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Economic Feasibility and Resource Use Efficiency of Coastal Cage Fish Farming in Kerala

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ABSTRACT

Fish farming in open water cages is a recently introduced technology in India. The successful cage farming demonstrations in the open sea led to its popularisation in the coastal waters in the country. The economic viability of cage fish farming was analysed based on primary data collected from 60 farm units in Kerala state in the South west coast of India. Asian seabass, pearlspot, tilpaia, redsnappers and caranx were the major species cultured in the study area. The average size of a farm unit was 115 m^3 with a stocking density of 32 fishes per m^3. The gross revenue and average cost were ₹ 8584 and ₹ 4331 respectively per m^3 of farm area. The Benefit–cost ratio and operating ratios were 2.02 and 0.42 respectively indicating cage farming as an economically viable farming technology. Resource use efficiency analysis indicated that stocking density and quantity of feed used had positive and significant influence on fish production and economic efficiency could be improved by increasing the use of these inputs.

Keywords: Cage farming, cobb-douglas function, economic viability, resource use efficiency

Aquaculture is one of the fastest growing food producing sectors in the world and global aquaculture production reached 106 million t in 2015, with an estimated value of US$163 billion (FAO, 2017). In India fresh water aquaculture contributes 95% of the total aquaculture production followed by brackish water shrimp culture (ICAR, 2013). Sea cage farming is of recent origin in India and was popularised by several institutional agencies in the country through front line demonstrations in different maritime states. Cage farming of high value finfishes gained widespread popularity in the maritime states of the country after the introduction of low cost cages and development of seed production techniques for high value finfishes. Cage culture of fishes allows for intensive exploitation of water bodies with relatively low capital investment. The introduction of cage culture into the aquatic ecosystem maximises the carrying capacity per unit area as the free flow of current brings in fresh supply of water and ensures optimum growth by removing the metabolic wastes, excess feed and faecal matter (Vikas *et al.* 2010).

The farmers in the coastal areas of Kerala state were the pioneers in adopting cage farming in the brackishwater areas in the country. The state located in the southernmost part of India is endowed with abundant coastal and inland water resources. The state contributed an average marine fish production of 5.4 lakh t in 2016 which was 15% of the total marine fish production in the country. There is an estimated 1.26 lakh ha area of coastal water resources comprising 0.65 lakh ha of brackish waters, 0.46 lakh ha of backwater canals and 0.13 lakh ha of prawn filtration fields in the state (www.fisheries.kerala.gov.in). Even though extensive areas of backwater available for fish culture in the state, most of the areas are currently left unused (Imelda Joseph and Gopalakrishnan, 2017). Cage farming in the coastal waters is of recent origin in the state. The major species cultured were Asian sea bass (*Lates calcarifer)*, pearlspot (*Etroplus suratensis)*, tilapia (*Oreochromis* sp.), mullet (*Mugil* sp.), red snappers and caranx. The study was conducted in Ernakulam district where more than 80% of the cage farms in the state are located. The economic viability analysis occupies a key role in micro level investment decisions as well as for developing polices and promotional activities in any sector. Farmers would try to maximise their returns by allocating resources in an efficient manner. The resource use efficiency is a major indicator on how investment, subsidies and credit are used in an efficient manner in farming activities.

Cage farming is a recently introduced technology in India and very few studies focussed on the economic viability of cage farming. The economic viability of cage farming in open sea and reservoirs were studied by many authors (Conte *et al.* (2008); Das *et al.* (2009); Narayanakumar *et al.* (2009); Phimphakan *et al.* (2013); Christ Ulrik Pedersen (2016), whereas studies in the coastal areas are limited (Azazy *et al.* (2012) in Egypt; Aswathy, N & Imelda Joseph in Kerala (2018))

METHODOLOGY

Ernakulam district (9.9816^0 N and 76.299^0 E) in Kerala state was purposively selected for the study as more than 80% of the coastal cage farms in the state are located in this region. Data on costs and revenues from selected cage farms in Ernakulam district of Kerala was collected during the year 2017. The sample consisted of 60 farmers covering 320 cage farm units installed in the backwaters of Ernakulam district. The sample farmers were selected randomly and consisted of owners of cage farms. The resource use efficiency was studied based on selected variables. The sample farms varied with number and dimensions of cages, cultured species and stocking density. The economic performance of cage farms were analysed using various indicators like Net profit, Operating ratio, Net Benefit-Earnings ratio , Benefit-Cost Ratio (BCR) and Return On Investment. Net profit is calculated by deducting all costs including operational expenses, depreciation and interest on fixed capital from the Gross earnings. Other economic indicators used for economic efficiency were calculated as follows.

