Socio-Economic Interdependencies and Implications of Cage Fish Farming in Northern Kerala

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Abstract

The present study was conducted during 2022-23, and a sample of 30 cage farmers from two districts, namely Malappuram & Kozhikode, was interviewed using a structured questionnaire to assess the socio-economic status of the farmers practicing cage culture in Northern Kerala and the resultant economic benefits. Data on demographic features, Technical specifications, farming activities and farm management practices, economics and problems related to cage farming are collected. The share of total variable and fixed cost was 45.36% and 54.64%, respectively to the total cost. Feed was the major cost component accounting for about 60.67% of the total cost. High price of feed and seed are found to be the major constraints. BCR of 1.25 makes the project economically viable with a moderate level of profitability.

Keywords: Cage Culture, Northern Kerala, BCR, Socio-economic Status

Introduction

Cage aquaculture, an innovative and emerging practice in India's inland aquaculture landscape, presents novel opportunities for enhancing fish production in diverse aquatic environments, including freshwater ecosystems, brackish water areas, and open oceans; fish are cultivated from fry to marketable size within a confined environment that facilitates water exchange with the surrounding ecosystem, developing new competencies and augmenting potential earnings for fishers and entrepreneurs, particularly given India's substantial 1.24 million hectares of brackish water resources, such as backwaters, estuaries, and coastal lagoons (National Fisheries Development Board, 2016 & Shilta et al., 2023). Cage fish farming, or cage culture, has become one of the most efficient techniques for fish cultivation in Kerala's many aquatic environments, such as ponds, rivers, lakes, and the ocean (Aswathy & Joseph, 2019; KJASONS, 2023). The ICAR-Central Marine Fisheries Research Institute (CMFRI) established cage farming in Kerala in 2007 by introducing marine cages at Munambam in

Ernakulam District. In 2009, the CMFRI successfully demonstrated cage farming in coastal waters, which led to widespread adoption in brackish water areas. Cage farming is rapidly expanding in coastal districts of Ernakulam, Alappuzha, Kollam, Thrissur, and Thiruvananthapuram because to rising demand for high-value fishes and promotional efforts by institutional organizations (Aswathy et al., 2018). Cage fish farming possesses significant potential for income generation and employment for the coastal fishing communities of North Kerala. A valuable resource for cage farming in this region is the estuarine bodies or backwaters, which contain substantial volumes of water, maintain considerable depth, and are non-drainable (Shilta et al, 2021). Northern Kerala were selected for this study, as research on cage farming in this region is limited compared to the southern part of the state. The existing literature indicates a notable disparity in the development of coastal cage farms, with a significant concentration of these operations in Southern Kerala. According to Aswathy et al., 2019 approximately 80% of coastal cage farms are situated in this southern region, underscoring the need for further investigation and development of cage farming practices in northern Kerala. In this context the present study is to understand the socio-economic viability of cage fish farming in Northern Kerala. This evaluation will focus on understanding the economic potential and sustainability of this aquaculture practice within the region.

Materials and Methods

The data for this study was gathered from both primary and secondary sources. Secondary data was obtained from the Department of Fisheries, Kerala, while primary data was collected through personal interviews with the fish farmers using a structured questionnaires specifically designed for this research. Systematic random sampling was utilized to select fish cage farmers based on the list provided by the Department. Farmers who had active cages for more than 3 years of production cycle were considered. Information on cage farming for the production cycle was collected using a structured questionnaire through face- to face interviews with the farmers. Face- to face interviews have the advantage of allowing for fast follow-up and clarification. The interviews were conducted only after informed concerned from the respondents. The data included personal details of the farmers, the farming activities , specific farm management practices , economics, problem related to cage farming and experiences in farming. The survey covered 30 active farmers from Vettom, Tanur, Veliyancode, Kadalundi, Ponnani, Chettuva and Farook of Malappuram and Kozhikode district. To assess the socio-economic status of the farmers information related to the age, gender, education, occupation, and status were collected. Besides the details on the species cultured and stocking density, type of culture, procurement of seed and feed, materials and size of the cage, maintenance of the cage , cost of inputs, quantity of fish produced in kilogram (kg) and details of prices of fish produced and sold were also collected.

For the economic analysis of the culture system, fixed cost, operating/ variable cost, gross revenue, annual profit rate and payback period of the culture system were carried out. The total cost comprised sum of the yearly fixed cost and the operating cost. Fixed cost estimates for materials and equipment in cage culture typically include expenses such as cage construction, netting, and essential tools. The operating cost, also called as variable cost formed the cost incurred when the farm was under operation and included the costs of seed, maintenance and medication cost if any and the transportation cost. Fixed cost is the cost incurred even if the farm is not operating and included the interest on capital investment. The following economic parameters were employed in this study to conduct a comprehensive analysis of the cage fish farms.

