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Small scale pond fish farming in a tribal district of India: an economic perspective

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ABSTRACT

Economic evaluation of pond fish farming in Gondia District, Maharashtra, India is presented. The results indicate that pond fish farming is an economically viable enterprise with the benefit-cost ratio ranging from 2.22 to 4.44. Producer's share in consumer's rupee ranges from 52 to 93% . The study also highlights the major constraints hampering the growth of fish farming in the district. Production function was of quadratic type and the pond size, number of fingerlings, labour involved in feeding as well as harvesting and use of farm yard manure as feed are the major determinants of the revenue accrued from fish production. Lack of technical know-how, plurality of ownership, and lack of credit were rated as the most important constraints affecting growth of fish farming practices in the district. Based on the analysis, policy changes like extension of lease period up to 10 years from the current policy of 5 years, as practised by state agencies and possible ways of extending credit and repayment options are discussed. The analysis indicated necessity of developing infrastructure to realise potential of fish farming and marketing as a premier enterprise in the district. The results are important for the central India, cutting across states of Madhya Pradesh, Maharashtra, Chhattisgarh, Andhra Pradesh and Odisha, where similar agro-climatic conditions prevail.

Keywords: Benefit-cost ratio, Market channel, Pond fish farming, Price spread

Introduction

Planning commission, Govt. of India has identified 150 most backward districts in the country on the basis of backwardness index and it is not surprising that these districts depend on rain-fed agriculture as a main source of livelihood. By all standards, these districts provide ample evidence on the disparities of income. Gondia district in Maharashtra is one such district located in the eastern most corner of the state, adjoined to predominantly tribal pockets of Madhya Pradesh, Chhattisgarh and Odisha states. The contiguous belt is home to most of the tribal population living in central India. The main reason for poverty is apparent from the land holding pattern which shows that 87% of the farmers have 0 - 2 ha area of land as per the report of the Directorate of Economics and Statistics, Maharashtra State. Gondia is known as the district of tanks due to the existence of large number of water tanks (natural as well as man made). Ironically, many villages in the district still struggle for drinking water.

The economy of the district is characterised by interactions between forests, agriculture and migration. Partly due to diminishing forest cover and partly with enactment of forest preservation laws as well as implementation of environment protection guidelines, the dependence on forest as a source of substantial income has declined over the years. Agriculture is in fact a tertiary source of income for the tribal. Forest based activities contribute to 40% of the income, while, 46% income is generated from employment like collection of *tendu* leaves and miscellaneous works under civil works contracts. The net returns from agriculture are abysmally low (₹ 4100 $acre^{-1}$ $annum^{-1}$). No other crop except paddy is feasible in high rainfall area. Moreover, no other source of income is available during the monsoon season.

The present research initiative was undertaken with the assumption that improved management of natural resources would strengthen tribal livelihood and make it sustainable. The initiative was based on hypothesis that in high rainfall area (mean annual rainfall >1300 mm), i) dependence on sole crop constrained by vagaries of monsoon must be minimised by increasing income from other sources and ii) fish farming (pisciculture) could be an effective source of additional income in a district with more than 7000 surface water tanks. Many farmers have taken up fish farming as a supplementary enterprise on variable scale. In fact, benefits of fish farming without disturbing crop cultivation are well known (Jayaraman, 1997). The returns from fish farming are two to four times better than agriculture (Chen and Ma, 1989). As per state estimates, Gondia District has 22,265 ha potential area for fisheries with fish production of 15,143 t. Fisheries contribute around 10% of the agricultural income of the district. Like any other enterprise, fish culture is also influenced by size of operations (pond area), overheads (fishing equipments), input costs (fishing, feed, labour cost) *etc*. However, quantitative enumeration of these factors in this region is not known. This study was therefore taken up to evaluate economic viability of fish farming as practised by the farmers and to identify constraints hindering the growth of fishery sector as well as producer's share in consumer's rupee in the prevailing market conditions. The information will provide an important insight into the profitability of pond fish culture in the region as a supplementary land use option.

