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Carp Culture in Thanjavur District, Tamil Nadu, India: An Economic Analysis

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Abstract

Carp culture is attracting farmers' attention as a means to increase farm income in Thanjavur district, the rice bowl of Tamil Nadu State, India. Data from 40 randomly chosen farmers were collected to analyze the economics of carp culture and to determine the reasons for yield variations using the Probabilistic Frontier Production Function model. Average figures per hectare reported by the respondents were 888.11 kg annual yield, Rs. 19,961 (US$ 665.37) gross income, Rs. 9,397 (US$ 313.23) total cost, and Rs.10,564 (US$ 352.13) net income. The highest mean yields for ponds less than 1 ha each were related to the highest levels of adoption of inputs recommended, indicating that the wide yield variations were due largely to gaps in input adoption. Widespread and successful culture of the three Indian major carps — catla, rohu, mrigal, — as against the six-species combination recommended under composite fish culture, pointed to a research gap. As expected, among the three market channels found, the one in which farmers sold live fish directly to consumers fetched a 33% higher price and consequently more income. A two-pronged approach of strengthening research on relevant field problems (like species mix, optimal input mix, disease control, feed, and supply of credit) and extension support for widespread dissemination of technology to fish farmers would bridge research and extension gaps, and maximize output from the fishponds. Probabilistic Frontier Production Func-tion analysis clearly brings out this potential.

Introduction

Demand for fish in the Indian domestic market by 2000 A.D. has been estimated to be 12.5-20 million tonnes. Assuming that half of the lower estimate of the demand is to be met by inland fisheries, inland fish production has to increase sevenfold to augment supplies (Srivastava and Vathsala 1984). Chauhan (1993) reported that aquaculture production was 1.19 million tonnes from 0.325 million ha out of the total inland fish production of 1.7 million tonnes from 2.2 million ha in the country in 1991-92. However, average yield in carp ponds is reported to be about 15% of the highest yield obtained, indicating a widespread yield gap (Gupta 1984). It is argued that bridging the gap between maximum possible yield and average yield realized by the fish farmers would help boost inland fish production significantly.

In Tamil Nadu State, India, marine fish landings rose from 0.24 million tonnes in 1981-82 to 0.31 million tonnes in 1992-93. Annual marine fish landings averaged 0.30 million tonnes from 1989-90 to 1992-93. In contrast, inland fish production has been declining, and was reduced by half from 0.18 million tonnes in 1981-82 to 0.09 million tonnes from 1992-93. However, the state is rich in inland resources: 0.05 million ha reservoirs, 0.10 million ha major irrigation and long seasonal tanks, 0.16 million ha ponds and short seasonal tanks (Anon. 1992-93).

Thanjavur district predominantly constitutes the Cauvery Delta Zone and is the rice bowl of the state, contributing over a quarter of rice production (Fig. 1). It is endowed with about 6,000 canal-fed ponds measuring about 0.02 million ha (Srivastava and Vathsala 1984). Without disturbing crop cultivation, and in fact supplementing it, fish culture could well be profitably undertaken in the ponds and tanks for at least 6-9 months a year (Jayaraman et al., in press). The Fish Farmers Development Agencies (FFDAs), set up in 13 districts of the state, offer free consultancy to farmers on composite culture of carps (catla *Catla catla*, rohu *Labeo rohita*, mrigal *Cirrhinus mrigala*, common carp *Cyprinus carpio*; silver carp *Hypopthalmichthys molitrix*, and grass carp *Ctenopharyngodon idella*). They also provide inputs, particularly seedfish, recommend proposals for funding by banks, and conduct free training programs on carp culture for fish farmers. However, they do not guarantee loan repayment by the fish farmers to the banks, and hence do not take part in marketing the farmed fish which are sold through private market intermediaries. The National Council for Applied Economic Research (NCAER) evaluated FFDA performance and found that they played a successful role in developing carp culture. It ranked the FFDA, Thanjavur, sixth in terms of performance among the FFDAs established before April 1977 in the country. Further, the average yield of farmed carps was estimated at 330 kg·ha^{-1}·crop^{-1} before

