Livelihood enhancement through cage farming -A success story

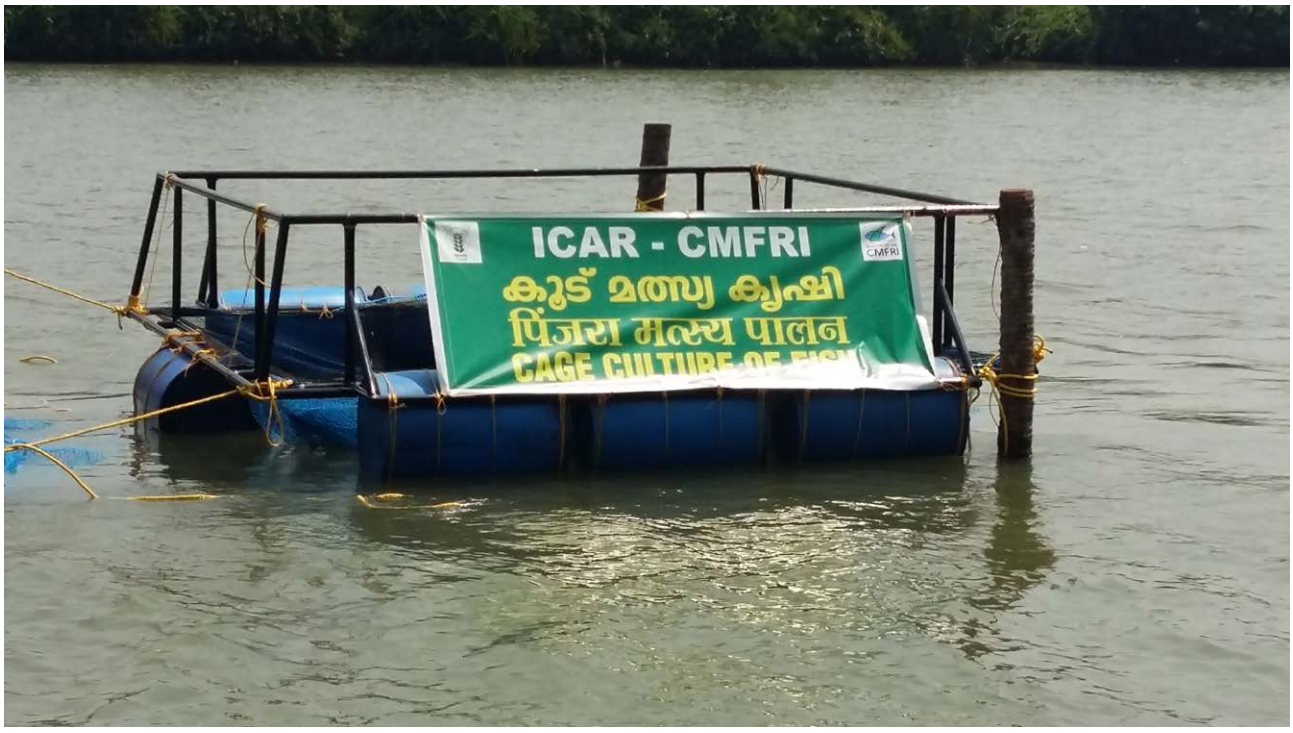
M.T. Shilta, P.K. Asokan, K. Vinod, P.P. Suresh Babu, Ramya Abhijith and Imelda Joseph
Calicut Regional Station of ICAR-Central Marine Fisheries Research Institute, Kozhikode-673 005, Kerala

Cage culture is an emerging technology suitable to a wide range of freshwater ecosystems, brackish water ecosystems or in open seas through which freshwater or brackish water or marine fishes are reared from fry to fingerling, fingerling to table size or table size to marketable size under captivity in an enclosed space that maintains free exchange of water with the surrounding water body. It is estimated that there are 12.40 lakh ha of brackish water resources in India, comprise of backwaters, estuaries, lakes, tidal creeks, canals, coastal lagoons, mudflats, etc. and the estuarine waters in India are highly productive. Cage fish farming in the estuarine waters can be recommended as an alternative livelihood and income generation programme for the coastal population. Recently, Central Government and Kerala State Fisheries department are providing financial assistance for promotion of cage farming.

With successful demonstrations, cage culture was introduced in the estuarine and coastal waters in different parts of North Kerala. At present, more than 150 cages are installed across various estuarine water bodies of North Kerala with the technical support from ICAR-CMFRI. In North Kerala, seabass, pearl spot and mangrove red snapper have been introduced recently for brackish water cage culture and the culture is gaining popularity among the aqua farmers.

The most popular cage dimension introduced to the estuaries in the North Malabar is 4x 4 x 3m^3 with GI pipe as frame and netlon net as inner and outer net cages. During the initial year of fish farming, both technical and financial assistance were provided followed by technical support alone throughout the subsequent farming years. The cage dimensions adopted by the farmers varied widely for farming in the coastal waters from 2x1x2m (4m^3), 3x 3 x 3m (27m^3) and 4x4x3m (48m^3). The recommended size of cages in the coastal waters considering the operational efficiency and profitability is 48m^3 (4x4x3m). The major species selected for farming are Asian seabass (*Lates calcarifer)*, pearlspot (*Etroplus*

Onsite demonstration of cage fabrication to farmers of North Kerala



Floating cage of dimension 3x 3 x 3m installed for culture of fishes

suratensis), tilapia (*Oreochromis* sp.) and red snapper (*Lutjanus argentimaculatus*). Seed production techniques for red snapper is not developed in the country and these fishes are cultured through capture based aquaculture, whereby the juveniles of the fishes are caught alive and allowed to grow to marketable size in cages. The stocking density varied depending on the cage volume and species of fishes selected for farming in the coastal areas.

