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Economic efficiency analysis of fish farming in Bharatpur District, Rajasthan: A corporate social responsibility (CSR) initiative

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ABSTRACT

The innovative corporate social responsibility (CSR) initiative of Lupin Human Welfare and Research Foundation, Bharatpur, Rajasthan, India, through fish farming in Kaman Block of Bharatpur has transformed the lives of the local population. Fish farming started with 240 families in 1980, is now benefiting 2000 people and has brought economic and social transformation in this region. Cost-benefit analysis indicated that fish farmers culturing Indian major carps (IMC) for 18 months from spawn to table size registered a benefit-cost ratio (BCR) of 2.15. The fish farmers who cultured IMC for 12 months (from fingerlings to table size) achieved a BCR of 1.77. The results of data envelopment analysis (DEA) showed that the technical efficiency was around 0.95, indicating highly efficient farms. Polluted water, disruption in power supply and poaching were found to be major constraints faced by the farmers.

Keywords: Constraint analysis, Costs and returns analysis, Data envelopment analysis, Indian major carps

Introduction

One of the best examples of corporate involvement in fisheries in India is the role played by the Tata Trusts' Open Source Fisheries Project aimed at helping rural communities in Andhra Pradesh, Jharkhand and Maharashtra, to expand and improve inland fish farming and adopt culture fisheries practices to enhance productivity and assist in increasing the incomes of 150,000 families in India in the next five years (TNIE, 2017, India CSR, 2020). But under this initiative, not many projects in fisheries have been undertaken by corporates under corporate social responsibility (CSR). But a few examples of marine, riverine and eco-system conservation drives by companies are available, which include the Save the Whale Shark drive by Tata Chemicals in 1972; Mangrove conservation in Mumbai by Godrej and Boyce in 1985; My Ganga, My Dolphin initiative by HSBC Bank in 2012 and the River Watch Project in Punjab by Nokia in 2019, besides several other companies taking up CSR initiatives on a smaller scale in different parts of the country (Fernandez, 2019).

The credit for the most dramatic CSR initiative on fish farming in a backward region goes to Lupin Human Welfare and Research Foundation (LHWR Foundation), Bharatpur, Rajasthan, which started during the 1980s. The pick-up of this initiative was slow and it was only during the last decade it caught the attention of the nation in respect of the transformation that it has brought to the lives of the Meo Muslims living in this region. Rajasthan is India's largest state by area with 342,239 km^2 which form 10.4% of India's total area. The state has freshwater as well as saline water resources which cover 4.23 lakh ha freshwater area, besides 0.30 lakh ha area as rivers and canals, 0.80 lakh ha of waterlogged and 1.80 lakh ha salt affected areas (Department of Fisheries, Rajasthan, (https://fisheries.rajasthan.gov.in). Kaman Block, Bharatpur has 55 ponds in 40 to 50 acres which have become unfit for agricultural purpose. Freshwater fishes such as rohu (*Labeo rohita*) and catla (*Catla catla*) along with mrigal (*Cirrhinus mrigala*), common carp (*Cyprinus carpio*) and grass carp (*Ctenopharyngodon idella*) were farmed by the Kaman farmers. There is good demand for the farmed fish from Kaman in the markets of Gurugram and Delhi. This has motivated the farmers to take up aquaculture as their primary occupation and the Kaman Block now has around 200 ponds for aquaculture. Bharatpur District produced 1500 t of fish and provided livelihood to 2000 families both directly as well as indirectly. With the astounding success of fish farming in Kaman Block, the LHWR Foundation has started a fish seed hatchery with capacity of one crore seeds. This hatchery supplied seeds to the farmers on no profit no loss basis. Currently the farmers are reported to be selling fish seeds to others farmers. In this backdrop, the present study was taken up aimed at identifying the positive externalities of this CSR intervention in the Kaman Block by analysing the economic and social transformation, the cost and returns, constraints and externalities of fish farming under this initiative.

Materials and methods

Data for the study were collected from 60 fish farmers from Kaman Block of Bharatpur District. Within the Kaman Block, the sample size was fixed as 15 for each of the four villages *viz.,* Jeeraheda, Jeeredi, Bamni and Navagava thus totalling 60. The 15 farmers within each village were selected over the spread of the village to avoid clustering and not to collect more of same information even though strictly randomisation was not followed owing to non-availability of complete sampling frame and preferring practical considerations. The farmers can be divided into two categories, the first category consisted of those farmers who are engaged in fish culture for a period of 18 months from spawn to table size (STS). There were 46 fish farmers in this category (76.67%). Their holdings were between 1-2 ha. The second category consisted of farmers who culture fish for a period of 12 months and raised the fish fingerlings to table size (FTS). In the second category there were 14 fish farmers which formed 23.33% of the sampled fish farmers. These farmers were marginal and operated ponds less than 1 ha. Based on the data collected from the sampled fish farmers basic cost and returns analysis was performed.

