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Economics of Cage Culture of Fish in Karnataka

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Abstract

Cage culture has emerged as a suitable alternative to fishermen to sustain their livelihood. Cage culture is extensively practiced in Karnataka. The present study aimed at assessment of economics of cage culture in Udupi district of Karnataka. Cage culturing of sea bass and red snapper in two small cages (2S), one small and one large cage (S+L) and two small and one large cage (2S+L) was observed in the study area. The capital investment was highest in case of 2S+L at Rs. 1,34,380. The total cost incurred on production of sea bass and red snapper came to Rs. 4,38,885 and Rs. 8,11,939.20 in case of S+L and 2S+L, respectively. Fishermen following 2S+L was found to be economically successful in terms of net returns (Rs. 233.37/kg and Rs. 122.94/kg) compared to S+L (Rs. 226.45/kg and Rs. 78.14/kg) in cage culture of sea bass and red snapper due to the operation of scale economies. The cage system 2S+L was found economically viable but was fraught with constraints in operational and financial management.

Keywords: Cage culture, Economics, Fishery

Introduction

Indiscriminate fishing in open access has led to depletion of natural fish stocks and consequently constrained supply. In order to bridge this gap, aquaculture has become an indispensable alternative. Fish production in net cages and ponds are the better alternatives available to the fish farming communities. Cage culture is a viable alternative to fishermen practiced in wide range of fresh water and marine water ecosystems. In cage culture, rearing of fish from fry to fingerling, fingerling to table size, or table size to marketable size takes place in an enclosed space by maintaining the free exchange of water with the surrounding water body (Das et al., 2009). Cage culture provides employment, efficiently utilizes the productivity of water bodies and consequently reduces pressure on natural fish stock leading to sustainability. Cage culture involving simple technology can be designed using locally available resources. Karnataka state has three coastal districts and a coastline of 300 km beside brackish water/ estuarine area of 8000 ha. Among three districts, Uttara Kannada has 13 estuaries with total estuarine area of 4200 ha followed by Udupi having 8 estuaries with area of 1885 ha and Dakshina Kannada with 5 estuaries having a total area of 1140 ha. Estuarine Cage culture is prominent in Karnataka and fishermen of Uppunda region of Udupi district are pioneers in practicing cage culture. In this region, cage culture of sea bass (*Lates calcarifer)* and red snapper (*Lutjanus campechanus*) is common. This study presents three cases of cage culture of this region.

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Materials and Methods

The study was conducted in Uppunda village of Kundapura taluk of Udupi district known for its pioneer work in cage culture. Estuarine cage culture was the practice followed by fishermen as an alternative to their capture fishery. Eighteen fishermen of Uppunda village formed a formal association in the name of Sea bass cage culture group, using the technology of open sea cage culture developed by ICAR-CMFRI (Megarajan et al., 2019) culturing two predominant species sea bass (*Lates calcarifer)* and red snapper (*Lutjanus campechanus*). Since, they practiced cage culture the group was purposively selected for the study. Sea bass fingerlings are procured from Tamil Nadu while red snapper fingerlings are available locally. They follow cage culture in three different systems such as two small cages (2S), one small and one large cage (S+L) and two small and one large cage (2S+L). The data pertaining to demographic factors like age and education of the fishermen, species of fish reared, system of cage culture practiced, capital investment on cage structure, recurring expenses on production, and yield was elicited from the eighteen farmers of the group for the year 2016-17. The data was analyzed using budgeting technique, simple ratios and percentages. Variable costs include the expenditure made by the fishermen towards rearing of sea bass/red snappers on variable resources such as human labour (man days), fingerlings, feed, opportunity cost of working capital estimated at the bank rate of interest of 12 percent. Fixed costs include depreciation of cages and its components, interest on fixed capital indicating the opportunity cost was estimated at the interest rate of 12 percent (Aswathy & Joseph, 2018). Depreciation was worked out following straight line method considering the actual cost incurred on the asset, junk value and useful life of the asset. For the culture systems (S+L and 2S+L) that involved both sea bass and red snapper for 12 months out of the 18 months, depreciation of cage and its components was worked out separately using straight line method. The depreciation amount was apportioned between sea bass and red snapper based on the extent of utilization of cages. Same analogy was used to apportion the interest on fixed capital estimated at the rate of interest of 12 percent for 18 months across sea bass and red snapper. Summation of variable costs and fixed costs is the total cost incurred towards rearing of respective fish species. Gross returns was estimated by multiplying live weight of the fish at the time of sale after duly accounting for the mortality rate with the prevailing market prices. Net returns was worked out by deducting the total cost incurred from the gross returns realized. (Nunoo & Asamoah, 2012).