The coastal water resources of our country have been widely utilized for fish production by cage culture and ICAR-Central Marine Fisheries Research Institute (CMFRI) has played a vital role in disseminating the coastal cage culture technology. The success story reported is a part of ICAR-CMFRI in house project "Innovations in sea cage farming and coastal mariculture" and CMFRI-NFDB project on "Integrated coastal water Cage Culture in selected districts of Kerala and Karnataka (Proj. Code 1010222)".

Mr. Sathyan, from Mujukunnu, Moodady grama Panchayat, Kozhikode engaged in masonry work and fishing activities in estuarine waters for the past 40 years, had passion for fish farming practices too. He resides near Akalapuzha backwater, one of the ecotourism sites in Kozhikode district. During 2016, he had initiated a small scale cage farm with 40 numbers of 2×2m PVC cages stocked with 250 numbers of 5 cm size Asian seabass *Lates calcarifer* in each cage. But, due to lack of technical knowledge, he lost the entire stock due to cannibalism.

During 2017, Mr. Sathyan was identified for the participatory cage fish culture under the ICAR-CMFRI in-house project. Cage culture was undertaken at Mujukunnu (11°50'12.4"N 75°66'86.4"E), in Akalapuzha backwater, Moodady Grama Panchayat, Kozhikode District, Kerala. Field demonstration on cage fabrication and installation were conducted at Mujukunnu by Calicut Regional Station of ICAR-CMFRI and technical and financial assistance for cost effective Galvanized Iron (GI) cage culture also provided. A floating cage of 3m x 3mx 2m was stocked with 250 numbers of Pearl spot, *Etroplus suratensis* (5-10g) in the identified site on during February 2018. The fish were fed with commercial floating pellet with 20% crude protein. All technical support including net change, feeding, growth and health monitoring of fishes were provided by Calicut Regional Station of ICAR-CMFRI. Growth parameters were recorded at monthly intervals and average growth rate was assessed. Fishes attained 175- 225 g with 95 % survival in the 12 months culture period. Mr. Sathyan could obtain a production of 50 kg from the single cage (18m^3 volume) and the fish were sold at ₹550/kg.

During 2019, with the technical support from CMFRI an attempt for capture based aquaculture was done using juveniles of mangrove snapper, *Lutjanus argentimaculatus* and pearl spot, *E. suratensis* collected from Kadalundy and Korapuzha estuaries by local fishermen using traps. The seeds thus collected were stocked continuously for 30 days in 3m x 3m x 2m cage. A total of 125 numbers of *L. argentimaculatus* measuring 10±3 cm and 500 numbers of 10±2.5 cm *E. suratensis* juveniles were stocked in the cage during January 2020. Locally available low-value fishes were used for feeding the fish. After a grow-out period of six months, the fish were harvested in July 2020, during the COVID-19 lockdown period. Red snapper had attained 500-700 g with an average weight of 655 ± 45g and pearl spot 100-150 g with an average weight of 125 ± 25g. A survival of 60% for red snapper and 90% for pearl spot were recorded. Total production from the cage was 90 kg (40 kg snapper and 50 kg pearl spot). The fishes were sold at farm gate itself @ ₹600/ kg for snapper and ₹550/kg for pearl spot and the revenue generated was ₹51, 500.

Further Mr. Sathyan got an opportunity to attend the three days training programme on "Open Sea Cage Farming and Mariculture" conducted by Calicut Regional Station of ICAR- CMFRI under the NFDB Skill Development Programme for the beneficiaries of Kozhikode district at Anapara (Atholi, Kozhikode) from 29-05-2019 to 31-05-2019. Under this scheme Mr. Sathyan has installed a GI cage of 4m ×4m x 3m during 2019 for farming of seabass, *L. calcarifer* along with pearl spot, *E. suratensis* with financial and technical support from ICAR-CMFRI. During, January 2020 the cages were stocked with 600 numbers of seabass and 500 numbers of pearl spot fingerlings (8-10 cm) in the cage and were fed with low-value fishes. The outbreak of pandemic covid-19 during the cage operational period has brought forth significant changes and operational challenges in the cage fish farming activities. During lockdown, the farmer had faced difficulties in feeding fishes due to scarcity of low value-fishes and the price hike of the available fishes. Six months culture period recorded an average individual weight of 600-1450 g for seabass and 100-125g for pearl spot. About 50% survival of seabass and 95% survival of pearlspot were observed in cages. A production of 175 kg of seabass and 50 kg of pearl spot was obtained from the cage (48m^3 volume) after the farming period of 8 months. Seabass were sold @ ₹720/kg and pearl spot 550/kg at the farm gate itself. The 225 kg harvested fish had fetched an income of ₹1,53,500/-. Even though the total production from the cage was less, the cage fish culture carried out during the COVID 19 lockdown turned out to be a livelihood support to the farmer since the farmed fish had a great market demand due to the scarcity of marine fish landings during the lockdown.