- Total Fixed Costs=Total Costs−(Variable Cost per Unit×Units Produced)
- Operational Cost=Feed Costs+Seedcost+Health Management+Utilities
- Gross Revenue=Price Per Fish×Number of Fish Sold

- Net Profit=Gross Revenue−(Total Fixed Costs+Operational Cost)
- Annual Profit Ratio=(Net Profit÷Grossrevenue)×100
- BCR= Total Benefits ÷ Total Costs
- OER=(Gross Revenue Operating Expenses)×100

Figure 1 Showing Some Cage Fish Farming Locations Selected for the Study from Northern Kerala

Results and Discussion

Technical Specifications& Farming Practices of Cage

The installation of cages in the coastal area required essential licenses from both the municipality and the Port Authority NOC, with all cage fish farms in the region registered under the Department of Fisheries, Kerala; these selected farms practiced aquaculture in brackish water where river water experiences saline intrusion, which reduces to zero salinity during the monsoon season, and farmers chose these sites based on favorable water quality, adequate depth, protection from extreme weather, and market accessibility; the cages were cylindrical to enhance water flow and minimize current resistance, with dimensions ranging from $2 \times 2 \times 3$ m^3 to $4 \times 3 \times 2.5$ m^3, where two cages form a unit, and farmers typically managed between 8 to 10 cages; constructed from corrosion-resistant materials like galvanized steel used by 95% of farmers while 5% opted for high-density polyethylene (HDPE) pipes, the cages featured HDPE frames, nets, galvanized iron chains, mooring equipment, stone anchors, floats, ropes, and epoxy paints sourced from local markets; predominantly rectangular floating cages utilized knotless netting with mesh sizes varying from 18 to 30 mm, including outer predator nets and inner rearing nets fully covered to protect against avian attacks; flotation devices consisted of 4-8 plastic barrels per cage for buoyancy and stability; anchoring systems employed concrete blocks and rocks collected nearby; designed for easy access for maintenance and cleaning, the cages included walkways and platforms; safety measures incorporated walkways and guard rails, with 50% of farmers installing CCTV cameras for monitoring poaching and illegal fishing activities while some also employed dogs for additional protection against poachers.

Stocking, Feeding, Health Management and Harvesting

The seeds are mainly procured from Government agencies (MPEDA- RGCA Multispecies Aquaculture Centre, Vallarpadam) due to their high quality, disease-free, high resistance seeds. The seeds selected for the culture practice by the farmers varied from 2.5 cm-11.5 cm with a rate of Rs. 9-39 respectively. The seeds are directly transported from the centre to the farming sites and kept in separate hapas for acclimatization. Some farmers directly introduced the seeds into the cage. Stocking density in the cage varied with different cages, but a maximum of 1000-1200 fingerlings were stocked in most of the cages. The Government of Kerala, Department of Fisheries provides 40% of unit cost for new units and 20% of operational cost for the already established unit. Selecting the right fish species is critical for the success of any cage fish farming venture. The most preferable species are Lates calcarifer (Asian Sea bass) and Etroplussuratensis (Pearl spot) in these areas. Farmers prefer these species because they can thrive well in a wide range of water temperatures and salinities. The feeding practices for Asian Sea bass and Pearl spot in different areas vary according to growth size; 2.5 cm-10 cm size fishes were initially fed with floating pellets twice a day for up to 1-2 months, and the fish were fed with commercial extruded floating pellet feed containing 45% crude protein, 10% crude fat, 3% crude fiber, and 12% moisture content. The feed ingredient for the pellet feed mainly consists of fish meal, soybean meat, wheat products, rice products, fish oil, vegetable oil, soy lecithin, amino acid, vitamins, and minerals. After reaching the size of 10 cm, Asian Sea bass were fed with seasonally available fin fishes like oil sardines, anchovies, ribbon fishes, and small prawns twice a day for a culture period of another six months. Some of the cage farmers opted for grinded/minced fishes for fingerlings itself. The farmers near to the coastal area usually prefer live fishes for feeding and they fed 15 kg fishes per day for each cage; others prefer the collection of cheaply available fishes at low cost and kept them in freezers for feeding. The growth rate of Asian Sea bass was higher as it attained 3000 g weight on average in an eight-month duration while Pearl spot attained 600g weight on average in the same culture period. Most of the cage-reared fishes in this area are free from diseases; however, some instances like heavy rain or changes in water color led to the spread of fungal disease in less than 10% of cage farms. Sudden environmental changes or overcrowding can stress fish, making them more susceptible to diseases. At the time of introduction, stress can lead to mortality of species; competition among fishes for feed can create lesions that attract bacterial attacks leading to fish loss. No incidence of disease was encountered in any of the cages during the culture period, with survival rates varying from 80-90% in different locations. Harvests were conducted at eight months into the culture period; the average lengths of harvested fish were 15cm- 70cm and average weights were 1 kg for Pearl spot and 3 kg for Asian Sea bass. A total catch of about 100 to 150 kg of fishes is being caught daily during peak season. Partial harvesting is also practiced by harvesting larger fish first; harvested fish are weighed and sold at farm gate prices before being taken to market for selling. The live fish market is fueling widespread interest in cage aquaculture; harvested Asian Sea bass and Pearl spot are sold in local markets at prices ranging from Rs. 400-550/kg, reflecting high demand due to their quality and taste.

