeds based on insect meal. Ongoing research efforts in this direction in CMFRI is focussed on fish feeds based on the larvae of black soldier fly (*Hermetia illucens*) which has the potential for large scale culture. Further, efforts may be directed to develop species specific feeds including microfeeds meant for larval nutrition, which are customized to suit the growth patterns of individual prioritized mariculture species for efficient and economically viable production. As mariculture picks-up momentum, commensurate efforts are needed to establish decentralized fish feed production centres both under private management as well as in PPP mode to meet the demand for feed.

Aquatic Animal Health Management

In Indian mariculture scenario, most of the bacterial diseases are caused by opportunistic pathogens such as *Vibrio* sp., *Photobacterium* sp. and *Streptococcus* sp. resulting in significant economic losses. Similarly, the disease caused by *Perkinsus olseni* and *P. beihaiensis* is a major threat to bivalve farming. Diagnostic tools to detect these pathogens have been developed by ICAR-CMFRI. Fish farming favours infectious diseases and therefore requires investment in disease management. A National Surveillance Programme Aquatic Animal Diseases (NSPAAD) was launched in India under the leadership of the National Bureau of Fish Genetic Resources (NBFGR) during 2013 for five years funded by the NFDB to monitor aquatic animal diseases including those which infect marine finfish and shellfish species covering fourteen Indian states with passive and active surveillance in more than 100 districts covers. In this project, CMFRI has been actively involved in screening of bivalve pathogens such as *P. olseni* and *P. beihaiensis* along the west coast of India.

Green Certification of Marine Ornamental Species

CMFRI has successfully standardized the breeding and seed production of 27 high value marine ornamental fish species which are highly demanded in the international market. Four crossbreds/designer varieties of Percula clown fishes have also been developed. The potential for the development of ornamental fish trade in India is immense, though it is still in a nascent stage. The Government of India has identified this sector as one of the thrust areas for development to augment exports. The turn of the century has seen a spurt in the collection, culture and trade in marine ornamental fishes. For the trade to prosper, the three pre-requisites are quality, quantity and sustainability. A large part of ornamentals is still collected from the wild thereby damaging the fragile coral ecosystem and hence awareness generation among local communities and stakeholders to desist from unlawful and illegal practices of catching ornamental fishes from the wild are important. The trade should also encourage protection of the habitat for an eco-friendly approach. Green certification is the certification given to a product to ensure its environmental and socioeconomic sustainability. It ensures product quality, safety and traceability. Keeping in line with these concepts, CMFRI is currently preparing guidelines on Green certification on Indian marine ornamental fishes.

Marketing and Value Chain Development

Due to the seasonality involved in Mariculture production systems, chances are high for market glut during harvest seasons. The highly perishable nature of the harvested produce makes it necessary to develop efficient value chains that ensure timely clearance of harvested produce at minimum cost. Value chain of Mariculture produce starts from the farm and extends through an elaborate set of intermediaries such as auctioneers, wholesalers, commission agents, retail outlets and processors till it reaches the consumer. Efficient market logistics (insulated trucks/refrigerated containers, cold/chilled storage facilities, packaging, etc.) play a major role in ensuring the quality of the final product. Post-harvest processing and value addition also constitute an important link of the extended value chains of Mariculture produce. In this backdrop, the government need to take special initiatives to ensure the comprehensive development of Mariculture value chains. Infrastructure requirements for Mariculture produce marketing should be addressed on a priority basis. Necessary financial assistance, capacity building, technical guidance and institutional support are to be extended to the various stakeholders involved in the value chain.

Way Forward

There is growing recognition that mariculture is an emerging sector that will evolve with innovative technologies and inputs as it grows. It is envisioned that by 2050, India can produce about 4.1 million tonnes per annum of marine fish through cage culture alone if one per cent of the total coast line (8118 kms) can be utilized for mariculture. For this, the country has to develop dedicated mariculture parks as envisaged in the draft NMP, which would be managed by local fishermen groups/co-operatives/entrepreneurs. It is to be ensured that, the requirements of seed (about 2460 million) and feed (about 6.15 million tonnes) are to be commensurately ensured to meet the future demand from the sector. Sustainable development of mariculture would go a long way in making India a leading seafood producer in the world.

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