During 2018-2019, farming was initiated in two GI cages provided by ICAR-CMFRI, and later on, with the support from Department of Fisheries, Kozhikode, the number of cage units have been increased to 6 in 2020, 8 in 2021 and 18 by 2022. Currently, Mr. Sathyan has 36 cages out of which 33 cages are used for stocking seabass, one cage for pearl spot, one cage for red snapper and another one cage for chitralada. Thus convinced that cage fish farming is a lucrative business with proper planning, information and management he has moved from being a mason to a full time cage fish farmer. During 2021, he could get

Cage farm at Mujukunnu, Kozhikode during 2022

a profit of ₹8,00,000/- with an average production of 350 kg/cage from 8 cages within the farming period of 8 months.

This success has inspired many fish farmers and non-farmers at Moodady Panchayath to initiate the cage farming in Moodady gram panchayath with 37 individuals in four self help groups operating 76 cages at Moodady. The economic performance of cage farming of different species of fishes were calculated for comparing the profitability. Depreciation on cage frame and accessories were calculated using straight line method with an expected life of 5 years and the financial indicators such as NPV, BCR and IRR were calculated for a project period of 5 years at 15% discount rate as per the method followed by Aswathy *et al*. (2020).

Experience shared by Mujukunnu fish farmers in fish farming

The farmers prefer monoculture of fish species like Asian sea bass (*Lates calcarifer*), pearl spot (*Etroplus suratensis*), Red snapper (*Lutjanus argentimaculatus*) and Nile tilapia (Chitralada) in cages.

Species farmed	Number of cages	Reason for culturing
Lates calcarifer (seabass)	55	Fast growth rate, good market price and availability of good quality hatchery produced seeds
Etroplus suratensis (pearl spot)	15	Good market price
Lutjanus argentimaculatus (red snapper)	3	Good market price, easy to culture
Oreochromis niloticus (Chitralada tilapia)	3	Fast growth rate in 6 months culture period

Sea bass culture

The farmers prefer the farming of *Lates calcarifer* locally known as Kannikan or Kalanji because of their faster growth rate, good market price and availability of good quality hatchery produced seeds. They prefer low stocking density farming of *Lates calcarifer* by stocking 300 numbers of hatchery produced *Lates calcarifer* fingerlings of 5.0 – 5.5 cm size purchased @ ₹30/

Species farmed	Size of the cage	Stocking density/ cage	Culture period	Harvest size of the fish	Production/ cage (kg)	Average selling price (₹/kg)	Constraints
Lates calcarifer (seabass)	3×3m	300 numbers	8 months	1.5-2.0 kg	300-350 kg	₹500/kg	Higher price for fish seeds from private hatcheries
Etroplus suratensis (pearl spot)	3×3m	500 numbers	12 months	225-250 gm	75-100 kg	₹500/kg	Slow growth rate in cages
Lutjanus argentimaculatus (red snapper)	3×3m	300 numbers	8 months	850-1500 gm	250-300 kg	₹500/kg	Non availability of hatchery produced fish fingerlings
Oreochromis niloticus (Nile tilapia/Chitralada)	3×3m	500 numbers	6 months	850-900 gm	400-450 kg	₹250/kg	Low market price

fingerling in 3m x 3m x 3m cages. During the first two months of culture, they fed the fishes with pellet feed (Growel) initially at15 percent of the body weight, then reducing to 5 percent of the body weight as the culture progressed. From 3-8 months, the feed given is low-value fishes. Fishes reached 1-2 kg within 8 -9 months culture period with 100 percent survival and the fishes were sold at the rate of ₹500-700/kg. The farmer's could get an average production of 300-350 kg of seabass from a single cage of 27m^3 earning a gross income of ₹1,50,000-2,00,000 per cage.

Feeding schedule adopted for Asian seabass in 3×3m GI cage (Stocking density- 300 numbers):

Month	Fish size (g)	Feeding rate (%)	Pellet/fresh fish	Protein content	Size	Quantity	Price (₹)
1st	10-20	15	pellet	45%	1.2 mm	20 kg	2,500
2nd	25-50	12	pellet	45%	1.2 mm	40 kg	5,000
3rd	50-100	12	Fresh fish			75 kg	1,500
4th	100-200	8	Fresh fish			100 kg	2,000
5th	200-500	6	Fresh fish			150 kg	3,000
6th	500-700	5	Fresh fish			200kg	4,000
7th	700-1000	5	Fresh fish			250kg	5,000
8th	1000-2000	5	Fresh fish			250kg	5,000
TOTAL						1,085 kg	28,000

Economic performance of cage farming of seabass (Cage Dimension 3x3x3m (27m^3) Culture period: 8 months):

Particulars	Amount (₹)
I. Capital Investment	
1. Cost of cage frame (1.25 inch B class pipe with ISI)	25,000.00
2. Cost of nets	30,000.00
3. Cost of floats (8 numbers for each cage) and accessories	10,000.00
4. Mooring (2 numbers of 20 kg GI anchors) and installation charges	5,000.00
5. Deep freezer	15,000.00
Total fixed cost (1+2+3+4+5)	85,000.00
6. Depreciation (20%)	17,000.00
7. Interest on fixed capital (12%)	10,200.00
Annual Fixed cost (6+7) (A)	27,200.00
II. Operating costs	
8. Seed (Cost of 300 numbers of seabass seeds @ ₹30/seed & Transportation charges)	9,000.00
9. Feed (Trash fish) 1085 kg@ ₹20/kg and 60 kg pellet feed	28,000.00
10. Labour 2 hours/day @ ₹1200/month for 8months	9,600.00
11. Harvesting & Miscellaneous Expenses	2,000.00
Total operating cost (7+8+9+10) (B)	48,600.00
Total cost (A+B)	75,800.00
III. Returns	
12. Production	300 KG
13. Gross revenue @ ₹500/kg for 300 KG	1,50,000
14. Net profit	74,200
15. Cost/ kg of fish (₹)	252
16. Price/ kg of fish (₹)	500
17. Operating ratio	0.32
18. NPV	2,31,256
19. BCR	1.92
20. IRR	99.5%

The 27m^3 cage with a stocking density of 300 numbers of seabass yielded a gross revenue of ₹1.5 lakhs and net profit of ₹74,200 in an 8 months culture period. The internal rate of return was 99.5% with a benefit cost ratio of 1.92.