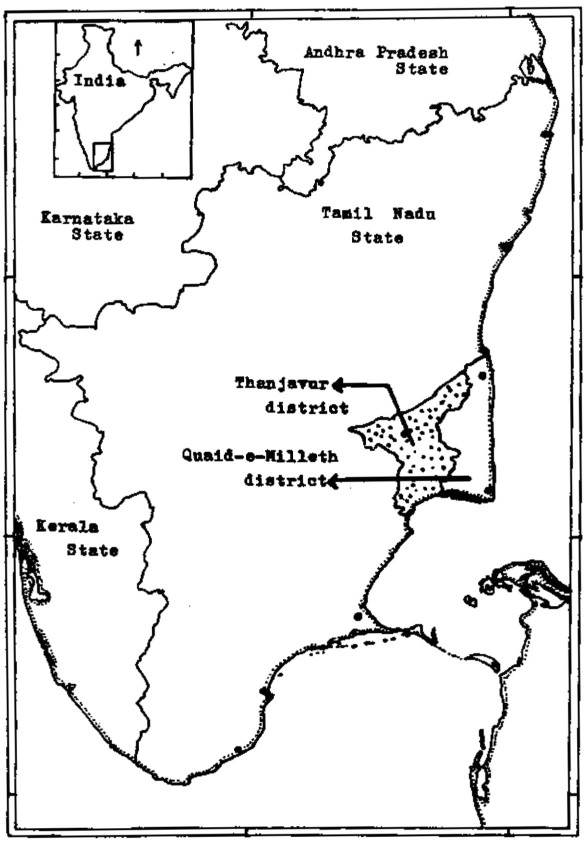

Fig. 1. Map of Thanjavur District.

the FFDA was established, which rose to 1,434 $kg \cdot ha^{-1} \cdot crop^{-1}$ in 1991-92 (Anon. 1992, NCAER 1981). Farmers evince interest in aquaculture but demand more information on technology, particularly the causes of yield variations, and its economics. Therefore, the present study investigated the status of the adopted carp culture, technology, inputs used, yield gaps, economics of carp culture and scope for enhanced farmed carp production in the Thanjavur district in 1992-93.

Materials and Methods

Forty fish farmers having fishponds with a total area of 47.71 ha were randomly selected from a list of 205 fish farmers maintained by the FFDA, Thanjavur. A pre-tested enquiry schedule was used to collect information by personal interview of the respondents regarding their aquaculture practices, lease period, inputs used, yield, marketing of farmed carps, and costs and returns from carp culture, from August 1992 to July 1993. Information collected from each respondent was cross-checked to the extent possible, for example, with the FFDA or seedfish suppliers on seedfish stocked, and with feed suppliers on feeds procured, etc. The ponds were post-classified into six categories based on their individual area to determine the relationship between pond area and yield. Yield gaps I and II were estimated. Yield gap I refers to the gap between on-farm yield and experimental station yield, considered as potential yield in this study (8,000 $kg \cdot ha^{-1} \cdot year^{-1}$, Tripathi and Ranadhir 1982). Yield gap II is the gap between on-farm yield and adaptive research yield (2,250 $kg \cdot ha^{-1} \cdot year^{-1}$, the average yield of five adaptive research trials realized in the ponds of progressive fish farmers in the district). A major prerequisite for frontier analysis is homogeneity in terms of aqua-ecological, soil and climatic conditions in the study area; and it was available. Total variable cost (TVC) included all items of variable costs like inputs, and interest on variable cost at 4.5% p.a. Total fixed cost included lease amount, interest on capital costs at 10% p.a. and depreciation at 10-15% p.a. of various farm implements. Total income included sale proceeds of fish and other farm income. Farm business income was obtained by subtracting TVC from total income. Total income minus total cost gave net income. Percentage and budgeting analyses were employed to analyze the data.

To estimate the average production function by conventional Ordinary Least Square method and the Probabilistic Frontier Production Function (PFPF), the following variables were included:

1) Pond size (X_1) measured in hectares (ha);

2) Stocking ratio (X_2) was considered as 100% for the recommended stocking ratio of six carp species, and it decreased proportionately if less than six species were stocked.

