



Economic impact of aquaculture in floodplains - a case study of Sonmar Chaur in Bihar, India

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ABSTRACT

*Chaur*s are shallow water logged areas and have limited scope for agriculture, but can be better utilised for agriculture cum fish production. About 70% (28.34 ha) area of Sonmar *chaur* in Bihar has been converted into small ponds for aquaculture purposes. Income and employment generated from the *chaur* from both agriculture and fisheries and fish disposal pattern were studied. The study revealed aquaculture as most profitable enterprise (₹3,28,000 ha⁻¹) with BC ratio 1.46 followed by agriculture (₹37,900 ha⁻¹) and culture based fisheries (₹34,400 ha⁻¹) with B-C ratio 2.1 and 2.6, respectively. Maximum employment was generated from aquaculture (1411 man days ha⁻¹) followed by culture based fisheries (70 man days ha⁻¹) and agriculture (35 man days ha⁻¹). The higher employment generation in culture fisheries was mainly due to requirement for watch and ward. The fish was sold either directly to the ultimate consumers or through the vendors. Among the two marketing channels operating Channel-I in which producer sells directly to consumers was found more efficient (69.7). Though, aquaculture was more profitable and generated higher employment, it requires much higher resources for its practice which may hinder small holders to adopt such practice and also it may impact certain indirect uses of these water bodies. Environmental impact assessment and support to small farmers are needed to utilise such water bodies through aquaculture.

Keywords: Chaur, Disposal pattern, Employment, Flood plains, Income, Modified marketing efficiency

Introduction

Flood plain wetland ecosystems are very productive both for agriculture and fisheries (Islam, 2003). The floodplains in the form of tectonic lakes (*chaur*s) between river Gandak and Koshi in north Bihar have the distinction of nurturing huge number of open water fishery resources. *Chaur*s are shallow transitional lands, left with enough fish after the flood recedes. It can support lucrative fisheries without much of inputs. The seasonal nature of *chaur*s makes their property regime very unique. Agricultural land is cultivated under individual ownership, whereas the submergence of the land makes the fishery management practices dependent upon collective effort of the farmers. At present, average yield of fisheries practiced in *chaur*s of Bihar is about 40-50 kg ha⁻¹ yr⁻¹ (Govt. of Bihar, 2008).

To increase their production and profitability, a number of strategies have been proposed *viz.*, cooperative management of *chaur*s, community participation in management and management by private parties on contractual basis, but none of them worked satisfactorily for their development and poor adoption of these strategies resulted in poor yield and returns. For achieving high yield and profitability, some farmers of Sonmar *chaur* in Samastipur District of Bihar formed a

co-operative society “Sonmar Chaur Matsaya Vikash Pariyojana Samiti”. The society with the help of Government of Bihar converted 28.34 ha of 40.15 ha *chaur* area into ponds. This 28.34 ha land belonged to 37 individuals. They used respective ponds for aquaculture individually. Remaining 11.81 ha area of the *chaur* was used for culture based fisheries during submergence, by two persons who have taken *chaur* on lease. The owners of land undertook agriculture activities once water receded. Farmers cultivated paddy, maize, wheat, mustard and tobacco. During normal monsoon year, only single crop is possible in most farms of the *chaur*; and during drought year, opportunities do exist for raising more than one crop.

Farmers practicing aquaculture had better yield and returns (Das *et al.*, 2014). The paper analysed the economic impact of the strategy of converting *chaur* area into ponds for practicing aquaculture. The specific objectives of the study were to investigate the cost and return structure and to compare the income and employment from aquaculture, with culture based fisheries and agriculture as well as to analyse economics of marketing of fish and to identify efficient marketing channel.

Materials and methods

The study was based on primary data collected from sample households by personal interview with the help of specially designed pre-tested questionnaire. Study was conducted at two levels; namely, producer and the market. Sample farm households were selected following multistage stratified random sampling based on size of their land holdings (Kumar, 1998). A total of 30 farmers proportionate to the population in each farm size group were selected randomly from a total of 95 farmers spread over 3 villages as shown in Table 1. Out of 37 aquaculture farmers from Sahajadpur in the *chaur*, 17 were selected randomly for the study. The lessee of the *chaur* who practiced culture based fisheries was also selected for the study. Since entire fish produce of the *chaur* was sold either to vendors, locally known as *paikars*, or to consumers directly, 15 *paikars* were selected randomly for market level study.