Red snapper culture

The farmer's prefer the farming of *Lutjanus argentimaculatus* locally known as "chemballi" because of their faster growth rate and good market price. One of the major constraints in red snapper farming is the non-availability of hatchery produced seeds. Farmers usually collect the snapper fingerlings from the estuary and stock them in cages. About 300 numbers of wild collected snapper seeds were stocked in 3m x 3m x 3m cages. The fishes were fed with low value fishes initially at15 percent of the body weight then reducing to 5 percent of the body weight as the culture progressed. Fishes reached 1-1.5 kg within 8 months culture period with 99 percent survival and the fishes were sold at the rate of ₹500-700/kg. The farmer's could get an average production of 250-300 kg of seabass from a single cage of 27m^3 earning a gross income of ₹1,25,000-1,50,000 per cage.

Pearl spot culture

The pearl spot required longer culture duration of 12 months in cages at Mujukunnu to reach marketable size (200-250 gm). Five hundred fingerlings (4 cm) purchased @ ₹10/ fingerling were stocked in 3m x 3m x 3m size cages. During the twelve months of culture,

Red snapper weighing around 1 to 1.5 kg harvested from the cages

Culture protocol for Red snapper in 3×3m GI cage (Stocking density- 300 numbers):

Month	Fish size (g)	Feeding rate (%)	Pellet/fresh fish	Quantity	Price (₹)
1st	10-20	15	Fresh fish	25 kg	500
2nd	25-50	12	Fresh fish	50 kg	1,000
3rd	50-100	12	Fresh fish	75 kg	1,500
4th	100-200	8	Fresh fish	100 kg	2,000
5th	200-500	6	Fresh fish	150 kg	3,000
6th	500-700	5	Fresh fish	200kg	4,000
7th	700-1000	5	Fresh fish	250 kg	5,000
8th	1000-1500	5	Fresh fish	250 kg	5,000
TOTAL				1,100 kg	22,000

Economic performance of cage farming of red snapper (Cage Dimension 3x3x3m (27m^3) Culture period: 8 months):

Particulars	Amount (₹)
I. Capital Investment	
1. Cost of cage frame (1.25 inch B class pipe with ISI)	25,000.00
2. Cost of nets	30,000.00
3. Cost of floats (8 numbers for each cage) and accessories	10,000.00
4. Mooring (2 numbers of 20 kg GI anchors) and installation charges	5,000.00
5. Deep freezer	15,000.00
Total fixed cost (1+2+3+4+5)	85,000.00
6. Depreciation (20%)	17,000.00
7. Interest on fixed capital (12%)	10,200.00
Annual Fixed cost (6+7) (A)	27,200.00
II. Operating costs	
8. Seed (Cost of 300 numbers of red snapper seeds @ ₹35/seed & Transportation charges)	10,500.00
9. Feed (Trash fish) 1100 kg@ ₹20/kg	22,000.00
10. Labour 2 hours/day @ ₹1200/month for 8months	9,600.00
11. Harvesting & Miscellaneous Expenses	2,000.00
Total operating cost (7+8+9+10) (B)	44,100.00
Total cost (A+B)	71,300.00
III. Returns	
12. Production	280 KG
13. Gross revenue @ ₹500/kg for 300 KG	1,40,000
14. Net profit	68,700
15. Cost/ kg of fish (₹)	254
16. Price/ kg of fish (₹)	500
17. Operating ratio	0.31
18. NPV	2,12,819
19. BCR	1.74
20. IRR	93.19%

The 27m^3 cage with a stocking density of 300 numbers of red snapper yielded a gross revenue of ₹1.4 lakhs and net profit of ₹68,700 in an 8 months culture period. The internal rate of return was 93.19% with a benefit cost ratio of 1.74.

Harvest and local sale of pearl spot

the fishes were fed with pellet feed (Growel) initially at12 percent of the body weight then reducing to 3 percent of the body weight as the culture progress. Pearl spot is also having very good market demand (about ₹500-600/ kg) in local market. An average production of 100 kg/cage with a gross income of ₹50,000 could be obtained.