Results and discussion

Majority of fishermen (50.05%) were found practicing cage culture with 2S as they are easy to manage, operate and involves less capital investment as compared to the other systems (Table 1). The cage culture system with 2S+L was practiced by 33.33 percent of fishermen and 16.70 percent of fishermen were found practicing S+L system. It was clear that younger and educated fishermen have adopted cage culture.

Three different systems of cage culture, two small cages each of dimension 12 x 6.5 x 6.5 ft {2S}, one small (12 x 6.5 x 6.5 ft) and one large (20 x 6.5 x 6.5ft) {S+L} and two small cages (12 x 6.5 x 6.5 ft) and one large (20 x 6.5 x 6.5 ft) {2S+L} were adopted. The summary of capital investment on three different systems (Table 2) indicates that the total investment ranged from Rs. 80050 to Rs. 134380. The

Table 1. Socio-demographic characteristics of fishermen practicing cage culture of fish (n=18)

Particulars		Cage culture with	
	Two small cages	One small and	Two small and
	one large cage	one large cage	
1) Number of fishermen	9 (50.05)	3 (16.70)	6 (33.33)
2) Age (years)	32.67	34.67	34.00
3) Education			
a) Primary	3 (33)	-	2 (33.33)
b) Secondary	5 (56)	3 (100)	4 (66.67)
c) College	1 (11)	-	-
4) Species reared	Sea bass	Sea bass and Red snappers	Sea bass and Red snappers

Note: Figures in the parentheses indicate percentage to the total

Table 2. Summary of capital investment on cage systems

Particulars/Cage system	Rate (Rs.)	2S Qty.	Value (Rs.)	S+L Qty.	Value (Rs.)	2S+L Qty.	Value (Rs.)
I. Small cage							
1. Cage frame of GI pipes (each of 20 ft length)	1200	8	9600 (11.99)	8	9600 (9.71)	16	19200 (14.29)
2. Cage bag							
a) Outer HDP mesh (sq.ft.)	14	535.71	7500 (9.37)	535.71	7500 (7.58)	1071.43	15000 (11.16)
b) Inner mesh (Kg)	450	10	4500 (5.62)	10	4500 (4.55)	20	9000 (6.70)
c) Nylon ropes (3mm) (Kg)	250	3	750 (0.94)	3	750 (0.70)	6	1500 (1.12)
d) 8 mm rod with plastic slit (no.)	16.67	12	200 (0.25)	12	200 (0.2)	24	400 (0.30)
e) Hapa cage (fine mesh net in kg)	500	10	5000 (6.25)	10	5000 (5.06)	20	10000 (7.44)
Sub total			17950 (22.4)		17950 (18.09)		35900 (26.72)
3. Floating system							
a) Cans (No.)	250	4	1000 (1.25)	4	1000 (1.01)	8	2000 (1.49)
b) PVC pipes (Length)	1000	3	3000 (3.75)	3	3000 (3.03)	6	6000 (4.46)
Sub total			4000 (5.00)		4000 (4.04)		8000 (5.95)
4. Service system (PVC pipe attached with collar in number)	1000	1	1000 (1.25)	1	1000 (1.01)	2	2000 (1.49)
5. Labour to prepare cage (mandays)	500	6	3000 (3.75)	6	3000 (3.00)	12	6000 (4.46)
Investment on small cage/s			71100 (88.8)		35550 (35.85)		71100 (52.91)
II. Large cage							
1. Cage frame (each of 20 ft length)	1200			12	14400 (14.50)	12	14400 (10.72)
2. Cage bag							
a) Outer HDP mesh (sq.ft.)	14			845	11830 (11.90)	845	11830 (8.80)
b) Inner mesh (Kg)	450			16	7200 (7.20)	16	7200 (5.36)
c) Hapa cage (fine mesh net in kg)	500			10	5000 (5.06)	10	5000 (3.72)
d) Nylon ropes (3mm) (Kg)	250			6	1500 (1.50)	6	1500 (1.12)
e) 8 mm Rod with plastic slit (no.)				24	400 (0.40)	24	400 (0.30)
Sub total					25930 (26.06)		25930 (19.30)
3. Floating system							
a) PVC pipes (Length)	1000			4	4000 (4.05)	4	4000 (2.98)

