MARICULTURE ADVANCEMENTS SUITABLE FOR DEVELOPING NATIONS

Boby Ignatius and N. Rajesh

ICAR-Central Marine Fisheries Research Institute, Kochi
E-mail: bobycmfri@gmail.com

Introduction

Mariculture, which involves the cultivation of marine organisms for food and other products, holds significant potential for developing countries. In developing countries, mariculture can provide a sustainable source of food, income, and employment opportunities. There are various mariculture technologies available that can be adapted to local conditions and resources. Some of these technologies include cage culture, Marine finfish hatchery, marine ornamental fish farming, and seaweed farming. These technologies can help improve food security, reduce poverty, and promote sustainable development in coastal communities.

Key considerations and potential benefits

1. Diversification of Livelihoods: Mariculture can provide an alternative source of income and livelihood diversification for coastal communities in developing countries. It has the potential to create employment opportunities, particularly for small-scale fishers and local communities.
2. Food Security: The practice of mariculture can contribute to improving food security by providing a sustainable source of seafood, reducing pressure on wild fish stocks, and increasing access to nutritious marine protein.
3. Environmental Sustainability: When managed responsibly, mariculture can contribute to the conservation of marine resources by reducing the need for overfishing and preventing habitat destruction.
4. Economic Development: Mariculture has the potential to contribute to the economic development of coastal areas in developing countries through the export of marine products, tourism related to aquaculture activities, and investments in related infrastructure.
5. Technological Transfer and Capacity Building: Implementing mariculture projects can facilitate the transfer of relevant technologies and knowledge, as well as the development of local expertise. This can contribute to building institutional and human capacity in the field of sustainable aquaculture.
6. Community Empowerment: Supporting local communities in establishing and managing mariculture operations can empower them to take ownership of their resources and economic activities, leading to improved governance and social well-being.

It's important to note that successful mariculture development in developing countries requires careful planning, consideration of environmental and social impacts, and adherence to sustainable practices. Collaboration with local communities, government agencies, and international organizations is crucial to ensure that mariculture initiatives are implemented responsibly and inclusively. Additionally, addressing challenges such as access to financing, market development, and infrastructure is important for the long-term success of mariculture in developing countries.

Mariculture technologies for enhancing livelihood options

The dwindling catch rates in capture fisheries and rampant unemployment in the coastal region focus towards the development of mariculture and coastal aquaculture as a remunerative alternate occupation. Mariculture is the only sunrise sector for increasing seafood production in the coming years as a substantial contributor to seafood production in the country.

Marine cage farming

Cage farming stands as a pivotal technology in mariculture, significantly bolstering fish production. These cages, comprised of a floating frame, net materials, and a mooring system, take various shapes such as round, square, or rectangular, facilitating the housing and cultivation of a substantial number of fish. Positioned in the sea, these enclosures serve as habitats where juvenile aquatic animals are stocked, nurtured, and raised to a marketable size.

The practice of fish farming within cages not only optimizes the utilization of marine systems for production but also presents a lucrative opportunity for impoverished coastal communities. Looking ahead, marine fish aquaculture is expected to gain more traction, possibly being adopted on a smaller scale by residents living along coastlines. The utilization of floating fish cages simplifies harvesting procedures and shields the fish from potential predators. The confined space within the cages results in reduced energy expenditure for the fish, thereby enhancing food conversion efficiency. Moreover, the cages' mobility and the abundance of clean, oxygenated water typically eliminate constraints in cultivation. However, this method does come with its own set of challenges. Fouling or algae accumulation on cage walls necessitates regular cleaning and replacement. High density within the cages may contribute to disease and parasite outbreaks, demanding labour-intensive and meticulous care. Additionally, the susceptibility of many fish species to elevated pollutant levels poses a significant concern in this farming method.

Cage-farmed fishes include mostly cobia, pompano, grouper seabass and snappers. For cobia, an average production of 5 tonnes per 6m diameter cage per crop is been achieved and for seabass, grouper and pompano, an average production of 3 tonnes per 6m diameter cage per crop is been achieved. The average cost of production is around Rs. 250 per kg and the farm gate price realized ranges from Rs. 400 to Rs. 450 per kg.