Nile Tilapia culture

The farmer opined that Nile tilapia locally called as chitralada requires only 6 months culture duration and two crops could be harvested annually. The farmers stocked around 500 number of Chitralada fingerlings (4.0 cm) purchased @ ₹8/ fingerling in 3m x 3m x 3m

Feeding schedule adopted for Chitralada in 3×3 GI cage (Stocking density- 500 numbers):

Month	Fish size (g)	Feeding rate (%)	Pellet/fresh fish	Size	Protein (%)	quantity	Price
1st	4-5	10	pellet	1.2 mm	40	10 kg	1,200
2nd	10-15	8	pellet	3.0 mm	40	40kg	4,800
3rd	250-500	5	pellet	3.0 mm	40	75 kg	9,000
4th	500-650	3	pellet	6.0 mm	40	75 kg	9,000
5th	650-700	3	pellet	6.0 mm	40	50 kg	6,000
6th	750-900	3	pellet	8.0 mm	40	50 kg	6,000
TOTAL						300 kg	36,000

Economic performance of cage farming of chitralada (Cage Dimension 3x3x3m^3 Culture period: 8 months):

Particulars	Amount (₹)
I. Capital Investment	
1. Cost of cage frame (1.25 inch B class pipe with ISI)	30,000.00
2. Cost of nets	25,000.00
3. Cost of floats (8 numbers for each cage) and accessories	10,000.00
4. Mooring (2 numbers of 20 kg GI anchors) and installation charges	5,000.00
Total fixed cost (1+2+3+4)	70,000.00
5. Depreciation (20%)	14,000.00
6. Interest on fixed capital (12%)	8,400.00
.Annual Fixed cost (5+6) (A)	22,400.00
II. Operating costs	
7. Seed (Cost of 500 numbers of chitralada seeds @ ₹8/seed & Transportation charges)	4,000.00
8. Feed(pellet feed) 300 kg	36,000.00
9. Labour 2 hours/day @ ₹1200/month for 6months	7,200.00
10. Harvesting & Miscellaneous Expenses	2,000.00
Total operating cost (7+8+9+10) (B)	49,200.00
Total cost (A+B)	71,600.00
III. Returns	
11. Production	450 KG
12. Gross revenue @ ₹250/kg for 450 KG	1,12,500
13. Net profit	40,900
14. Cost/ kg of fish(₹)	159
15. Price/ kg of fish(₹)	250
16. Operating ratio	0.43
17. NPV	1,22,713
18. BCR	2.36
19. IRR	70.9%

The 27m^3 cage with a stocking density of 500 numbers of chitralada yielded gross revenue of ₹1,12,500 and net profit of ₹ 40,900 in 6 months culture period. The internal rate of return was 70.9% with a benefit cost ratio of 2.36.

size cages. The fishes were fed with pellet feed (Growel) throughout the culture period. Fishes reached 800-900 g within 5-6 months culture period with almost 100 percent survival. They could obtain an average production of 400-450 kg of Chitralada from cages of 27m^3 within a farming period of 6 months and the fishes were sold at the rate of ₹250/kg. They earned a gross income of ₹1,00,000-1,10,000 per cage.

Technology upgradation introduced by farmers of Mujukunnu in cage farming

Surveillance

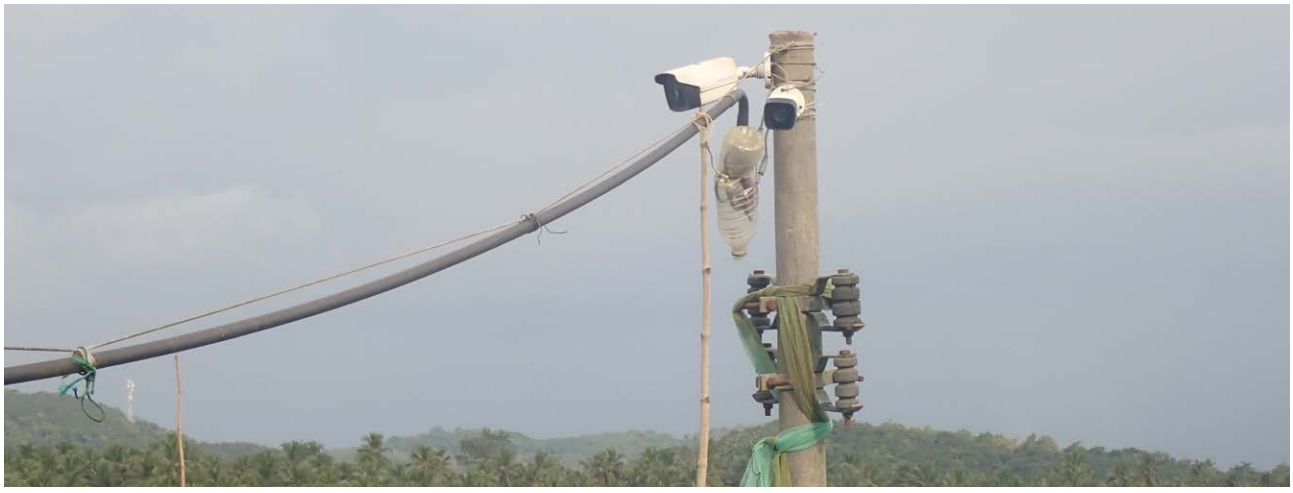
The farmer's installed surveillance unit at cage site for continuous monitoring of culture activities. The fish cages are fitted with solar panels, cameras and sensors to collect data and monitor images. The data and images are transmitted to the shore station via a mobile phone network. This system allows the remote monitoring of fish and the installation of surveillance unit costs around ₹80,000.