Materials and methods

Fifty six fish farmers having fish ponds with a total area of 58.79 ha were randomly selected from the list of fish farmers maintained by the Fish Farmers Development Agency, Gondia. A pre-tested questionnaire was used to collect information by personal interview of the respondents regarding aquaculture practices, lease period, inputs used, yield, marketing of farmed carps and cost as well as returns from fish culture, during the period from July, 2010 to June, 2011. Following the methodology adopted by Jayaraman (1997) for the district of Thanjavur, Tamil Nadu, the ponds were post-classified into six categories based on their individual area. Total variable cost was estimated by adding the cost of inputs and interest on variable cost. Estimation of total fixed cost was obtained by adding the costs on leased amount, interest on capital cost and depreciation on various farm implements. Return over variable cost was estimated by subtracting total variable cost from the gross value of fish production. Net return was obtained by deducting the total cost from the gross value of the fish production. Percentage and budgeting analysis was performed for data analysis. Different channels for marketing of fish were identified and percentage share of producers to consumer's rupee was estimated.

Production function

The determinants of the revenue from pond fish farming was examined by multiple regression analysis using ordinary least square techniques. The model as adopted by Olawumi *et al.* (2010) is specified below:

$R = f(X_1, X_2, X_3, X_4, X_5, X_6, X_7, X_8, X_9, e)$

where,

R = Total revenue per production season (₹)

X_1 = Pond size

X_2 = Number of fingerlings

X_3 = Labour for feeding (man days)

X_4 = Labour for harvesting (man days)

X_5 = Dummy variable for using lime (1 if used, 0 otherwise)

X_6 = Dummy variable for using fertilizer (1 if used, 0 otherwise)

X_7 = Dummy variable for using ration feed (1 if used, 0 otherwise)

X_8 = Dummy variable for using farm yard manure (FYM) (1 if used, 0 otherwise)

X_9 = Fish culture system dummy (polyculture = 1, monoculture = 0)

e = Error term

Four functional forms were estimated (linear, semi log, double log and quadratic). The lead equation (quadratic functional form) was selected on the basis of economic, statistical and econometric criteria.

Results and discussion

Upon analysis of the information collected, three types of ownership of farm ponds were distinguished in the district: I) Individual, II) State and III) Common Property Resources (CPR)

Distribution pattern of ponds is shown in Table 1. Each type of ownership has distinct constraints. Individually owned ponds are mostly small (category I and II) in size. Primary objective of these ponds is to provide life saving or supplemental irrigation and hence farmers are always unsure of quantum of water that could be spared for fish farming. It could be seen from the table that ponds measuring 0.51 – 1.00 ha (category II) constituted 32.14% of the total number of ponds followed by 23.14% of ponds measuring 1.01 – 1.50 ha (category III). About 89% of the total number of ponds were less than 2 ha area. The sample farmers had ponds with lease period of 5 years. Mean area of the ponds varies from 0.39 to 3 ha. Mean stocking ratio of carp per ha ranges from 2,956 in ponds measuring 1.01 – 1.50 ha (category III) to 4,434 in ponds measuring 0.51 – 1.00 ha (category II). Catla (*Catla catla*), rohu (*Lobeo rohita*), mrigal (*Cirrhinus mrigala*) and common carp (*Cyprinus carpio*) are reared by the sample fish farmers.

Economics of pond fish culture

Economics of pond fish culture is presented in Table 2. The table reveals that the total variable cost formed 79.98% of the total cost. Ratio of total variable cost to total cost ranged from 0.74 in category I (0.01 – 0.50 ha) ponds to 0.76 in category VI (2.51 to 3 ha) ponds. It was observed that with the decrease in area of pond, the amount of total variable cost increases signifying intensive use of inputs in small size ponds. Similar findings were also reported by Jayaraman (1997) in his study in Thanjavur District of Tamil Nadu. Cost of fingerlings constituted the

Table 1. Distribution of sample fish ponds with stocking density

Pond category	Pond area (ha)	Total area (ha)	Number of pond	Mean area of pond (ha)	Mean stocking density of carp (no. ha^{-1})
I	0.01 - 0.50	3.51 (5.36)	8 (14.29)	0.39	4084
II	0.51 - 1.00	11.64 (19.80)	18 (32.14)	0.65	4434
III	1.01 - 1.50	15.50 (26.37)	13 (23.21)	1.19	2956
IV	1.51 - 2.00	17.18 (29.22)	11 (19.64)	1.56	3980
V	2.01 - 2.50	8.32 (14.15)	5 (8.93)	1.66	3652
VI	2.51 - 3.00	3.00 (5.10)	1 (1.79)	3.00	3716
Total		58.79 (100.00)	56 (100)	1.28	3722
Average		_	_	1.28	3722

Figures in parentheses indicate percentage to total.