Table 1. Sampling plan at farm level

Village	Total number of farmers	No. of sample farmers			Aqua-farmers
		Large	Medium	Small	
Sahajadapur	60	3	5	10	17
Surmar	20	1	4	3	0
Mayari	15	0	1	3	0
Total	95	4	10	16	17

Price of inputs purchased from markets was taken as it is and home grown inputs were priced on the prevailing market price. Main product and byproducts of farms were evaluated at prevailing market prices at the time of harvest. The data collected for the study pertained to the agricultural year 2011-12. Besides simple statistical tools such as average and percentage, farm business analysis (Kumar, *et al.*, 2008 and Das *et al.*, 2013), measure of price spread and marketing efficiency were used to meet the objectives of the study. Benefit Cost ratio (BC ratio) was estimated to ascertain the economic viability of each of the enterprise:

$$\text{BC Ratio} = \frac{\text{Gross income}}{\text{Total cost}}$$

Modified marketing efficiency (MME)

According to Acharya and Agarwal (2004) an ideal measure of marketing efficiency for comparing efficiency of alternate marketing channels is calculated as modified measure of efficiency (MME)

$$\text{MME} = \frac{\text{PF}}{(\text{MC} + \text{MM})}$$

where, MC = Total marketing cost, MM = Net marketing margin, PF = Prices received by the farmer.

Results and discussion

Cost and return structure

Economics of *chaur* depends on both fish and agricultural crop production as these are the major economic activities in the *chaur*. Cost and return structure of all the major agricultural crops and fish enterprises were estimated and is presented in Table 2. The total cost of cultivation and gross return from paddy, the most popular crop in the *chaur*, were estimated at ₹31,198 ha⁻¹ and ₹66,796 ha⁻¹ respectively. Variable cost was the major component of total cost accounting for about 58.7% and the rest 41.3% was contributed by fixed cost. Among variable costs, labour cost was the major component accounting for about 54.9% of total variable cost followed by fertilisers (20.7%) and irrigation charges (9.2%). Maize was the second most popular crop in the *chaur*. Maize was cultivated mainly as fodder for livestock and used for fisheries too in some of the farms. Gross income and total cost from maize was ₹ 90,377 ha⁻¹ and ₹ 46,094 ha⁻¹ respectively. Variable cost was the major component of total cost accounting for about 71.2% and remaining 28.8% was contributed by fixed cost. Among variable cost, contribution of expenditure on labour was the maximum (30.14%) followed by cost of manure and fertilisers (30.1%) and irrigation charges (20.8%). A number of other crops like potato, onion, pea and vegetables were also being cultivated in the *chaur*. The average total cost and gross return from other crops was about ₹34,700 ha⁻¹ and ₹1,03,300 ha⁻¹, respectively.

The gross return from aquaculture and culture based fisheries was ₹10,41,600 ha⁻¹ and ₹55,900 ha⁻¹, respectively whereas, total cost was ₹7,13,500 ha⁻¹ and ₹21,500 ha⁻¹, respectively. Variable cost was the major component that constituted about 96% of total cost in aquaculture and 60% in culture based fisheries. Among the variable costs, cost of seed (78.7%) was the major cost followed by labour cost (41%) in case of culture based fisheries whereas in case of aquaculture major component of variable cost was feed cost accounting for about 48% of total variable cost followed by labour cost (34%), seed cost (5.5%) and others. The results are in conformity with Kudi *et al.* (2008) who estimated 97.6% contribution of variable cost in the total cost of aquaculture in Kaduna State, Nigeria. The proportion of fixed cost was very low as almost all farmers of the *chaur* were not having boats and gears. The major component of fixed cost was depreciation towards pond, water pump and farm building on *chaur* side and land rent. Chandra *et al.* (2010) found average fish production as 2920 kgha⁻¹yr⁻¹ from *beels* of Bangladesh whereas production from Sonmar *chaur* was only 382 kg ha⁻¹yr⁻¹ indicating poor management of culture based fisheries in the *chaur* in comparison to *beels* of Bangladesh. However production from aquaculture in the *chaur* was about 6413 kg ha⁻¹yr⁻¹.