Cost and Benefit analysis of cage fish farm

Capital Investment

In cage culture, the funds allocated for the installation of cages, along with the major and minor accessories involved, constitute the capital investment. This capital investment includes key components such as the HDPE cage frame, HDPE nets, floats, ropes, and the one-time launching charge.

Particulars	Investment	Percentage
HDPE Cage frame	125000	50.38
HDPE Net	20000	8.06
Floats	10800	4.35
Ropes	300	1.20
Security	12000	4.83
One time launching Charge	80000	32.24

Total Fixed Cost(1+2+3+4+5+6)= 248100

Operational Cost

Operational costs in cage fish farming are the essential expenses needed to run the operation on a daily basis.

Particulars	Cost	Percentage
Feeding	1,25,000	60.67
Seedling	40,000	19.417
Net cleaning	1,000	0.48
Water inspection	2,000	0.97
Labour Charge (600/Per day)	18,000	8.73
Net mending and Maintanance	20,000	9.70

Operational Cost(1+2+3+4+5+6)= 2,06000

Returns

Economic Metrices	Asian Seabass
Gross revenue	600000
Net Profit	145900
Annual Profit ratio	24.316
BCR	1.25
OER	34.33%

The success of cage farming depends on factors like as capital investment, operational costs, yield, and mortality rates(Aswathy et al., 2020). The capital investment is primarily allocated towards the HDPE cage frame and net, which are critical components for effective aquaculture operations. Specifically, the HDPE cage frame represents the largest share of the investment of 50.38% of the total expenditure. The HDPE net follows, comprising 8.06% of the investment. This allocation underscores the importance of these materials in ensuring the structural integrity and durability of the farming system, as well as facilitating optimal fish growth and management practices in floating cage culture(Cardia & Lovatelli., 2015). The operational costs for the aquaculture project are distributed across several key areas, reflecting essential activities for maintaining effective fish farming practices. Feeding accounts for the largest portion of the expenses, making up 60.67% of the total operational costs, while seedling expenses represent 19.42% of the overall costs. The Economic performance metrics for the project indicate strong profitability and economic viability. With a gross revenue of Rs 600,000 and a net profit of Rs 145,900, the project achieves an annual profit ratio of 24.316%, reflecting effective cost management and operational efficiency. The Benefit-Cost Ratio (BCR) of 1.25 shows that for every rupee spent, the project generates Rs 1.25 in benefits, demonstrating its capacity to provide returns that exceed costs.

Fish cage culture is a viable business that can help combat hunger, unemployment and poverty (Kevin, 2022). The cage practiced here in brackish water condition, Suitable locations in India's long coastline, vast brackish water areas available in the coastal states and other underutilized water bodies can be better utilized by adopting cage culture (Charles et al.2022). From the study area 95% of farmers used GI pipes for constructing cage frames with knotless type, Commonly used materials for cage frames are bamboos, mild steel (MS), galvanized iron (GI), poly-vinyl chloride (PVC) and virgin-grade HDPE (High Density Polyethylene) (for runner-based & pontoon-based frames). Cage frames are fabricated either with High Density Poly Ethylene (HDPE) or Galvanized Iron (GI) material to withstand rough conditions in the Indian seas (NFDB, 2018) Knotless nylon nets are recommended for cage fabrication. This study reveals that farmers prefer smaller sized cages as larger sized cage fish farmers faced problems in changing net, cleaning and grading. This study suggests that cage mounted by iron pipes and anchored by iron at the bottom is more economical compared to floating nylon cage with bamboo frames.