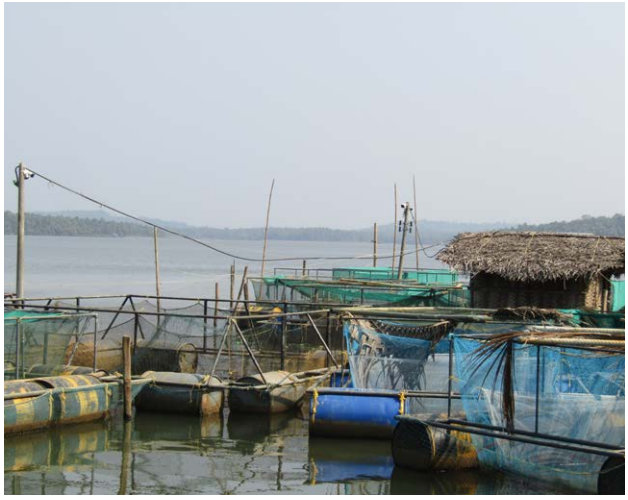
On-field feed storing shed-cum-watch shed

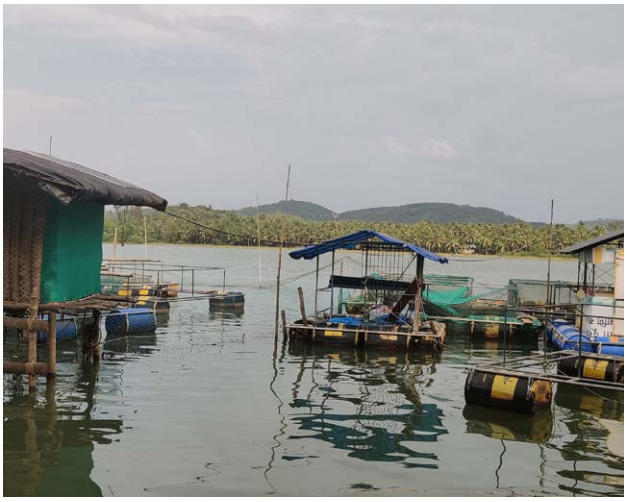
The farmer's fabricated and installed an on-field feed storing shed-cum-watch shed for feed storage, management and monitoring of culture activities. The fabrication and installation of feed-cum-watch shed unit costs around ₹50,000.

On-site marketing facilities

The partial harvest of fishes was undertaken as per the demand from consumers. The support through social







Fish Cage farmers of Mujukunnu felicited by ICAR-CMFRI on the occasion of KISAN DIWAS on 23rd December, 2023

media like Facebook, Whatsapp etc. played an important role in achieving good sales for the farmer. The harvest of fishes are planned to coincide with occasions like Onam, Vishu, Bakrid etc.

According to the farmers, cage fish farming is a profitable venture and vast unutilized areas in the estuarine and brackishwater region offer promising scope for augmenting fish production through cage farming in North Kerala. The constraints listed as major bottlenecks for large-scale cage fish farming were, lack of credit facilities, lack of insurance, high seed cost, natural calamities, attack of otters and conflict with tourism boats operated. For increasing adoption of cage culture technology, farmers suggested establishment of finfish hatchery in North Kerala for continuous supply of hatchery produced good quality fish seeds, financial support from the government to initiate cage farming, meeting insurance needs for cage farming

Conclusion

Cage farming with proper planning, information and management offers tremendous scope for boosting the fish production in North Kerala, mainly from the estuarine water bodies. The vast unutilized water resources and conducive environmental conditions in the coastal waters are excellent for large-scale cage farming. Cage culture appears to be a rapidly expanding industry and it offer opportunities even on a small-scale. Recently, due to the frequent occurrence of flood in Kerala farmers are unsure about the returns from cage farming. Therefore, insurance schemes for mitigating risks due to natural calamities or anthropogenic activities are also necessary for large-scale commercialization of cage farming in the coastal waters. In addition, there is an urgent need for the formulation of leasing policies and regulatory measures for large-scale promotion of cage fish farming.

Reference

Aswathy. N. *et al.,* 2020. CMFRI Special Publication No. 134. ICAR-Central Marine Fisheries Research Institute, Kochi, 36pp.

NFDB, 2015. NFDB Schemes & Blue Revolution- Inland Fisheries Schemes, National Fisheries Development Board, Department of Animal Husbandry, Dairying & Fisheries, Government of India, 15p

Successful region specific coastal mariculture activities towards achieving Sustainable Development Goals – A report

P. P. Suresh Babu[1], A. Anuraj[1], Jayasree Loka[1], Mahendra Pal[1], I. Boby [2] and A. Gopalakrishnan[2]
[1]Karwar Regional Station of ICAR-Central Marine Fisheries Research Institute, Karwar, Uttara Kannada-581 301, Karnataka
[2]ICAR-Central Marine Fisheries Research Institute, Kochi-682 018, Kerala

*e-mail: sbabukkd@rediffmail.com.

In the face of growing demand for animal protein sources, aquaculture continues to contribute immensely for sustainable development. A record high of 114.5 million tonnes of fish production including 32.4 million tonnes of aquatic algae, 26,000 tonnes of ornamental fish, clams and pearls, and 82.1 million tonnes of farmed fish were produced in 2018 (FAO, 2020). Aquaculture accounts for nearly half of the global fish production and human fish consumption and is expected to increase in the future. Fish is a major source of protein for over 3.3 billion people worldwide with 20% of the average per capita intake of animal protein (FAO, 2020). The United Nations upholds 17 Sustainable Development Goals (SDGs) that act as a framework for global collaboration to support the well-being of people and the planet (Morton *et al.*, 2017). The UN's 2030 Agenda for Sustainable Development Goals (SDGs), such as SDG 1 (No Poverty), SDG 2 (Zero Hunger), and SDG 14 (Life Below Water), emphasize ensuring global food security, given emphasis to the importance of aquaculture and fisheries resources in achieving sustainable food systems, developing economic advantages, and providing nourishment. These 17 goals are primarily intended to combat poverty, inequality, and climate change. When aquaculture is developed appropriately, it has a significant role in achieving a number of the UN's SDGs by 2030. Coastal mariculture activates can play a major role in contributing to these SDGs directly or indirectly. Importance of coastal mariculture to achieve these SDGs and the possible interventions are discussed herewith. Also, the region-specific initiatives taken by Karwar Regional Station of ICAR-CMFRI to contribute to these SDGs through coastal mariculture activities also deliberated.