b) Cans (No.)	250			8	2000 (2.02)	8	2000 (1.49)
Sub total					6000 (6.07)		6000 (4.47)
4. Service system (PVC pipe attached with the collar at rear end in number)	1000			1	1000 (1.01)	1	1000 (0.74)
5. Labour to prepare cage (mandays)	500			14	7000 (7.08)		7000 (5.21)
Investment on large cage					54330 (54.72)		54330 (40.43)
Common investment made on all the cages							
1. Anchoring arrangements							
a) Rope nets (Kg)	250	5	1250 (1.56)	5	1250 (1.20)	5	1250 (0.93)
b) Labour to prepare anchor system with sand (mandays)	500	4	2000 (2.49)	4	2000 (2.02)	4	2000 (1.49)
Sub total			3250 (4.05)		3250 (3.22)		3250 (2.42)
2. Mooring system							
a) 14 mm ropes (Kg)	250	10	2500 (3.12)	10	2500 (2.50)	10	2500 (1.86)
3. Nylon fishing dip net (Kg)	500	4	2000 (2.49)	4	2000 (2.02)	4	2000 (1.49)
4. Weighment Scale (no.)	1200	1	1200 (1.50)	1	1200 (1.21)	1	1200 (0.89)
Sub total			8950 (11.20)		8950 (8.95)		8950 (6.66)
Total investment			80050		98830		134380

Figures in parenthesis indicates percentages

major investment was on cages (ranging from 88.80 percent to 93.34 percent of the total investment) with the remaining on anchoring and mooring systems (Table 2). Anchoring system is required for holding cages and their components in a particular site. Dead weight anchors of sand bags were used. Anchoring was given at two points with 25 bags of sand each weighing 50 kg in a rope net. It is preferred because of its consistent holding power. Mooring is the other vital system in cage culture which depends on depth, substratum and intensity of water current. It is essential to hold the cage in suitable position according to the direction and depth from sea bed. Nylon ropes are used for mooring. It joins the cage at the anchor system. It must have enough strength to resist the forces of water and wind currents. Around 10 kg of nylon ropes of 14 mm thickness was used for mooring. Floating system is vital in cage farming as it provides buoyancy and holds the system at a suitable level on the surface of water. Fishermen used PVC pipes as floats for suspending the cage in water. Additional floatation was given using empty plastic oil cans.

Sea bass is commonly cultured in estuarine cage system because of its attributes such as relatively hardy, physiological tolerance, rapid growth, commercial availability of seed due to very high fecundity of female fish and early harvest age (Mathew, 2009). The 2S cage system enabled fishermen to rear only sea bass and its economics is presented in Table 3. The variable costs formed 73.53 percent and fixed costs cornered remaining 26.47 percent of the total cost in the case of 2S cage system. Sea bass attains marketable size after 18 months. Hence, economics of cage culturing of sea bass was estimated for 18 months. On an average, 633 fingerlings were stocked in one of the small cages for the initial 6 months period. Fishermen encountered mortality due to cannibalism at the rate of 33.65 percent leaving 420 fishes alive. In order to have better growth of fishes, 420 fishes were distributed to two small cages and reared for another 12 months to attain marketable size. Among the variable costs, the expenditure on feed was highest accounting for 38.07 percent of the total cost. The results were in conformity with the findings of Gammanpila & Singappuli (2012) and Arikan & Aral (2019). It was followed by labour which accounted for 17.97 percent of the total cost. Cage culture is highly labour intensive and requires labour to perform various operations like stocking of fingerlings, feeding, cleaning of cages, supplementing medicines, harvesting etc (Michael, 1988). Feeding required cleaning and chaffing of the low value

Table 3. Economics of Sea bass in 2S cage system

Particulars		2S	
	Rate (Rs.)	Qty.	Value (Rs.)
I. Variable cost			
1) Seed / fingerlings (nos.)	40	633	25320 (9.49)
2) Feed (kg)			
a) Upto 2 months	15	379.8	5697 (2.14)
b) 2-6 months	15	1026	15390 (5.77)
c) 6-18 months	15	5365.5	80482.5 (30.17)
Sub total			101569.5 (38.07)
3) Labour (man-days)			
a) Feeding	500	79.375	39687.5 (14.87)
b) Cleaning	500	13.5	6750 (2.53)
c) Harvesting of fish at market size	500	3	1500 (0.56)
Sub total			47937.5 (17.97)
4) Medicine			352 (0.13)
5) Interest on working capital @12%			21021.48 (7.88)
Total variable cost			196200.50 (73.53)
II. Fixed cost			
1) Depreciation			56206.25 (21.07)
2) Interest on fixed capital @12% p.a.			14409 (5.40)
Total fixed cost			70615.25 (26.47)
III. Total cost (I + II)			266815.70
IV. Returns			
1) Gross returns	430	1155	496650
2) Net returns			229834.30
3) Cost per Kg			230.98
4) Net returns per Kg			198.99