3) Labor (X_3) was measured in man-day equivalents (8 h);

4) Feed cost (X_4) in rupees (US$ 1= Rs. 30 approx.) included cost of rice bran, groundnut oilcake and other oilcakes fed to the carps farmed; and

5) Average price of fish (X_5) realized by the respondents in rupees per kilogram.

Analytical Model

Economic efficiency is a combination of technical and allocative efficiencies. The study of technical efficiency, as to how carp farmers can maximize production with the existing production technology, and without additional cost, is of vital importance to planners, administrators and scientists. The frontier model provides adequate economic rationale to measure technical efficiency which refers to the proper choice of production function among those actively in use by farms. Allocative efficiency refers to the proper choice of input combinations. The widely used Cobb-Douglas production function assumes that all farms are technically efficient, and derives maximum output from any chosen level of inputs. The production function assumes constant returns to scale and a perfect competitive market. It neglects differences in the environments of farms compared. These assumptions are unrealistic because the optimum utilization of inputs depends on the farmers' level of knowledge about the chosen technology.

As the objective of the analysis is to measure yield gaps and explore the scope for enhancing farmed carp production, the Probabilistic Frontier Production Function (PFPF) model was used and is briefly explained below. Let the production function be:

$$\ln Y = \ln f(X) + W$$

where

Y is an (n x 1) vector of observed outputs
X is a (n x k) matrix of inputs
W is the error term subject to the restriction, $0 \leq e^{w} \leq 1$

Suppose the maximum yield-producing farm is observed to have a production plan (X^o, Y^o), such a plan is said to be technically efficient if $Y^o = f(X^o)$, and inefficient if $Y^o < f(X^o)$ and implies that there is still scope to raise production with the given technology bridging the gap in technology adoption. Its assumption of deterministic relationship is, however, a major limitation. Aigner et al. (1977) introduced a stochastic disturbance variable which had two components, a stochastic disturbance term, V_i, and a one-sided efficiency disturbance, W_i, and set a joint density function of U_i (error term):

$$\ln Y = \ln f(X) + (V + U)$$
$$U_i = V_i + W_i \,,\; W_i \leq 0 \qquad \text{for all } i$$

They named it Stochastic Frontier Production Function (SFPF). However, its estimation involved an iterative procedure and hence was not widely accepted. Farrell (1957) suggested a programming technique that minimizes the sum of absolute residuals or the sum of squared residuals under the constraint that all residuals be non-positive. However, this model is extremely sensitive to outliers. To overcome this, Aigner and Chu (1968) expressed the equation in probability form:

$$\text{Prob } \{\Sigma B_j X_{ij} \geq Y_i\} > P,$$

$$i = 1, 2, 3.....n$$

where P is a specified probability within which the above statement holds. Essentially, this approach consists of estimating the frontier by using all observations and re-estimating the frontier by discarding first 100% efficient farms until the predetermined level of P is obtained. Timmer (1971) called this Probabilistic Frontier Production Function and used it to measure technical efficiency. The frontier production function analysis helps to estimate bridgeable potential yield gaps in farming systems (Forsund et al. 1980; Greene 1980; Kalirajan 1981, 1982, 1990; Huang and Bagi 1984; Battese and Coelli 1992; Battese 1993; Batesse and Tessema 1993; Shanmugam 1994).

Results

Distribution Pattern of Ponds

Ponds measuring 0.50-1.00 ha each were dominant followed by those measuring 1.01-1.50 ha and 1.50-2.00 ha each (Table 1). About 48% of the ponds were less than 1.00 ha each. Only four ponds were over 2.00 ha each. The average size was about 1.19 ha. About 75% of the respondents had ponds with lease periods of 1-3 years and the rest had ponds with a lease of 3-5 years.

Table 1. Distribution of sample carp ponds.