Table 2. Costs and returns from aquaculture, agriculture and culture based fisheries in sample farms in the *chaur* during 2011-12 (₹ ha⁻¹)

Particulars	Agricultural crops			Fisheries (Culture based)	Aquaculture
	Paddy	Maize	Others		
Area (ha)	9.03	2.37	0.18	5.11	28.34
Seed	938.5	2544.3	1041.7	7620.7	38099.7
Fertilizer	3784.3	9873.4	5222.2	0.00	9088.6
Lime	0	0	0	0.00	2373.8
Feed	0	0	0	0.00	332455.3
Irrigation	1686.8	6808.9	1247.4	0.00	18751.5
Machine hiring	1013.3	1935.7	1666.7	0.00	1180.6
Labour	10062.3	9886.6	11252.6	6203.7	235509.2
Miscellaneous	693.8	1396.6	138.9	677.4	10262
Interest on working capital	139.6	354.6	205	524.9	39932.8
Total variable cost	18318.6	32800.1	20774.5	15026.7	687653.5
Depreciation	467.8	674.9	1289.7	349.3	12885.7
Repair and maintenance	135.1	301.1	79.4	0.00	2234.7
Interest on fixed capital	1223.9	1263.4	1320.1	264	16986.6
Imputed value of land rent	11052.9	11054.8	11203.7	5842.5	11050.2
Total fixed cost	12879.7	13294.2	13892.9	6455.9	43157.2
Total cost	31198.3	46094.3	34667.4	21482.7	713465.3
Production (kg)	5733.5	7341.8	1722.2	381.9	6412.9
Price (₹ kg ⁻¹)	11.7	12.3	60	146.4	162.4
Gross return	66796.1	90377.2	103333	55922.5	1041583.2

Income and employment

Income and employment generation vary from enterprise to enterprise. With a view to compare and contrast the practice of aquaculture with culture based fisheries and agriculture, income and employment generated and BC ratio obtained for these practices followed in the *chaur* were estimated (Table 3). Since culture based fisheries and agricultural crops were taken on same piece of land in a year, income and employment generated from both the enterprises were added to compare with aquaculture which was practiced round the year on a piece of land. It is clear from Table 3 that aquaculture with net income of ₹3,28,100 ha⁻¹yr⁻¹ was much more profitable than the combination of agriculture and culture based fisheries which yielded net income of only ₹72,300 ha⁻¹yr⁻¹ in the *chaur*.

However, BC ratio was more in case of agriculture along with fisheries in *chaur* (2.3) than that of aquaculture alone (1.46) which was mainly due to high cost involved in

case of aquaculture than that of agriculture with fisheries in the *chaur*. Katiha *et al.* (2005) estimated BC ratio for carp polyculture which varied from 1.22 for high input carp culture to 1.79 for low input carp culture in India. An estimate by McInnes (2004) showed that BC ratio varied from 2.92 to 4.80 from aquaculture in Mary river wetlands of Australia. Labour absorption in terms of monetary value in aquaculture was ₹2,35,500 ha⁻¹year⁻¹ which was comparatively very high in comparison to agriculture along with culture based fisheries (₹16,250 ha⁻¹year⁻¹). As the *chaur* was away from the human inhabitation, intensive watch and ward was required to avoid poaching which made aquaculture more labour intensive. Engaging common watch and ward by all the aquaculturists may help in reducing the labour requirement, whereas culture based fisheries mainly employed labour for harvesting operations and stocking of fish seeds, hence employment opportunities were low.

Singh (2006) and Singh and Dey (2010) found that promotion of aquaculture was helpful in improving income

Table 3. Comparison of income and employment generated from aquaculture and culture based fisheries along with agriculture in the *chaur* (₹ha⁻¹)

Particulars	Agricultural crops	Fisheries (Culture based)	Fisheries along with agriculture	Aquaculture
Labour absorption	10044.8	6203.7	16248.5	235509.2
Total variable cost	21320.6	15026.7	36347.3	687653.5
Total fixed cost	12980.3	6455.9	19436.3	43157.2
Total cost	34300.9	21482.7	55783.6	713465.3
Gross income	72190.2	55922.5	128112.7	1041583.6
Net income	37889.3	34439.9	72329.2	328117.9
BC ratio	2.10	2.6	2.3	1.46

and employment across the rural masses. The higher return and higher levels of employment in aquaculture during recent past have increased the interest of people in aquaculture (Das, *et al.*, 2014). Conversion of the *chaur* lands into ponds helped to increase the income and provided employment opportunities to the rural masses in the study area. The findings of study are also supported by Singh (2006), Singh and Dey (2010) and Das *et al.* (2014). Though aquaculture is more productive, profitable and generating more employment opportunity, its requirement for resources are also very high in comparison to agriculture along with culture based fisheries. This may hinder adoption of such practices in small farms. Also, there is need to study the environmental impact or loss to ecological biodiversity, groundwater recharge and other losses due to the conversion of *chaur* into ponds before supporting/popularising this strategy on larger scale in *chaur* areas of the state.