Operating ratio = Operating costs/ Gross revenue …(1)

Net benefit earnings ratio = Net Cash Flow (NCF)/Total Earnings (TE) …(2)

The ratio expresses the NCF or net benefit as a percentage of TE. A ratio of more than 10% can be considered as good (Lery *et al.* 1999, Tietze *et al*. 2001).

Return on investment (ROI) = Net profit/capital investment …(3)

The ratio shows how much money needs to be invested in an enterprise in order to generate a certain level of net profit (Zugarramurdi *et al*. 1995; Tietze *et al*. 2001).

Resource use efficiency analysis

An efficient farmer allocates his resources in an optimal manner, so as to maximise his income, at least cost, on sustainable basis. Multiple regression model used by Emokaro & Ekunwe (2009), Williams *et al.* (2012), and Apu Das (2017) was applied to measure the resource use efficiency in cage farming. The following production function model was employed to analyse the resource use efficiency.

$$P = F\ (A, S, F) \qquad \ldots(4)$$

P = Fish production per farm (kg)

A = Area of cage farm unit or cage volume in m^3

S = Stocking density in numbers

F = Quantity of feed in kg

Allocative efficiency

Allocative efficiency was calculated by equating the marginal value product (MVP) of inputs to their respective marginal factor costs (MFC). In order to determine optimal use of a resource keeping the use of other resources constant, MVP and factor cost of their resource were compared. The MVP of each resource is calculated by using the following formula.

$$MVP = MPP_{xi} * P_y \qquad \ldots(5)$$

Where MPP_{xi} is the marginal physical product of the i^{th} input (change in output due to a per unit change in the specified input) and P_y is the price per unit of fish. P_{xi} is the cost per unit of the i^{th} input obtained by dividing the total cost of the i^{th} input by the quantity of input. $MPP_{xi} * P_y$ is the value of marginal product and P_{xi} is marginal factor cost. Hence allocative efficiency can also be expressed as, Allocative efficiency = Marginal value product (MVP) / Marginal Factor Cost (MFC) …(6)

If MVP/MFC equal unity then resource is optimally used. A value of less than unity implies over-use of the resource, and of greater than unity under-use of the resource.

RESULTS AND DISCUSSION

Cage fish farming is a recently introduced technology in the coastal waters of Kerala. Several institutional agencies including Central Marine Fisheries Research Institute, Fisheries University, State Department of fisheries, and few Non-Governmental Organisations were involved in popularisation of this technology among the coastal fish farmers.

General particulars of cage farmers

Data were collected from 60 farm units consisting of 320 cages located in Ernakulum district of Kerala state. The panchayat authorities in Ernakulam district issued licenses for installing cages in the coastal waters at specified rates for each culture season based on the size of farm. The average age of respondent farmers was 42 years. The cage dimensions and stocking density adopted by the farmers varied owing to availability of technical and financial resources. The selected farms had an average farm size of 115m^3 with a stocking density of 32 fishes per m^3. The dimensions of cages varied from 2×2×1.5m^3, 4×4×2m^3, 8×4×2m^3, 4×4×4m^3, 8×4×4m^3 and 6×6×4m^3. The average feed conversion ratio in the sampled farms was 4.34(79 kg feed was used for producing 18 kg fish per m^3) (Table 1).

Table 1: General particulars of cage farms

Particulars	Farm size	
	115m^3	1 m^3
Stocking density (no)	3745	32
Feed (kg)	9082	79
Production (kg)	2090	18
Labour days (no.)	80	0.7

Analysis of ownership pattern of the cage farms showed that 55% of the cage farms in the study area were under single ownership, 28% owned by self-help groups and 17% through partnership (Table 2).

Table 2: Ownership status of cage farms

Category	No	%
Single	33	55.00
Partnership	10	16.67
SHG	17	28.33
Total	60	100.00

Economic viability of cage farming

The major species cultured in the selected cage farm units consisted of Seabass, Etroplus, Tilpaia, Pompano, Cobia, Redsnappers and Carangids. The yield and revenue per farm were 2.09 t and ₹ 9,90429 respectively. The net profit was ₹ 4,99,957.2 with net benefit earnings ratio of 0.5 and operating ratio of 0.42. Among the various cost components 56% of the operational cost was incurred as feed cost followed by seed cost (21.9%). The average cost of fish production and price per kg of fish was ₹ 235 and ₹ 474 respectively. The benefit- cost ratio was 2.02 with return on investment of 241 % (Table 3 & 4). The economic analysis of sea cage farming in Vizaghapatnam by Narayanakumar *et al. (2009)* reported the cost of production per kg of sea bass to ₹ 94.24 against the unit value of ₹ 189.89 per kg. The benefit-cost ratio was on par with that of fish farming reported in other locations. The economics of fish farming in Saki-East Local Government Area (LGA) of Oyo State, Nigeria by Tunde *et al*. (2015) showed Benefit-Cost Ratio (BCR) of 1.9, indicating fish farming as a profitable venture.