Marine finfish hatchery

A marine finfish hatchery refers to a specialized facility designed for the controlled breeding, incubation, and early rearing of various species of finfish in a marine environment. These hatcheries play a critical role in the aquaculture industry by providing a controlled setting for the reproduction and development of marine finfish species, from the initial stages of egg fertilization to the production of juvenile fish ready for transfer to grow-out facilities or release into the wild. Marine finfish hatcheries contribute significantly to livelihoods in various ways, particularly in coastal communities and the broader aquaculture industry. These hatcheries create employment opportunities, both directly and indirectly. Additionally, the industry's growth may generate ancillary jobs in transportation, equipment supply, and other related sectors, benefiting local economies. In coastal areas where traditional livelihoods might be reliant on fishing, marine finfish hatcheries provide an alternative or complementary source of income. This diversification helps reduce reliance on unpredictable wild fish stocks and offers stability in income generation. By contributing to increased fish production, hatcheries help enhance food security by providing a consistent supply of fish for local consumption and commercial markets. The establishment and operation of marine finfish hatcheries not only support the growth of the aquaculture sector but also play a pivotal role in fostering sustainable development, enhancing livelihoods, and bolstering resilience in coastal communities.

Commercial seed production technologies for cobia (*Rachycentron canadaum),* Silver Pompano *(Trachinotus blochii),* Indian Pompano *(Trachinotus mookalee)* Orange spotted grouper *(Epinephelus coioides)* and Pink ear emperor bream (*Lethrinus lentjan)* are developed by CMFRI. Year-round seed production of these fishes was achieved by CMFRI through the installation and operation of Recirculation Aquaculture Systems (RAS). Sustainable production of bio-secure marine finfish seed all through the year employing photo-thermal conditioning is possible only by recirculating systems and this facility can pave the way for commercial level seed production.

Integrated Multi Trophic Aquaculture (IMTA)

Integrated Multi Trophic Aquaculture is the practice which combines an appropriate portion of the cultivation of fed aquaculture species eg. Finfish/shellfish) with organic extractive aquaculture species (eg. Shellfish/ herbivorous fish) and inorganic extractive species (eg. Seaweed) to create balanced systems for environmental stability (bio-mitigation), economic stability (product diversification and risk reduction) and social acceptability (better management practices). IMTA is well recognised as a mitigation approach against the excess nutrients/organic matter generated by intensive aquaculture activities, especially in marine waters, since it incorporates species from different trophic levels in the same system.

The CMFRI has successfully developed an Integrated Multi Trophic Aquaculture (IMTA) model, the practice which combines an appropriate portion of the cultivation of fed aquaculture species with organic extractive aquaculture and inorganic extractive species by integrating seaweed *Kappaphycus alvarezii* with cage farming of Cobia (*Rachycentron canadum*). In one crop of 45 days, the seaweed rafts integrated with the cobia cage gave an addition of 110 kg of seaweed/ raft. In addition to the revenue generated from cobia farming, an additional income of Rs.32,000/- could be realized due to increased seaweed yield from IMTA.

Marine ornamental fish culture

On a global basis, a lucrative marine ornamental fish trade has emerged in recent years which has become a low-volume high-value industry. The ornamental fish trade with a turnover of US $ 20 Billion and an annual growth rate of 8 per cent offers a lot of scope for development. A long-term sustainable trade of marine ornamental fishes could be developed through hatchery-produced fish can earn a sizeable foreign exchange. The Central Marine Fisheries Research Institute has developed technologies for the hatchery production of 34 species of marine ornamental fishes like clown fish and damselfishes for dotty backs and fire gobies and recently for marine invertebrates like ornamental shrimps, sea anemones and soft corals. Hatchery production and culture of marine tropical ornamental fish can prove to be more economically feasible than that of marine food fish culture, due to the high price per unit of ornamental fish.

A backyard unit spanning 216 sq. ft, capable of producing 2300 fish annually, can yield a net annual income of INR 0.26 million. This model is well-suited for fisherwomen seeking supplemental income by dedicating a portion of their available time to this endeavour.

Marine ornamental culture not only serves the aquarium trade but also contributes to conservation efforts by reducing the reliance on wild-caught specimens. When practised sustainably and responsibly, it can provide economic opportunities, support biodiversity conservation, and advance research and understanding of marine species and ecosystems. The earning potential of this industry and the relatively simple techniques involved in the growing of these fish have helped the aquarium industry to evolve and provide rural employment and subsequent economic upliftment in many countries including India. The potential for the development of the ornamental fish trade in India is immense, though it is still in a nascent stage.

Seaweed culture

Seaweeds are exploited commercially for their cell wall polysaccharides such as agar, algin, carrageenan etc and manure, fodder and bioactive metabolites. Seaweed also represents an excellent source of fatty acids, vitamins and minerals. Seaweed farmers in India are generally small-scale farmers, who produce crops of (mostly) red algae in small patches of intertidal sand flats. The main culture methods involve either vegetative propagation using fragments from mother plants or different kinds of spores. In the fixed off-bottom long line method, seaweed-inserted ropes are tied to the posts planted in the sandy and muddy bottom of the intertidal regions. In the raft method (12 x 12 feet bamboo poles), vegetative fragments inserted ropes were tied to the floating raft. The first harvest can be made in 45 to 60 days depending on the species. The net tube method is the recent method in which long sleeves (10 m long 6 cm dia.) made of nylon nets (1 cm mesh) are seeded with vegetative bits that appear like "net tubes". A farmer employing 45 rafts of 12x12 feet, can harvest 760kg of fresh seaweed (*Kappaphycus* spp.) in a year having 4 farming cycles. This production capacity translates into a net income of INR 0.28 million annually. The large-scale cultivation of seaweed could have a large-scale impact on reducing local poverty, ecosystem management and climate change mitigation. With the availability of vast areas for seaweed culture along the coastline, large-scale cultivation could provide rural employment, the development of indigenous seaweed processing industries which will also aid in boosting the export of seaweeds from the country.