Data envelopment analysis

Charnes *et al.* (1978) and Seiford and Thrall (1990) used data envelopment analysis (DEA) to measure the relative efficiency of homogeneous set of fish farmers using linear programming. This approach is capable of estimating maximum production using several inputs and output, helping to assess the fish farming households *vis-a-vis* the maximum fish production possible. Technical efficiency (TE) of a fish farming household (FFH) is defined as the maximum output a FFH can produce with the given inputs (output-oriented) or the use of the minimum feasible amount of inputs to produce a given level of output (input-oriented). In other words, the fish farm which produces maximum fish is the one which produces more with same level of inputs or the same level of output with less inputs compared to other less efficient fish farms in the sample. Therefore, DEA helps in the comparison of each sampled fish farm with the best performing farm in the sample. DEA provides a platform for applying a range of formal statistical tests, according to Banker (1993, 1996) and Sharma *et al*. (1998). DEA has been used in several aquaculture studies in the past (Sharma *et al.*, 1999; Idda *et al.*, 2009; Chang *et al.*, 2010).

Following Charnes *et al*. (1978), a separate relative efficiency score was estimated for every fish farming household by solving the following LPP:

$$\text{Maximise the objective function } h_0 = \frac{\sum_{k=1}^{s} V_k\, y_{k0}}{\sum_{j=1}^{m} U_j\, x_{j0}}$$

$$\text{subject to the constraints } \frac{\sum_{k=1}^{s} V_k\, y_{ki}}{\sum_{j=1}^{m} U_j\, x_{ji}} \leq 1;\ i = 1, 2, ..., n$$

and V_k, $U_j \geq 0$; $k = 1,2, \ldots, s$; $j = 1, 2, \ldots, m$.

where y_{ki}, x_{ji} (all positive) are respectively the known quantities of output k produced and input j used by each fish farming household i; V_k, U_j are the weights associated with output k and input j to be determined by solving the above linear programming problem (LPP). It is also noted here that, this LPP is solved for each of the n fish farming households in the sample and hence, each of them is assigned a set of weights that are most favourable to them. In order to avoid infinite number of solutions, usually the denominator in the ratio given in the objective function is constrained as equal to one and also positing the constraint ratio as numerator minus denominator less than or equal to zero for solving the resultant multiplier form LPP. Further, the dual problem of this LPP is usually preferred to solve, as it involves fewer constraints than the multiplier form LPP. Thus the DEA model, following Coelli *et al*. (1998), finally can be written as:

Minimise θ, $\lambda\theta_i$ such that,

$$- y_{ki} + \sum_{i=1}^{n} y_{ki}\lambda_i \geq 0;\ \theta_i\ x_{ji} - \sum_{i=1}^{n} x_{ji}\lambda_i \geq 0 \text{ and } \lambda_i \geq 0;\ i = 1, 2, \ldots, n$$

It is noted here that the s are the new constants to be estimated by minimisation of this reformulated LPP. This LPP is solved n times, once for each fish farming household in the sample and a value of θ is obtained for each. θ_i is a scalar that indicates the input-oriented framework of TE for the i^{th} fish farming household, whose range lies between 0 and 1, where a value of 1 indicate a technically efficient fish farming household.

Similar to TE, cost efficiency (CE) implies efficient allocation of capital (credit) among the different inputs to maximise output. Following Ahmed *et al*. (2011), the CE can be found by solving the following LPP:

Minimise x_{ji},λ $w_{ji}'\, x_{j0}$ such that,

$$- y_{ki} + \sum_{i=1}^{n} y_{ki}\lambda_i \geq 0;\ \theta_i\ x_{ji} - \sum_{i=1}^{n} x_{ji}\lambda_i \geq 0 \text{ and } \lambda_i \geq 0;\ i = 1, 2, \ldots, n$$

Here w's are the vector of input prices for the FFH i; is the cost minimising vector of input quantities subject to input prices w_{ji} and output y_{ki}. It is noted here that the subscript notation 0 is defined on the similar lines as discussed in the aforementioned LPP. The CE for each FFH i is then calculated as the ratio. Finally, Allocative Efficiency (AE) is calculated by the ratio of (CE/ TE).

Results and discussion

The sampled fish farmers belonged to 4 villages of Kaman Block, Bharatpur District as detailed in Table 1. The time line of LHWR Foundation initiated CSR farming is described in Table 2. The logistics for fish farmers were served by 8 wholesalers based in Kaman who were tied up with 40 fish retailers in Delhi NCR (Bunkar, 2017).