During the study, 31% of women is practicing cage fish farming in Malappuram and Kozhikode district but they are not directly involved in farming activities but indirectly support in fishing activities by feeding and marketing of the fishes. Male dominant society accepted that women are also equally important for the family and to make small or large business successful and women are supporting their family by earning money by themselves. Some ethnic groups which are mainly engaged in fishing involves women in cage fish farming like feeding the fish and cleaning the cages, but recently they are involved in decision making, meetings, workshops, excursions and aquaculture related activities. Gurung (2003) concluded that cage fish culture has strengthen women's empowerment, as women are active in activities like attending meetings, making decisions, boating, harvesting, marketing and even in transportation. Kapapa (2003) study documented that woman are engaged in cage fish farming. They are engaged in fish processing and farming activities but not in fish harvesting in Tanzania (Kapapa, 2003).Ng'Wigulu also mentioned that in an area around Lake Victoria women are participating in harvesting, processing and marketing activities based on cage fish farming.

Fish species that are suitable for cage culture vary considerably in their feeding habit, temperature water quality, pH and other characteristics (Bista et al., 2012). Most preferable species in the study area is Etroplussuratensis and Lates calcarifer rearing outer cage with Etroplussuratensis helps to keep the cages free from algaes and it also reduces the usage of pellet feeds. The frequency of feeding is a factor that influences the zoo technical performance of farmed fish. In the Epinephelustauvina, a frequency of one meal every two days optimizes the production yield in a floating cage (Thia-Eng and Seng-Keh, 1978). Webster et al. (1992) have shown that a frequency of one meal per day ensures good growth of Ictaluruspunctatus; and that at two meals per day, a good carcass yield is obtained.

The farmers prefer procuring of seeds from the government agencies than private farms due to its high survival rate, counter to that Kevin et al.2022 conducted study in Lake Victoria, Kenya states that fish seeds are mostly bought from the local hatcheries to reduce costs of transportation and improve their chances of survival.

For feeding in cages farmers using trash fishes also for better growth results, but Mohan et al., 2018 discussed that using trash fish as feed is not a green practice and therefore this practice should stop forthwith. One criticism against aquaculture is that its growth is a direct threat to the wild fish resources. This is because of the use of wild caught fish as feed as well as the use of large quantities of fishmeal from marine biodiversity resources including fish. The survival rate varied from 70-80% in different locations due to the presence of recreational, public drainage area near to the area and different weather conditions, similar studies conducted by Aswathy et al.2018 states the survival rate varied from 80-90% in the cage farms which is similar to the current study. The advantages of cage culture over other culture systems are its ability to use different types of water resources such as lakes, reservoirs, ponds and rivers, which could be unsuitable for fish farming due to difficulties in harvesting (Kenya, 2009). Cage farming at Nagayalanka in Krishna district reported an average body weight of 745 g at harvest, with a survival of 97.3%, feed conversions of 1 : 1.62, and biomass of 10.86 kg/m3 (Charles et al. 2022) that the approximately similar weight of fish at harvest from the present study. The yield per cage varied from 3 kg for Asian sea bass and 1 kg pearl spot. The selling price was Rs.550/kg. Study conducted in Pizhala showed the selling price (INR 500) for Asian sea bass and Pearl spot for cage dimension 2x2x1.5m3 (Aswathy et al, 2018). An increased interest of farmer's participation in this farming shows that this farming is gaining popularity because of high profits and income from low production cost.

Conclusion

The present study conducted in Malappuram & Kozhikode district for the assessment of cage farming practices and economic analysis of cage fish farms provided valuable insights into the current status of cage fish farms in the region. The study highlighted the different cage farming practices, fish species cultured, and management techniques employed by fish farmers. The economic analysis defines the profitability of cage fish farms, considering operational costs and revenue generation. Based on the findings, cage fish farming is contributing to the local seafood supply in the districts. The cultivation of Asian sea bass and Pearl spot demonstrated potential for growth and market demand. High quality feeds were found to influence the fish growth and production cost, suggesting the need for better feed management practices. The study also revealed the importance of water quality management and disease control measures for the overall productivity of cage fish farms. Cage farming in the coastal waters of Malappuram district offer tremendous potential for increasing the farm income and fish production in the district.

Cage farming of Asian sea bass and Pearl spot in the selected fish farms in Northern Kerala showed economically viable enterprise and showed better productivity. Cage farming in this area offers increased income for the farmers.

Cage farming in the coastal waters of Kerala offer tremendous potential for increasing the farm income and fish production in the state. Cage farming of Asian sea bass adopted by the farmers in the selected cage fish farms in Northern Kerala proved to be an economically viable enterprise and showed better productivity.

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