Pond category	Pond area (ha)	Total area (ha)	Number of ponds	Mean area of ponds (ha)
I	0.01 - 0.50	2.02	5	0.40
II	0.51 - 1.00	10.49	14	0.75
III	1.01 - 1.50	12.10	9	1.34
IV	1.51 - 2.00	13.58	8	1.70
V	2.01 - 2.50	6.72	3	2.24
VI	2.51 - 3.00	2.80	1	2.80
Total		47.71	40	—
Average		1.19		
SD		0.63		

Stocking Density and Ratio

Average stocking density and stocking ratio were 4,172 numbers•ha^{-1}; and catla 29, rohu 25, mrigal 21, common carp 14, silver carp 7 and grass carp 4 per 100 numbers, respectively (Tables 2 and 3). Against the recommended practice of stocking silver carp at 20-30%, the respondents stocked it at an average ratio of about 7% only since it reportedly fetched a low price owing to lack of consumer preference. According to the respondents, the fish has "too many spines" and turns red even when handled for a while, for example during sampling, and mortalities were not uncommon. Stocking densities and ratios varied widely over the different pond-size categories (Table 2). Pond-size category II (0.51-1.00 ha each) had the highest stocking density of 4,539 numbers•ha^{-1}, followed by pond category I (0.01-0.50 ha each).

Table 2. Stocking ratios in sample carp ponds.

Pond category	Stocking ratio numbers•ha^{-1}•crop^{-1}						Mean
	SC	C	R	M	CC	GC	
I	—	1,757	1,705	3,538	3,950	—	4,217
II	581	1,413	1,052	1,291	1,592	846	4,539
III	432	977	1,106	1,036	820	295	2,629
IV	622	1,169	961	661	850	503	4,156
V	505	1,384	1,272	671	847	—	3,952
VI	411	1,036	1,382	929	—	—	3,757
Mean	532	1,110	960	1,214	556	533	3,803
SD	342	318	511	236	1,482	384	—

Mean is not a sum of each row since all the six species were not stocked in all the ponds.
SC - silver carp, C - catla, R - rohu, M - mrigal, CC - common carp, GC - grass carp

Table 3. Distribution of stocking density.

Stocking density (numbers•ha^{-1})	Number of ponds stocked with					
	SC	C	R	M	CC	GC
0,001 - 1,000	14	13	8	15	7	8
1,001 - 2,000	2	16	20	15	6	2
2,001 - 3,000	-	4	1	2	1	-
3,001 - 4,000	-	1	-	-	-	-
4,001 - 5,000	-	-	-	1	-	-
5,001 - 6,000	-	-	-	1	-	-
6,001 - 7,000	-	-	-	-	-	-
7,001 - 8,000	-	-	-	1	-	-
Total	16	34	29	35	14	10

SC - silver carp, C - catla, R - rohu, M - mrigal, CC - common carp, GC - grass carp

Yield, Yield Gaps and Yield Variations

The average yield of farmed carps realized by the respondents was about 888 kg·ha^{-1}·crop^{-1}. About 68% of the farmers had yields of 500-1,000 kg·ha^{-1}·crop^{-1} (Table 4). Altogether 80% percent of the respondents had yields less than 1 t·ha^{-1}·crop^{-1}. Only one farmer's yield exceeded 3 t·ha^{-1}·crop^{-1}. The average yield ranged widely from 141 to 3,139 kg·ha^{-1}·crop^{-1}, and varied over the different pond sizes (Table 8). The average yield·ha^{-1}·crop^{-1} obtained by the farmers declined with increase in pond size indicating an inverse relationship. Variations in average yield were reflected in the varying levels of adoption of the inputs over the different pond sizes (Table 6). Overall, expenditure on inputs per ha decreased with pond size. The highest yield·ha^{-1} obtained in the carp ponds was 3,139 kg·ha^{-1}·crop^{-1}, about 39.24% of the maximum reported experimental station yield of 8,000 kg·ha^{-1}·year^{-1} (Tripathi and Ranadhir 1982). The average yield obtained by the respondents was about 11.10% of the highest experimental station yield reported or the potential yield. Yield gaps I and II were 88.90% and 60.53%, respectively. Though the mean size of the ponds was about 1.19 ha which could help in good pond management, 80% of them were *panchayat*-owned and, therefore, single ownership was not available which affected input adoption, particularly fertilizers and feeds, in these multi-purpose ponds (panchayat is the basic administrative unit in India, and comprises one or more villages).