Table 3 gives the type of fish culture with the details of prevailing condition and systems. It can be seen that there were two types of farms; out of the total 60 farmers 46 farmers (77%) belonged to FTS fish farmers category. These farmers farmed their fish in deeply flooded lowland. These lands also got flooded during the monsoon and the poor farmers could not do any modification of the land for fish culture owing to their poverty. Since they were poor, they used to involve only family labour. They stocked the fish fingerlings after fertilising the pond with organic manure. During the initial cycles of fish culture, they used only minimum supplementary feeding. Again, generally the fish culture period of IMCs is 12 months during which they could not harvest the fish as they had to wait for the fish to reach marketable size. Now of course, they are adopting multiple stocking and harvest scheduling.

Table 1. Distribution of sample farm household's respondents in Kaman Block

Village	FTS/ Marginal fish farmers	STS/ Small fish farmers	Total fish farmers
Jeeraheda	12	3	15
Jeeredi	11	4	15
Bamni	9	6	15
Navagava	11	4	15
Total	43	17	60

Conditions in the initial cycles of fish culture were such that, the farmers were not in a position to diversify the species that they cultured. The FTS/marginal farmers also suffered from inefficient resource utilisation. The only advantage was, no competing crop with fish was present in the same land area. Fish production in the initial cycles was erratic. Productivity was low particularly because of low supplementary feeding.

As far as the STS/small farmers were concerned who comprised 23% of the total fish farmers sampled, cultured their fish in plain and medium lowland fields. The source of water was the Indira Gandhi canal. These farmers also made high dikes and did sump excavation. In addition to family labour, these small farmers also used hired labour. They stocked fish seeds but used lower feed input. Owing to improved pond condition, the small farmers were able to harvest their fish in relatively short duration. These small farmers were in a position to intensify their culture and also diversify their species as per requirements of the market, and therefore enjoyed the benefits of fish as food as well as to gain additional income. Owing to improved farming practises, their output was higher and the productivity was also better. In the later cycles of fish farming, these small fish farmers were able to engage in multiple stocking and harvesting of fish.

Costs and returns analysis

The sample farms produced average of 4944 kg ha^{-1} of fish in 18 months (Table 4). The FTS fish farmers produced 5332 kg ha^{-1} in 12 months while the STS fish farmers produced 4427 kg ha^{-1}. Average costs worked out to be ₹54.39 kg^{-1} while the farm gate price was ₹104 kg^{-1} yielding a margin of ₹49.39 kg^{-1} for the fish farmer. FTS made a margin of ₹44.31 kg^{-1} and STS, ₹56.97 kg^{-1}. The B:C ratio worked in favour of the STS fish farmers at 2.15 while it was 1.77 for the FTS fish farmers. Overall, the B:C ratio worked out to 1.91 which was quite rewarding

Table 2. Time line of LHWR Foundation initiated CSR fish farming in Khaman Block, Bharatpur

Year	Activities and changes
Pre-1995	People of Kaman Block were engaged only in agriculture and lived as common agricultural farmers
1995-2000	Water of the Gurgaon canal slowly starts seeping into their agricultural land and cause serious water-logging. Agriculture was no longer possible. Fish seed introduced into panchayat *talab* (large pond). Fish farming pioneer, Sharis Mohammad turned his agriculture land to fish pond and started aquaculture
2001-2005	Number of fish ponds slowly increased within Jeeraheda Village and other farmers started building their own farms to culture fish. Area under fish culture increased
2006-2010	The farmers of other villages also started to take interest in fish culture
2011-2015	During this period fish culture area spread very fast and the number of fish ponds in Kaman reached around 200 ponds
Post-2015	Every week, 2-3 vehicles arrive in Kaman Block to cart away 5-6 quintals of harvested fish to markets across the State border and Delhi. Aquaculture offers livelihood to 2,000 people.

Table 3. Types of fish culture with characteristics of the farms

Characteristics of farms	
FTS (Fingerlings to table size) 46 (76.66%)	STS (Spawn to table size) 14 (23.33%)
Deeply flooded lowland fish ponds	Plains and medium lowland field
Highly flooded during the monsoon	Water source - mainly canal water fed
No modification of land for fish culture	Higher dikes and sump excavation
Less labour intensive	Labour intensive (mainly family labour)
Stocking fish with feed and fertiliser	Stocking fish with lower feed input
Long duration of fish culture	Short duration of fish culture
Non-diversification	Intensification and diversification
Inefficient resource utilisation	Better resource utilisation
No competition with any other crop	Mutual benefits of fish and food
Fish production was erratic	Increased output
Low productivity	Improved productivity
Lower feed (one crop)	Higher food supply (multiple stocking and harvesting)

for the fish farmers as they were now making net revenue of ₹2.52 lakh ha^{-1} for STS fish farmers and ₹2.36 lakh ha^{-1} for FTS fish farmers from a position of utter poverty before the introduction of fish farming in Kaman Block by LHWR Foundation (Bunkar, 2017).