Table 2. Economics of pond fish culture (₹ ha^{-1} $year^{-1}$)

Pond category	Finger-lings	Manure	Inorganic fertilizer	Fish feed	Human labour	Others	Interest	Total variable cost	Lease	Depre-ciation	Interest	Fixed cost	Total cost
I	7442 (20.35)	3438 (0.41)	2983 (8.36)	4316 (11.81)	8264 (25.34)	405 (0.11)	1313 (3.59)	27051 (74.00)	4150 (11.35)	2764 (7.56)	2590 (7.09)	9504 (26.00)	36555 (100.00)
II	6672 (25.08)	1592 (5.98)	1740 (6.54)	3371 (12.67)	4421 (16.62)	1474 (5.54)	906 (3.41)	20176 (75.84)	2729 (10.26)	1935 (7.27)	1762 (6.62)	6426 (24.46)	26602 (100.00)
III	2668 (16.89)	1011 (6.40)	2091 (13.24)	2285 (14.46)	2382 (15.08)	873 (5.52)	532 (3.37)	11841 (74.98)	1774 (11.23)	1173 (7.43)	1005 (6.36)	3952 (25.09)	15793 (100.00)
IV	6468 (26.91)	806 (3.35)	1608 (6.69)	3705 (15.41)	3826 (15.92)	706 (2.94)	1056 (4.39)	18265 (75.99)	2507 (10.42)	1719 (7.15)	1546 (6.43)	5772 (24.01)	24037 (100.00)
V	3946 (26.30)	1078 (7.18)	897 (5.98)	1918 (32.78)	1763 (17.79)	1405 (9.36)	517 (3.45)	11524 (76.80)	1542 (10.28)	1067 (7.11)	872 (5.81)	3481 (23.20)	15005 (100.00)
VI	4297 (44.00)	537 (5.50)	446 (4.57)	719 (7.36)	1036 (10.61)	483 (0.85)	333 (3.41)	7451 (76.29)	1000 (10.24)	713 (7.30)	603 (6.17)	2316 (23.71)	9767 (100.00)
Overall	7093 (21.58)	1804 (5.49)	6709 (20.41)	4051 (12.33)	4299 (13.08)	1264 (3.85)	1060 (3.23)	26288 (79.98)	2857 (8.69)	2089 (6.36)	1633 (4.97)	6579 (20.02)	32867 (100.00)

Figures in parentheses indicate percentage to total

highest share (21.58%) in the total cost, followed by cost of fertilizer (20.41%). Fixed cost constituted 20.02% of the total cost. Among the fixed cost , expenditure on lease constituted the highest share (8.69%) of total cost followed by depreciation (6.36%). Among the different categories of ponds, share of fixed cost to total cost was the highest (26%) in ponds of category I followed by category IV ponds with 25.02% . It is observed from the above findings that input use pattern was of similar nature in all the categories of ponds. The quantum of input use was thus higher in small size ponds as compared to big size ponds implying an inverse relationship between the area of ponds and the quantum of input use.

Yield and return

Yield and return variations with pond area is shown in Table 3. It could be seen from the table that the average yield of carp realised by the respondents was 1,480 kg ha^{-1}. The highest yield of 1,790 kg ha^{-1} was obtained by the respondents having category I ponds. Around 89% of the respondents had more than 1 t ha^{-1}yield. The average yield obtained by the farmers declined with the increase in pond size indicating an inverse relationship. These findings are in agreement with the report by Jayaraman (1997). Returns over variable cost per ha of pond area was found to be the highest in category II with ₹ 56,895/- followed by ₹ 54,036/- in category I. The table also indicates that the net returns from per ha was also maximum with ₹ 50,433/- in category II ponds followed by ₹ 44,532/- in category I ponds. Overall per ha return over total variable cost and net return was observed to be ₹ 41,511/- and ₹ 34,932/- respectively. The average price realised was ₹ 45.81 per kg of carp. In general, the net return showed a declining trend as pond area increased as also noted by Jayaraman (1997) and Chaudhury *et al.* (2004). The benefit-cost ratio (B/C ratio) with reference to total variable cost was observed to be the highest (4.28) for category III pondss followed by 4.04 in category V ponds . The B/C ratio with respect to total cost was found to be the maximum (4.44) for category VI and the lowest (2.22) in category I. The overall B/C ratio over total variable cost and total cost was estimated to be 2.58 and 2.06 indicating profitability of fishery enterprise. Benefit-cost ratio was more favourable to large ponds (Rathi *et al.*, 2004). This is further corroborated by the results reported by Dr. P. D. K. V., Akola, where it was shown that by adopting Magur fish farming in ponds of Anchal and Gowardhan villages in the Washim District of Maharashtra, farmers achieved B/C ratio of 3.44 and 2.44 in 2007-08 and 2008-09 respectively. Employment generated in one ha of paddy is 165 mandays per year whereas the same is 247 man days from one ha of pond fish farming.