Coastal mariculture activities involve the farming of marine organisms such as fishes, mollusks, crustaceans and seaweeds in marine and in land facilities such as cages, Pens, ponds, tanks and Recirculating Aquaculture Systems (RAS). In India, ICAR-CMFRI has standardized major coastal mariculture activities such as marine fish farming in coastal cages, Integrated Multi-Trophic Aquaculture (IMTA), RAS farming, mussel farming and seaweed farming.

In 2018, an approximate 59.51 million people were employed (full-time, part-time, or on an occasional basis) in the fisheries industry, with 20.5 million working in aquaculture, a modest rise from 2016 (FAO, 2020). Coastal mariculture will provide immense opportunities for employment for coastal fisherfolk which may ultimately help to reduce poverty. Coastal farming also may enhance employment opportunities for workers in other associated sectors such as fish processing, fish marketing, and feed and equipment manufacturing. Thus this sector can play a significant role in the overall socio-economic upliftment of poor people, especially the coastal population. Nearly half of the fish consumed worldwide comes from aquaculture. Due to rising population and food consumption as well as ongoing global degradation of the environment (land, water, and the climate), food security is crucial. Coastal aquaculture production needs to be enhanced further to meet the demands of the growing population which will lead to improved nutrition and food security for all communities.

The essential amino acids, vital fats including omega-3 fatty acids, vitamins and minerals are present in ample quantity in fish, which is a good source of protein. Coastal mariculture can provide economical and nutritious food for the world's poorest people, whose diets lack most

of the essential nutrients. Since men are involved in the production of majority of farmed fish, aquaculture is presumed to be gender biased. Women are mainly involved in fish feeding, harvesting, fish processing and marketing in local areas. Promoting increased women involvement in coastal aquaculture while ensuring equal pay and career prospects for valuing the industry and offering working women a respectable job coastal mariculture can involve in gender equity. Coastal mariculture has greater potential for women's employment as women can manage fish ponds and cages, feed mills and fish processing units which can help to improve livelihoods. Coastal mariculture activities by bringing the socially backward communities to this field can reduce the inequalities in society.

Aquaculture will be one of the most environment-friendly approaches for food production if it is being done carefully and responsibly. Efficient use of water bodies from a production perspective will reduce pollution of coastal waters. RAS, Biofloc systems, Aquaponics, and IMTA are some of the coastal mariculture technologies which provide higher production with less negative environmental impact. At present, many of the fish stocks were negatively affected by mechanized fishing and the exploitation level is well above the maximum sustainable yield. As an alternative to less sustainable marine capture fisheries, rapid growth in coastal mariculture may contribute immensely to reduce fishing pressure and thus to replenish natural fisheries resources, as well as their ecosystems. Some of the coastal maricuiture activities will have direct implications on climate action. For example, Seaweed culture plays a significant role, including potential CO_2 mitigation on climate action. Aquatic macro-algae offer a way to cut back the carbon emissions that cause climate change. Environmental carbon capture by aquatic organisms through sequestration can aid in lowering atmospheric CO_2 levels, addressing climate change implications and SDG 13. By defending shore lines, boosting pH levels, and adding oxygen to the water, seaweed culture helps to restore natural habitats and mitigates the local consequences of ocean acidification and oxygen depletion. Additionally, it balances the major nutrients in the water that cause algal bloom and lowers the rate of mass fish mortality in the ocean. Oysters, clams, and mussels are examples of bivalves that are crucial to the stability of the aquatic ecosystem.

Table 1. Region-specific interventions initiated by Karwar Regional Station

Goal	Title	Region-specific interventions by Karwar Regional Station	References*
1	No Poverty	Standardized the open water cage farming of various candidate species	Loka *et al*. (2019); Anuraj *et al.* (2022).
2	Zero Hunger	Demonstrated open water cage culture in a subsidized mode (161 cages) in Karnataka in collaboration with financial support received from the National Fisheries Development Board (NFDB), Hyderabad	Suresh Babu *et al.* (2021)
3	Good Health and Well-being	Under the All India Network Project on Mariculture from 2015-16 to 2021-22, around 25 marine cage culture demonstrations for 13 SHGs were carried out including mussel-fish integration (IMTA).	Anuraj *et al* (2021); Suresh Babu *et al.* (2022)
		Standardized seed production of new candidate species such as seabreams and rabbit fishes.	
4	Quality Education	The NFDB subsidy beneficiaries informed that the livelihood has enhanced by the scheme	Suresh Babu *et al.* (2021)
5	Gender Equality	Under the NFDB scheme around 47 cages were issued for women beneficiaries in Uttara Kannada.	Suresh Babu *et al.* (2021)
		Honorable Prime Minister of India, distributed the Kisan Credit Card to Mrs Supriya Sudhir Sarang who is the first fisher folk in Karnataka to receive the same	
6	Clean Water and Sanitation	For fish rearing, advanced feed management practices using artificial diets have been standardized for replacing the conventional low-value fish feeding practices for all the species introduced by ICAR-CMFRI	Suresh Babu *et al.* (2022) Anuraj *et al.* (2022)
		Development of land-based farming practices such as RAS, Aquaponics, and tank-based nursery rearing systems for reduce pollution.	
		Promoted farming of filter feeders such as mussels and oysters to reduce water pollution.	
7	Affordable and Clean Energy	Recommended coastal fish farmers to use solar lights and solar powered CCTVs for monitoring cages	