Data envelopment analysis

Table 5 gives the data envelopment analysis results. It can be seen from the table that technical efficiency was around 98% without bias correction for all the three systems considered and cost efficiency was 76% when the marginal and small farmers were combined. However, the cost efficiency is higher and around 92% when the two systems were separately considered. When the bias was corrected, the total efficiency declined and the confidence interval of bias corrected TE for FTS/marginal farmers ranged around 94% for the combined and marginal systems while it has been observed that for small farmers the range was more than 95%. Cost efficiency was slightly higher for small farmers when compared to marginal farmers. These results are comparable to the results obtained in similar studies (Khem *et al*., 1999; Ahmed *et al*., 2011; Oluwatayo and Adedeji, 2019).

Constraints of fish farming in Kaman Block

Though 2000 people are getting benefit from fish farming in Kaman Block, the enterprise is not sailing smoothly (Table 6). Using Rank Based Quotient (RBQ) (Sabarathinam and Vennila, 1996), the constraints faced by the fish farmers were identified. Polluted water from the canal and power outages ranked 1 and 2 in order of constraints faced by the fish farmers of Kaman Block. Poaching, mortality and fish disease problems were ranked as the next three major constraints. The other constraints are equally important.

The innovative CSR initiative of LHWR Foundation has made a significant contribution in changing the economic and social profile of Kaman District, Bharatpur, Rajasthan. The positive externalities of this game changing intervention can be from the fact that farmers now live in concrete houses and every family has bought accident

Table 4.Costs and returns to fish farming on sample fish farms in Kaman Block

Particulars	FTS/Marginal	STS/ Small	Overall
Production (kg)	5332.03	4427.48	4944.37
Cost of production (₹ kg^{-1})	57.32	49.70	54.39
Selling price (₹ kg^{-1})	101.63	106.67	103.79
Farmers' margin (₹ kg^{-1})	44.31	56.97	49.39
Gross revenue (₹)	541867.68	472263.47	513154.07
Net revenue (₹)	236261.68	252231.17	244222.51
B:C Ratio	1.77	2.15	1.91

Table 5. DEA estimates for the fish farming systems

Farming system	TE	Bias	Bias corrected score of TE	CI	CE	AE
Overall	0.987	-0.043	0.944	0.936-0.952	0.756	0.766
Marginal	0.987	-0.033	0.944	0.938-0.950	0.915	0.927
Small	0.988	-0.015	0.973	0.966-0.980	0.935	0.946

AE: Allocative efficiency; CE: Cost efficiency; CI: Confidence interval; DEA: Data envelopment analysis; TE: Technical efficiency.

Table 6. Constraints faced by fish farmers in Kaman Block, Bharatpur

Constraints	FTS/Marginal		STS/ Small		Overall	
	Score	Rank	Score	Rank	Score	Rank
Lack of knowledge of modern technology	55.30	7	43.75	9	52.60	7
Non-availability of skilled labour	43.21	9	41.07	10	42.71	11
Unawareness of Govt. schemes	43.07	10	34.38	13	41.04	12
Poaching	78.80	4	86.16	4	80.52	3
High price of fish seed	30.57	13	87.05	3	43.75	10
High rate of mortality	86.28	3	54.91	8	78.96	4
High cost of input	40.90	11	61.61	5	45.73	8
Inaccessibility to marketing facility	39.40	12	35.71	12	38.54	13
Difficulty in obtaining credit	46.20	8	37.50	11	44.17	9
Disease problems	77.72	5	57.14	7	72.92	5
Unavailability of raw materials	69.84	6	58.93	6	67.29	6
Electricity problem	87.64	2	89.73	2	88.13	2
Polluted water in canal	93.75	1	94.20	1	93.85	1

insurance (life insurance). Those fish farmers culturing IMC for 18 months (STS) from spawn to table size registered a benefit:cost ratio of 2.15. The fish farmers who cultured fish for 12 months (FTS) achieved a benefit:cost ratio of 1.77. The data envelopment analysis results showed that the technical efficiency was around 0.95, indicating highly efficient farms. Polluted water in the canal, electricity problems and poaching were identified as the major constraints faced by farmers.

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