Economics of Carp Culture

Carp culture was reported to be profitable. Average gross income, total cost and profit per ha·crop^{-1} came to Rs. 19,961 (US$ 599), Rs. 9,397 ($ 313.23) and Rs. 10,564 ($ 352.13), respectively (Table 7). Farm business income was Rs. 12,594·ha^{-1}·crop^{-1}. Total variable cost formed 78.40% of total cost, while fixed cost accounted for the rest. Among the items of variable cost, fingerlings, labor, feed and fertilizer were the major items. Lease amount topped the items of fixed cost. The average price realized was Rs. 22.48·kg^{-1}. The cost-benefit ratio was 1.12-1.71. Profit showed a generally declining trend as pond area increased (Table 8). Ponds in category II (0.51-1.00 ha) topped in terms of profit·ha^{-1}·crop^{-1} followed by those in category I (0.01-0.50 ha).

Table 4. Distribution of yields realized by the sample carp farmers.

Yield (kg·ha^{-1}·crop^{-1})	Carp ponds	
	Number	Percentage
0,001 - 0,500	5	12.50
501 - 1,000	27	67.50
1,001 - 1,500	5	12.50
1,501 - 2,000	2	5.00
2,001 - 2,500	—	—
2,501 - 3,000	—	—
3,001 - 3,500	1	2.50
Total	40	100.00

Table 5. Expenditure on inputs ($Rs \cdot ha^{-1} \cdot year^{-1}$).

Pond category	Seedfish	Manure	Fertilizer	Feed	Labor	Others	Interest	Total variable cost (TVC)	Average yield ($kg \cdot ha^{-1} \cdot year^{-1}$)	Average net income ($Rs \cdot ha^{-1} \cdot year^{-1}$)
I	3,104	1,434	1,244	1,800	3,864	169	548	12,163	1,846	22,415
	(25.52)	(11.79)	(10.23)	(14.80)	(31.77)	(1.39)	(4.50)	(100)		
II	3,210	766	837	1,622	2,127	709	436	9,707	1,687	23,376
	(33.07)	(7.89)	(8.62)	(16.71)	(21.91)	(7.30)	(4.50)	(100)		
III	652	247	511	551	582	213	130	2,886	512	7,778
	(22.59)	(8.56)	(17.71)	(19.09)	(20.17)	(7.38)	(4.50)	(100)		
IV	1,476	184	367	866	873	161	185	4,112	744	11,855
	(35.90)	(4.48)	(8.93)	(21.06)	(21.23)	(3.90)	(4.50)	(100)		
V	893	244	203	434	399	318	117	2,608	308	4,634
	(34.24)	(9.36)	(7.78)	(16.64)	(15.30)	(12.18)	(4.50)	(100)		
VI	568	71	59	95	137	11	44	985	485	8,618
	(57.66)	(7.20)	(5.98)	(9.64)	(13.90)	(1.12)	(4.50)	(100)		

US$1 = Rs.30 approx.

Table 6. Input - adoption gaps.

Particulars	Number·kg^{-1}	(%)
Stocking density (Number·ha^{-1})		
Recommended	5,000	100.00
Adopted	4,582	91.61
Gap	418	8.39
Organic manure (kg·ha^{-1})		
Recommended	15,000	100.00
Adopted	9,433	62.89
Gap	5,567	37.11
Urea (kg·ha^{-1})		
Recommended	200	100.00
Adopted	54	27.00
Gap	146	73.00
Super phosphate (kg·ha^{-1})		
Recommended	250	100.00
Adopted	36	15.00
Gap	214	85.00
Ground nut oil cake (kg·ha^{-1})		
Recommended	1,500	100.00
Adopted	115	7.67
Gap	1,385	92.33
Rice bran (kg·ha^{-1})		
Recommended	1,500	100.00
Adopted	2,064	> 100.00
Gap	—	—
Mean yield (kg·ha^{-1})	888.11	

Table 7. Economics of carp culture in Thanjavur district, Tamil Nadu, India, 1992-93.