Table 3: Costs and revenues in cage farming (₹)

Particulars	115m^3	m^3
Fixed costs		
Cost of cage structure	191416.7	1659.0
Freezer & accessories	16133.3	139.8
Depreciation	49968.7	433.1
Interest on Fixed capital	24906.0	215.9
Annual Fixed cost	74875	649
Operational costs		
Seed	91168.8	790.2
Feed	233978.3	2027.9
Labour	64533.3	559.3
Other expenses	25916.7	224.6
Gross Revenue	990429.0	8584.1
Total operational cost	415597.1	3602.0
Total cost	**490471.8**	**4250.9**
Net profit	**499957.2**	**4333.1**

The economic analysis of cage culture of reservoirs in India by Das *et al.* (2009) reported the income per crop cultured over 3 months with a working volume of 320 m^3 at ₹ 61,642 with a cost: benefit ratio of 2:20.

Table 4: Economic indicators per m^3 of farm area

Economic indicators	Per m^3
Operating ratio	0.42
B-C ratio	2.02
Net- benefit -Earnings ratio	0.50
ROI (%)	241
Cost/ kg (Rs.)	235
Price/kg (Rs.)	474

Resource use efficiency analysis

Among the different production function models tested, Cobb-Douglas form showed the best fit. The parameters of the model estimated using SPSS software follows;

Table 5: Parameters of the regression model

Variables	B	Std error	t	Sig
Constant	-0.708	0.271	-2.612	0.012
Stocking density (no)	0.369**	0.046	8.012	0.000
Feed (kg)	0.614**	0.028	22.212	0.000
Farm size (m^3)	-0.054	0.042	-1.303	0.198

N=60, R2=0.953, F=381.4.

*** indicates significance at 1% level.*

The estimated production function indicated that feed, seed and farm size together contributed 95% of variation in fish production in cage farms. Feed and seed used had positive and significant influence on fish production whereas farm size was non-significant. Increasing the stocking density by 1% will increase fish production by 0.369% whereas increase in quantity of feed by 1% will increase production by 0.614% from mean levels.

Resource-use efficiency was estimated for those variables which had significant effect on fish Production. The ratio of marginal value product to marginal factor cost was more than unity for seed (7.91) and feed (10.54) indicating under utilisation of these inputs in fish production and there is scope to enhance profit by increasing these inputs. Similar results were obtained for resource-use efficiency in exotic carp production in Jammu & Kashmir (Nisar *et al.* 2017 and Singh *et al,* 2009). Resource use efficiency analysis by Apu Das *et al.* (2017) indicated that stocking density had significant and positive impact on fish production. Resource use efficiency of freshwater fish production system in West Bengal by Rahman *et al.* (2015) indicated that variables such as fish seeds (0.39), and human labour (0.49) were positive and significant at one percent level. However the results differed from the resource use efficiency models reported by Kingsly *et al. (*2014) among small scale fish farmers in Nigeria and Azazy *et al.* (2012) on commercial cage culture in Manzala Lake, Egypt which showed positive coefficients on farm size or cage volume on the economic performance of fish farming.

Conclusion

Cage fish farming adopted by the farmers in the coastal waters of Kerala was found to be a profitable venture. The cage dimensions and stocking density adopted by the farmers varied owing to technical and financial constraints. There is scope to increase the resource use efficiency by increasing stocking density and quantity of feed used. Considering the vast area of coastal water resources available for culture and profitability of the culture, cage farming may be promoted in the coastal districts of Kerala to enhance the income and livelihood security of fish farmers. However location specific standardisation on number and dimensions of cages to be installed, stocking density and feeding rates suiting the technical and financial constraints of the farmers are essential to harness optimal economic returns and ensure sustainable production system. The successful coastal cage farming in Ernakulum district can be suggested as a model for promoting cage farming in the coastal villages of the country for augmenting fish production and ensuring livelihood security of fisherfolk.

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