CMFRI developed health products/nutraceuticals and pharmaceutical substances from seaweeds as promising therapeutic agents against various diseases; all products are commercialized.

Microalgae

Numerous species of microalgae are reported to contain similar amounts of protein compared to the traditional protein sources like milk, soybean, egg and meat. Microalgal-derived food and nutraceutical products possess a huge potential as a source of protein in developing nations to combat malnutrition. The abundance of proteins and other essential nutrients in microalgae can develop a massive algae-based food industry, dedicated towards the commercialization of healthy and functional foods.

Recirculatory Aquaculture System (RAS)

Recirculatory Aquaculture System (RAS) is a technology where water is recycled and reused after mechanical and biological filtration and removal of suspended matter and metabolites. This method is used for high-density culture of various species of fish, utilizing minimum land area and water. It is an intensive high-density fish culture, unlike other aquaculture production systems. Instead of the traditional method of growing fish outdoors in open ponds and raceways, in this system, fish are typically reared in indoor/ outdoor tanks in a controlled environment. Recirculating systems filter and clean the water by recycling it back to fish culture tanks. The technology is based on the use of mechanical and biological filters and the method can be used for any species grown in aquaculture. New water is added to the tanks only to make up for splash out, evaporation and that used to flush out waste materials. The reconditioned water circulates through the system and not more than 10% of the total water volume of the system is replaced daily. To compete economically and to efficiently use the substantial capital investment in the recirculation system, the fish farmer needs to grow as much fish as possible in the inbuilt capacity. The management of recirculating systems relies heavily on the quantity and quality of feed and the type of filtration. Numerous filter designs are used in recirculating systems, but the overall goal of all filtration is to remove metabolic wastes, excess nutrients, and solids from the water and provide good water quality for aquatic organisms. It is important to consider all factors when designing and investing in aquaculture systems.

Bivalve farming

Mariculture of bivalves greater importance in meeting the increasing protein demands of the human population. Bivalve groups such as oysters, mussels and clams are the most important cultivable organisms all over the world. Among mussels, *Perna viridis* and *Perna indica* are the predominant species suitable for cultivation. The Central Marine Fisheries Research Institute (CMFRI) has devised environmentally friendly techniques for mussel culture. Optimal sites for farming include open sea and estuarine areas devoid of strong wave action. Ideal conditions for successful mussel culture comprise clear seawater with abundant plankton, and moderated water currents to facilitate planktonic food flow while removing excess pseudofaeces and silt. Water conditions such as salinity ranging from 27-35 ppt and temperatures within 26°C to 32°C are preferred. The chosen site must remain free from domestic, industrial, and sewage pollutants. Various methods of farming, including rack, raft, longline, horizontal culture, and stake culture, are practised based on the specific culture site's suitability.

In open sea farming environments, mussels display rapid growth, reaching sizes of 80-110 mm within 5-6 months. They exhibit an average growth rate of 13.5 mm per month, weighing approximately 35-45g. Similar growth patterns have been observed across various farming locations. In estuarine farming settings, mussels typically attain sizes of 75-90 mm within 5 months, with an average weight of 35-40g. Here, an average production of 10-12 kg/m rope is achieved. For instance, employing three racks sized 5x5m, each equipped with 150 ropes and seeded with 1kg of mussel spats per meter, can yield around 2.4 tonnes of mussels after 7 months of farming. This production translates to a net income of INR 0.48 million from three rafts.

Conclusion

The CMFRI's experiences have underscored that farmers are more inclined to adopt technologies if they bring tangible benefits. The mariculture technologies highlighted earlier offer promising profits, particularly when embraced as an additional livelihood avenue by farmers. Convincing farmers about the advantages of these technologies necessitates hands-on demonstrations held directly in their fields, allowing for their active participation. These initiatives have contributed to a notable social impact, fostering the rise of mariculture as a collective endeavour within groups or communities. This has led to the recognition of its potential for augmenting income and empowering women. Additionally, the adoption of mariculture has spurred the growth of several related industries such as cage fabricators, feed suppliers, packing material suppliers, and marketing entities, creating a ripple effect of economic opportunities within the community.