Figures in the parentheses indicates percentage to the total fishes used as feed to the desired size before being fed to fishes up-to the age of six months. From seventh month to 18^{th} month, fishes are fed with low value fishes without chaffing (Gouranga et al., 2011). Cleaning of cages is essential to avoid the incidence of bio-fouling, spread of diseases and reduce the turbidity of water. Bio-fouling by molluscs spat and bivalves is very common in estuarine cage culture and is unavoidable as net walls of the cage are a convenient surface for the attachment of organisms such as amphipod, polycheates, barnacles, molluscs spat and bivalves (Pabitra et al., 2017). The 2S system of cage culture has generated employment to the rural folk to the magnitude of 96 man-days. Of the fixed costs, the depreciation shared 21.07 percent of the total cost followed by interest on the fixed capital (5.40%). The average cost incurred per live weight of fish in 2S system came to Rs. 230.98 leaving a profit of Rs. 198.99 to the fishermen.

The combination of the small and large cages (S+L and 2S+L) enabled fishermen to rear both sea bass and red snapper. In the S+L system initially, fingerlings of sea bass procured from Rajiv Gandhi Centre for Aquaculture, Tamil Nadu was stocked in small cage for six months. Later, sea bass was allowed to grow in large cage for one year to attain marketable size. The small cage which remained idle after transferring six months old sea bass to large cage was used for rearing red snapper species. Fishermen practicing 2S+L system of cage culture reared sea bass and red snapper. Sea bass initially stocked in small cages, are transferred to one small cage and large cage after six months, to attain proper growth, to reduce competition among fishes for space and food and to overcome the problem of cannibalism. The other small cage which was lying idle after six months was used for rearing red snappers. Fishermen practicing 2S+L had better stocking capacity compared to previous two systems.

The economics of sea bass and red snapper is presented in Table 4. On an average, fishermen stocked 967 fingerlings of sea bass and 233 fingerlings of red snappers in S+L cage system and 1875 fingerlings of sea bass and 575 fingerlings of red snapper in 2S+L system. The fishermen in S+L system incurred a total cost of Rs. 323153.80 and Rs. 115731 towards rearing of sea bass and red snapper, respectively. The share of variable costs was 81.20 and 75.48 percent in case of sea bass and red snapper, respectively. Among the variable costs, feed cornered major chunk of 43.83 and 36.39 percent of the total cost in case of sea bass and red snapper, respectively. The other vital expenditure was on human labour required to stock procured fingerlings in case of sea bass, to capture fingerlings in case of red snapper from the estuaries, feeding of fishes with chaffed low value fishes, cleaning of cages, medication of fishes, regular supervision of cages etc. A total of 178.26 man-days of labour employment was generated by S+L cage system to the fishermen community. The livability percentage of sea bass and red snapper in case of S+L cage system was 58.64 and 91.42 percent, respectively. After duly accounting for mortality, the production of sea bass and red snapper was estimated at 1587.60 and 383.40 kg, respectively. The average cost incurred towards production of kg live weight of sea bass and red snapper worked out to Rs. 203.55 and Rs. 301.86, respectively. Fishermen realized net returns of Rs. 226.45 and Rs. 78.14 per kg live weight of sea bass and red snapper.

The livability of sea bass was comparatively lower in case of 2S+L due to intense stocking of fingerlings leading to rampant cannibalism (Patil et al., 2020) The variable cost cornered lion share of 87.34 and 77.84 percent of the total cost in this system as well. In the order of species, feed alone accounted for 50.37 and 48.93 percent of the total cost in case of 2S+L system. It was followed by human labour which accounts for 13.97 and 20.57 percent of the total cost in case of sea bass and red snapper. The average cost incurred per kg live weight of sea bass and red snapper worked out to Rs. 196.63 and Rs. 257.06 leaving a net returns of Rs. 233.37 and Rs. 122.94. The 2S+L system provided employment of 260.60 man-days to fishermen. Compared to other cage systems viz., 2S and S+L, the average cost incurred to produce either sea bass or red snapper was relatively lower in case of 2S+L. The obvious reason would be the operation of real and pecuniary economies. Economies of scale occurs due to increase in the scale of production, the cost incurred per unit of output reduces due to increased bargaining power in terms of input purchase, reduction in the actual requirement of inputs in physical units etc.