Table 3. Variation in yield and return with pond area

Pond category	Yield (kg ha^{-1} $year^{-1}$)	Price (₹ kg^{-1})	Gross return (₹)	Return over variable cost (₹)	Net return (₹)	Benefit-cost ratio	
						On total variable cost	On total cost
I	1790	45.30	81087	54036	44532	3.00	2.22
II	1645	46.83	77035	56859	50433	3.82	2.90
III	1140	44.50	50730	38889	34937	4.28	3.21
IV	1180	48.20	56876	38611	38611	3.11	2.37
V	945	49.32	46607	35083	31602	4.04	3.11
VI	960	45.15	43344	35893	33577	5.81	4.44
Overall	1480	45.81	67799	41511	34932	2.58	2.06

Production function analysis

The determinants of revenue of pond fish production are as follows:

$$-1075.82 + 496.94\,X_1 + 49.78\,X_2^{***} + OX_3 + 97658.62^{*}\,X_4 + 25692.35\,X_5 - 15321.34X_6 + 29878.61\,X_7 +$$
$$(-0.011)\quad (2.834)\quad (2.723)\quad (1.638)\quad (0712)\quad (-0.316)\quad (0.702)$$

$$98929.23^{**}\,X_8 + 30184.53\,X_9 - 0.0613^{**}\,X_1^2 + 0.00318^{***}\,X_2^2 - 56485.34^{***}\,X_3^2 + 1.8762.56^{*}\,X_4^2$$
$$(2.479)\quad (0.612)\quad (-2.723)\quad (3.234)\quad (-3.124)\quad (1.823)$$

R^2 = 0.798
Adjusted R^2 = 0.798
F stat = 7.120
Durbin Watson = 1.812

*** = Significant at 1%
** = Significant at 5%
* = Significant at 10 %

The R^2 is 0.798 indicating that the 79.8% of variation in the revenue is explained by the explanatory variables.The coefficient of fingerlings (X_2), together with its square(X_2^2) and the square of labour for feeding ($X_3^{2)}$ are significant at 1% probability level, the co-efficient of dummy variable for using FYM (X_8) and the co-efficient of the square of the variable *i.e.*, pond size (X_1^2) are significant at 5% probability level, while the coefficient for labour for harvesting (X_4) and its square (X_4^2) are significant at 10% probability level. The results further show that quantity of fingerlings (X_2) and its square (X_2^2), labour for harvest (X_4) and its square (X_4^2) along with dummy variable for using FYM (X_8) have significant and positive influence, while the square of pond size (X_1^2), the square of labour for feeding (X_3^2) significantly and negatively influence the revenue that accrued from pond fish production. These results are in consonance with the findings of Saini *et al.* (1991), Ogunderi and Ojo (2009), and Olawumi *et al.* (2010). The response of fish yield to pond size was quite high as a 10% increase in pond size will result in a 5% increase in fish output. Like pond size, the elasticity of output with respect to fish feed is high, as a 10% increase in feed utilisation will raise fish yield by 5%. A 10% increase in number of fingerlings will cause fish yield to rise by 4.8%, however, number of fingerlings must be supported by adequate feeding and suitable management measures. The labour (feeding) levels appear to have reached the optimum levels. The positive influence of the explanatory variable and the respective negative influence of the square of the variable signify that the revenue that accrued from fish farming will increase with the increase in utilisation of the variable inputs and at the level of each variable input, maximum revenue will be realised. A further increase in the utilisation of the variable inputs beyond the level that corresponds with the maximum revenue will result in a decline in revenue. The positive influence of FYM on the revenue generation from pond fish production signify that farmers should use FYM to feed the fingerlings for revenue generation.