		(Rs·ha^{-1}·crop^{-1})	(%)
A.	Variable cost		
	Fingerlings	2,357	25.08
	Fertilizer	737	7.84
	Manure	663	7.06
	Feed	1,326	14.11
	Labor	1,547	16.46
	Others	405	4.32
	Interest	332	3.53
	Sub-total	7,367	78.40
B.	Fixed Cost		
	Lease	920	9.79
	Depreciation	589	6.27
	Interest	521	5.54
	Sub-total	2,030	21.60
C.	Total variable cost (TVC)	7,367	
D.	Total fixed cost (TFC)	2,030	
E.	Total cost (TC)	9,397	
F.	Total income	19,961	
G.	Farm business income (F minus C)	12,594	
H.	Profit (F minus E)	10,564	
I.	Average yield (kg·ha^{-1}·year^{-1})	888.11	
J.	Average fish price (Rs·kg^{-1})	22.48	
K.	Cost-benefit ratio		
	i) On TVC	1.71	
	ii) On TC	1.12	

US$ 1 = Rs. 30 approx.

Table 8. Cost, income and yield variations with pond area.

Pond category	Average (Rs·ha^{-1}·crop^{-1})				
	Income	Cost	Profit	Yield (kg·ha^{-1}·year^{-1})	Price (Rs.·kg^{-1})
I	39,219	16,804	22,415	1,846	21.25
II	37,270	13,894	23,376	1,687	22.09
III	12,490	4,712	7,778	612	20.39
IV	17,994	6,139	11,855	744	24.19
V	8,645	4,011	4,634	308	28.08
VI	10,201	1,583	8,618	485	21.01
Overall	19,961	7,367	122,594	888.11	22.48

US$ 1 = Rs. 30 approx.

Production Function Estimates

A yield gap arises from technical inefficiency which marks failure to realize possible high yields. As earlier described, the PFPF measures the bridgeable yield gap for a specified level of probability. The average yield of fish realized by the farmers is very low, around 11% of the potential yield (8,000 kg·ha^{-1}·crop^{-1}, Tripathi and Ranadhir 1982). As it is difficult to aim at achieving 100% efficiency at least in the short run, an ad-hoc target of 60% efficiency was set, and that defined the probability (P = 0.60). For this, average production function was estimated and the PFPF was run in linear programming format that minimized total absolute deviation (MOTAD) by running the program in stages until the required probability (0.60) was achieved (Table 9).

The results showed that all the functions had good fit and were valid for interpretation with the expected positive sign for all coefficients having an R^2 value exceeding 0.83. All the functions showed increased return to scale. For the specified level of probability (P = 0.60), the coefficients stabilized (i.e., varied negligibly from previous level estimates). Technical efficiency refers to the proper choice of production function among all those actively in use by the farms. Now technical efficiency of any one farm can be measured by the ratio of actual (observed) value of the regress and value of the fish produced to its estimated value in the equation that showed stability. The frequency distribution of technical efficiency index of sample ponds is presented in Table 10.

Market Channels

Three market channels were identified in the present study :

1) Channel I. Fish farmer > consumer > (10%)

2) Channel II. Fish farmer > vendor > consumer (15 %)

3) Channel III. Fish farmer > primary / secondary wholesaler > vendor > consumer (75 %)

About 75% of the respondents sold fish through channel III though they reported lowest profits in it. Channel I was more profitable fetching a 33% higher price than other channels, but the quantity transacted was only 10%.

Discussion

The highest yield realized by the respondents was about 39% of the maximum yield reported with the composite fish culture technology (Tripathi and Ranadhir 1982). Results of the PFPF analysis revealed that 23 farms had technical efficiency of less than 0.50 probability, indicating that these farms could enhance their yield simply by bridging the adoption gap for inputs. Adoption of optimal stocking ratio in the ponds (X_2), adequate feeding (X_4) and good price for the harvested fish (X_5) would help. Earlier studies had also shown that yields of farmed carps under composite fish culture technology were greatly influenced by gaps in the adoption of recommended inputs (Haque 1981; Selvaraj 1987; Das et al. 1988; Rout and Tripathi 1988; Seenappa and Surendra 1988; Suresh et al. 1988, 1991; Chari 1991; Sivasankar et al. 1991; Suresh and Selvaraj 1991; Suresh 1993). The National Council of Applied Economic Research (NCAER 1981), quoting the Central Inland Fisheries Research Institute's data for 1972-76 on cost structure of cultivation of fish farming in all four regions of India, observed that, "as the per hectare expenditure on various inputs increased, the yield rate also increased." Thus, the adoption of recommended inputs would enhance yield and consequently income with improved economic efficiency.

Table 9. Estimated coefficients of Average Production Function and Probabilistic Frontier Production Function.