8	Decent Work and Economic Growth	Imparted training programmes to fisherfolks on recent production techniques such as seaweed farming, Mussel-fish integration, RAS systems etc for enhancing their income	
9	Industry, Innovation and Infrastructure		
10	Reduced Inequality	For social upliftment, several coastal water cage culture demonstrations for the scheduled cast community were conducted under NFDB scheme and the Scheduled Cast Sub-Plan (SCSP) programme in UttaraKannada district	Anuraj *et al.* (2022)
11	Sustainable Cities and Communities		
12	Responsible Consumption and Production	Recommended the farmers to use artificial diet instead of low value fish. Also suggested the fishermen to use the trash fish as feed for the fishes in cages that is otherwise thrown out	
13	Climate Action	The station has been involved in the popularization of seaweed farming in coastal belts of Karnataka and Goa and has conducted several training programmes on seaweed farming for farmers and entrepreneurs	
14	Life Below Water	Suggested to reduce the pollution by adopting better management practices for fish farming	
15	Life on Land		
16	Peace and Justice Strong Institutions	Educated the fisher folk regarding the availability of several government schemes such as PMMSY, SCSP Programmes etc.	
17	Partnerships to achieve the Goal	Taken lead for collaborating with other government agencies for the upliftment of fisher folk through coastal water cage farming	

*Available in eprints@cmfri.org.in

Region-specific interventions toward achieving SDGs

Aiming the upliftment of coastal fish farmers in Karnataka, Karwar Regional Station of ICAR-CMFRI has initiated several programmes which are in the line of achieving the sustainable development goals.

Enhanced fish production through coastal aquaculture can be attained through diversifying aquaculture systems, introduction of various new candidate species and optimum utilization of available water resources. In Karnataka, Karwar regional station of ICAR-CMFRI is involved in the popularization of marine and coastal water cages with standardized methodologies for openwater cage farming of various species such as cobia, silver pompano, Indian pompano, orange spotted grouper, red snapper, seabreams and seabass. Open water cage culture activities were carried out in 8 thaluks of three districts for 98 beneficiaries with 161 cage units. Majority of the cage units were stocked with Asian seabass (152 cages) and red snapper (8 cages) and cobia (1 cage). Under the All India Network Project on Mariculture from 2015-16 to 2021-22, around 25 marine cage culture demonstrations for 13 SHGs were carried out for demonstrating the farming of Asian Seabass, Silver pompano and for demonstration of Integrated Multi- Trophic aquaculture for mussel-fish integration. Recently the diversification of farmed species was done by standardizing the seed production of seabreams and rabbit fish. Around 47 cages were issued for women beneficiaries in Uttara Kannada district under the NFDB subsidy scheme for openwater cage culture aiming at social upliftment of this section of society. Several coastal water cage culture demonstrations for the scheduled caste community were conducted under NFDB scheme and the centrally sponsored Scheduled Caste Sub-Plan (SCSP) programme in the Uttara Kannada district. Under the SCSP scheme, during the period 2019 to 2022, around 10 coastal water cages for 4 self-help groups (SHGs) consisting of 5 members in each SHGs were deployed for Asian Seabass farming which helped economically backward farmers to earn profits.

To reduce pollution, several mitigation measures were introduced in coastal water cage culture practices. For fish rearing, advanced and precise feed management practices using balanced artificial diets have been standardized for almost all the candidate species introduced by ICAR-CMFRI to replace the conventional low-value fish feeding practices. Development of land-based farming practices such as RAS, aquaponics, and tank-based nursery rearing systems could drastically reduce pollution. The station has developed a low-investment RAS farming system for silver pompano farming. Farming filter feeders such as mussels and oysters also will reduce water pollution. IMTA demonstration cage was also harvested at Koderi, Udupi. Under the technical guidance of Karwar Regional

Station a fishers' self-help group, Karavali Friends, carried out integrated farming of seabass and green mussels in a 6m diameter GI cage.

The popularization of seaweed farming is progressing in coastal belts of Karnataka and Goa with several training programmes on seaweed farming for farmers and entrepreneurs being conducted. Several attempts to demonstrate seaweed farming have been taken up and the successful standardization of farming of seaweed for the first time on this coastline is in the pipeline. Also, efforts on micro-propagations of native species of seaweeds are being attempted for the first time.

As a way forward, the institute is planning to upscale the seed production of new candidate species for enhancing the production of fish farming. Also doing research for prolonging the seed availability of commercially important marine finfishes for which the seed production is already standardized. Selection of locally available seaweeds for climate resilient farming is in pipeline. Micro-propogation of seaweeds for continuous supply of seaweed seedlings for farming is being attempted. Development of better management package of practices for commercially farmed species is being carried out. Extensive training and awareness programme for adopting scientific technologies by the farmers is also being planned with the aim to attain the envisaged SDGs.