Price spread in different channels of fish market

Three channels of distribution were identified in the marketing of freshwater fish in the study area. They are:

Channel I: Producer–Consumer

Channel II: Producer–Retailer–Consumer

Channel III: Producer–Wholesaler–Retailer–Consumer

The price spread of major freshwater fishes *viz.,* Indian major carps for three prevalent market channels and results are placed in Table 4. It could be seen from the table that the net price received by producer (fisherman) was ₹ 70.70 per kg of fish in Channel I. It incurred a net cost of ₹ 5/- and received a net price of ₹ 65.70 per kg. Therefore, his share in consumer price was as high as 92.93%. In Channel II, the share of producer in consumer's price was 75.86%. It was reduced as the cost of market and retailers margin constituted 9.60 and 14.54% of consumer's price. The price received by producer formed only 53.12% of consumer's price in channel III. The remaining was market cost (10.69%), wholesaler's margin (14.54%) and retailer's margin (12.89%). This clearly showed that, where there are more intermediaries, produce becomes costlier to the consumer while the share of producer is greatly reduced (Chen *et al.,* 2008). Pisciculture is thus potentially viable option for augmenting income to poverty ridden rural population.

Major constraints faced by the fish producers

Major constraints faced by the fish producers of the Gondia District are presented in Table 5. More than 95% of the respondents stated inadequate technical knowledge as the major constraint in adopting fishery as a profession. Plurality of ownership for closed water bodies is hindering development of fish production as revealed by 91% of the respondents. Lack of access to credit is reported by 88% of the respondents as the major constraint. Fish farmers routinely borrow from private money lenders at an exorbitant rate of interest ranging from 36-60%.

Lack of lending institutions like credit co-operative society has negligible presence in this area. On the other hand, most of the farmers are defaulters in loan repayment and hence nationalised banks do not issue any loan to them. The non-compliance of repayment was discussed with the farmers. They believe that the loans will be waived and do not see any incentive/merit in timely repayment. Illegal poaching and deliberate poisoning of fishes are stated to be major constraints by more than 70% of the respondents. Non-availability of fish seed and high price of inorganic fertilizers are reported by the respondents as other major constraints. Lack of transport, poor road conditions and

Table 4. Price (₹) spread in different channels of fish market

	Channel I	Channel II	Channel III
Cost incurred by producer (fisherman)	5.00 (7.07)	_	_
Net price received by the fisherman	65.70 (92.93)	58.03 (75.86)	45.81 (53.12)
Cost incurred by wholesaler	_	_	9.22 (10.69)
Margin	_	_	12.74 (14.77)
Wholesale price	_	_	67.77 (78.58)
Cost incurred by retailer	_	7.35 (9.60)	7.35 (8.53)
Margin	_	11.12 (14.54)	11.12 (12.89)
Price received by the fisherman / price paid by the consumer (price received by the fisherman and price paid by the consumer are same as there are no intermediaries)	70.70 (100.00)	76.50 (100.00)	86.24 (100.00)

Figures in parenthesis indicate percentage to price paid by consumer

Table 5. Constraints faced by fish producers

Constraints	Rating/Percentage
Inadequate technical knowledge	95.60
Plurality of ownership	91.20
Lack of access to credit	88.70
Illegal poaching	80.36
Deliberate poisoning	73.61
Marketing problem	61.84
Non-availability of fish seed	57.40
High price of inorganic fertilizers	50.65
Lack of transport	44.20
Poor road condition	40.35
Lack of access to pond	35.26
Increased cost of feed	32.16
No skilled worker	28.22
Fish disease	24.11
Poor extension service	18.22

lack of access to ponds are stated to be the other constraints faced by the fish producers of the district. For improving the marketing of fish it is recommended that infrastructure for storage, processing and transportation need to be developed.

Policy implications

The district has more than 7000 ponds and our analysis indicates that there is huge potential for promoting pisciculture. The fish produce is sold to middlemen who sell it in big city markets like Raipur, Kolkata and Nagpur. Lack of storage facility causes low remuneration as the catch can not be held by the primary producer even for few hours. Strengthening of fish marketing system with provision of cold storage facilities is thus necessary in providing remunerative prices to the fish farmers. The results also indicated that pond fish culture is an economically viable proposition in the tribal belt/Gondia District. It can very well be incorporated as supplemental land use in all the districts with similar agro-climate and district plans could be prepared for augmentation of income. The production curve of the pond fish farmer is quadratic in nature. The pond size, number of fingerlings, labour in feeding and harvesting and the use of animal waste as feed are the major determinants of the revenue that accrue to the fish production. The constraints in adoption of fish farming were identified and recommendations based on analysis include extension of lease period to 10 years with different payment options. A linkage between leaser and credit institution is suggested to overcome the microfinance availability and loan repayment

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