Variables	Co-efficient	PFPF (92)	PFPF (60)	APF (OLS)
Intercept for fish production (Y)	B1	670.71	1996.10	320.62
Pond size (X_1)	B2	0.1694	0.3514	0.1134
	(0.1342)	(0.1875)	(0.1378)	
Stocking ratio (X_2)	B3	0.5956	0.5375	0.5007[1]
(Diversification index)		(0.1011)	(0.1370)	(0.1118)
Human labor (X_3)	B3	0.0144	0.1258	0.2260
	(0.0977)	(0.1876)	(0.1922)	
Feed cost (X_4)	B4	0.3562	0.1438	0.1410[1]
	(0.0869)	(0.0720)	(0.0871)	
Average price received	B5	0.0471	0.2365	0.1410[1]
($Rs \cdot kg^{-1}$) (X_5)		(0.0149)	(0.0632)	(0.0049)
R^2		0.8483	0.8748	0.8325
F		50.34	33.55	48.73
Returns to scale		1.1827	1.2743	1.1899

APF : Average production function-conventional form estimated by OLS
PFPF : Frontier production function estimated for the probability levels (0.92) and (0.60).
There were three intermediate stages. Estimates of these stages are not shown here.
Pond size was measured in ha of surface area (ha = 10,000 m^2).
Stocking ratio was considered similar to the crop diversification index and was 100 for monoculture and will exceed that value for more species.
Figures in parentheses are standard errors.
[1]Significant at 1% level.

Table 10. Frequency distribution of sample ponds by their technical efficiency.

Technical efficiency (class interval)	Ponds	
	Number	Relative frequency
0.21-0.30	7	0.175
0.31-0.40	10	0.250
0.41-0.50	6	0.150
0.51-0.60	8	0.200
0.61-0.70	4	0.100
0.71-0.80	2	0.050
0.81-0.90	2	0.050
0.91-1.00	1	0.025
Total	40	1.000

However, adoption of inputs (like lime, manure, inorganic fertilizer and feed) at recommended levels is constrained, at least partially, due to prevalent social problems, e.g., the public claims that the inputs impair water quality and make bathers' skin itch. Though the veracity of such unfounded fears is questionable, the producers had to bear the brunt of it. Furthermore eradication of weeds and pest fish, water quality maintenance, poaching and disease control were also difficult in such community-based ponds. Such problems could be overcome partly by extending the lease period to at least 5-10 years and simultaneously launching development programs to educate the public about the advantages of culturing fish in community ponds, and to allay unfounded fears.

The widespread and successful culture of three Indian major carps - catla, rohu and mrigal, as against the six-species combination recommended under the composite fish culture technology, indicated a research gap as it could not be a blanket recommendation. Factors such as seed availability, cost, consumer preferences in local markets, price, among others, influence choice of species stocked. Also, pond ownership is important to motivate fish farmers to adopt recommended technologies and increase yields. As most of the ponds were leased-out, a uniform leasing period of 5-10 years for all ponds owned by different organizations is essential and would go a long way in making the farmers committed to enhance yield by optimizing resource use.

Aquaculture marketing has not been given due attention so far (Srivastava 1988). Appropriate organization or regulation of fish marketing would help all concerned - producer, market intermediaries and the consumer. A good marketing strategy for fish farmers would be to plan the production process so as to enable continuous harvesting of fish and to sell them alive by matching the demand for fish with the supply to maximize profits.

Further, comprehensive extension service is essential to disseminate and diffuse technical know-how. Adequate information on new farming technology, and interaction with competent extension personnel are basic requirements to bring about changes in human behavior in any program of planned change (Haque and Ray 1983). Appropriate extension and research strategies would enable fish farmers to gain access to information needed for them to adopt modern farming technologies appropriately to maximize profits, as enhanced yield does not always result in profit maximization (Tripathi and Ranadhir 1982). Thus even with available technologies, yield could be enhanced. Continuous efforts to adopt modern technologies and bring more areas under farming backed up by research and extension strategies would significantly increase the production of farmed fish. With pragmatic policy support, farm income, production as well as the socioeconomic status of carp farmers could be enhanced by adopting carp culture as an integrated farming enterprise.

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