The economic efficiency of the cage systems with respect to production of sea bass and red snapper was captured in terms of net returns per kg of live weight of sea bass and red snapper. Higher the net returns per kg of live weight of fish, higher will be

Table 4. Economics of Sea bass and red snapper in cage systems (S+L and 2S+L)

Particulars	Rate	S+L Qty.	S+L Sea bass Value (Rs.)	S+L Qty.	S+L Red Snapper Value (Rs.)	2S+L Qty.	2S+L Sea bass Value (Rs.)	2S+L Qty.	2S+L Red Snapper Value (Rs.)
I. Variable cost									
1) Seed / fingerlings (nos.)	40	967	38680 (11.97)			1875	75000 (13.45)		
2) Feed (Kg)									
a) Upto 2 months	15	580.2	8703 (2.69)	139.8	2097 (1.81)	1125	16875 (3.02)	345	5175 (2.03)
b) 2-6 months	15	1620	24300 (7.52)	335.52	5032.8 (4.35)	3037.5	45562.5 (8.17)	931.5	13972.5 (5.49)
c) 6-18 months	15	7243.42	108651.37 (33.62)	2332.35	34985.25 (30.23)	14563.5	218452.5 (39.18)	7026.25	105393.75 (41.41)
Sub total			141654.37 (43.83)		42115.05 (36.39)		280890 (50.37)		124541.25 (48.93)
3) Labour (man-days)									
a) to catch red snapper	500			7.5	3750 (3.24)			15	7500 (2.95)
b) Feeding	500	90.26	45312.5 (14.02)	56.25	28125 (24.30)	135.94	67968.75 (12.19)	81.19	40593.75 (15.95)
c) Cleaning	500	12	6000 (1.86)	6	3000 (2.59)	12	6000 (1.07)	6	3000 (1.18)
d) Harvesting of fish at market size	500	4.25	2125 (0.66)	2	1000 (0.86)	8	4000 (0.71)	2.48	1237.5 (0.49)
Sub total			53437.5 (16.54)		35875 (30.99)		77968.75 (13.97)		52331.25 (20.57)
4) Medicine			500 (0.15)				890 (0.16)		
5) Interest on working capital @12%			28112.63 (8.70)		9358.8 (8.09)		52169.85 (9.35)		21224.7 (8.34)
Total variable cost			262384.5 (81.20)		87348.85 (75.48)		486918.6 (87.34)		198097.2 (77.84)
II. Fixed cost									
1) Depreciation			48584.63 (15.03)		22777.62 (19.68)		55676.25 (9.98)		47058.75 (18.49)
2) Interest on fixed capital @12% p.a. estimated for 1.5 years apportioned across sea bass and red snapper			12184.65 (3.77)		5604.75 (4.84)		14850.9 (2.66)		9337.5 (3.67)
Total fixed cost			60769.28 (18.80)		28382.40 (24.52)		70527.15 (12.66)		56396.25 (22.16)
III. Total cost (I + II)			323153.8		115731		557445.8		254493
IV. Returns									
1) Gross returns (@ Rs.430 per kg for sea bass and Rs. 380 per kg for red snapper)		1587.6	682668	383.4	145692	2835	1219050	990	376200
2) Net returns			359514.2		29960.8		661604.3		121707
3) Cost per Kg			203.55		301.86		196.63		257.06
4) Net returns per Kg			226.45		78.14		233.37		122.94

Figures in the parentheses indicates percentage to the total the economic efficiency. The 2S+L was found to be economically efficient with net returns per kg live weight of fish of Rs. 233.37 in case of sea bass and Rs. 122.94 in case of red snapper. The technical efficiency of cage culture with sea bass and red snapper captured through feed conversion ratio of 6.61 and 8.39 in case of 2S+L was lower compared to S+L (5.95, 7.32) and 2S (5.86).

Culturing of sea bass and red snapper was extensively practiced in Udupi district of Karnataka under three cage systems such as 2S, S+L and 2S+L. 2S+L was found to be economically efficient compared to S+L with respect to sea bass and red snapper. Though, 2S+L was found to be economically efficient it was fraught with maintenance and financial constraints. Hence, majority of fishermen were found-practicing cage culture in 2S system. The existing pressure on natural fish stock in open access can be reduced by resorting to cage culture of sea bass and red snapper. The fishermen inclining towards cage culture should be encouraged by the Government through provision of production related subsidies.

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