Distribution of employment

Agriculture as well as fishery are labour intensive and generate ample employment opportunities. The employment generated from both aquaculture and agriculture along with fisheries in the *chaur* was estimated for both family and hired labour (Table 4). It is clear from the table that per hectare labour absorption in aquaculture (1,411 man days ha⁻¹ yr⁻¹) was substantially higher than agriculture (35 man days ha⁻¹ yr⁻¹) and the combination of agriculture and culture based fisheries (105 man days ha⁻¹ yr⁻¹). Further, study of human labour composition revealed that higher proportion of family labour is required for aquaculture than that in agriculture with culture based fisheries in the *chaur* and hence by increasing area under aquaculture, employment opportunities can be increased substantially in the labour surplus area of the country.

Marketing of chaur fishes

Disposal pattern

Fish is a highly perishable commodity and cannot be stored for long. Therefore, they were sold in the market or at farm itself after harvesting. About 2% of total produce was used for self-consumption and 8% was distributed among fishers as harvesting charges and remaining 90% was sold to either consumers or vendors (Table 5). Out of the total marketed surplus, about 93% was sold to *vendors* and 7% directly to local consumers at farm.

Marketing channel

Two marketing channels were operating for disposal of fish from production site to consumer. Channel-I consisted of only two players where producer sells their produce directly to ultimate consumers. This channel was the shortest with maximum efficiency (69.7). Only 7% of the fish was disposed through this channel. Channel-II comprised three players including producer, vendor and consumer. Vendor after purchasing fish from farmers/fishers were selling fish to consumers door to door either on bicycle or by foot. This was the most popular channel for marketing of *chaur* fishes. Maximum quantity (93%) of marketable surplus on sample households was disposed through this channel.

Movement of fish from point of production to point of consumption involved cost towards transportation, communication charges, labour charges and other miscellaneous expenditures. In channel-I, farmer incurred a total of ₹2 kg⁻¹ as marketing cost out of which 44% was labour cost and 32% miscellaneous charges, whereas marketing cost at vendor level was ₹11 kg⁻¹. At vendor level, the major component of marketing cost was labour cost accounting for

Table 4. Employment from agriculture with culture based fisheries and aquaculture on sample households during the year 2011-12

Enterprise	Percentage of total labour		Total labour (man days ha ⁻¹)
	Family labour	Hired labour	
Culture based fisheries	4.05	95.95	70.36
Agriculture	18.40	81.60	35.21
Agriculture and culture based fisheries	8.84	91.16	105.57
Aquaculture	69.71	30.29	1411.5

Table 5. Disposal pattern of fishes

Particulars	Quantity (in kg)
Total production	72248.99 (100.0)
Self-consumption	1517.23 (2.1)
Paid as wages	5779.92 (8.0)
Marketable/marketed surplus	64951.85 (89.9)
Sold at farm to:	
Vendor	60535.12 (93.2)
Consumer	4416.72 (6.8)

Note: Figures in parenthesis indicate the percentage to total production

78% followed by fixed cost (7%), cost of communication (4%), transportation (2%) and miscellaneous costs (9%).

Price spread

Price spread refers to consumer price spread among the market intermediaries and the producer. It involves marketing costs and marketing margins of intermediaries, which ultimately determine the overall effectiveness of the marketing system (Acharya and Agarwal, 2004). The price spread analysis was done for both the marketing channels and

results are presented in Table 6. It was observed that farmers when sold the fish directly to consumers, received highest price of ₹149.9 kg⁻¹ in marketing channel-I. Price spread for marketing channel-I was ₹2.1 kg⁻¹ of fish as cost of marketing.

The lowest price (₹136 kg⁻¹) was received when farmers sold produce to vendors with no marketing cost in marketing channel-II. The sale prices of fish to vendors by producers were the same and equal to ₹150 kg⁻¹, which they

Though channel-I was most efficient and profitable for farmer, maximum quantity of fish was getting disposed through marketing channel-II. This indicates the lack of adequate demand at the point of production, so there is a need to sell fish in distant market. But small quantity of catch of individual farmer/fisher cannot be transported to distant markets. Therefore, collective action on part of farmers/fishers is required for marketing their produce collectively in wholesale market, where they may get better prices.

Table 6. Price spread analysis in marketing of fishes

Particulars	Marketing channel-I		Marketing channel -II	
	₹ kg ⁻¹	%	₹ kg ⁻¹	%
Sale price of producer	149.9	100.0	136.27	100.0
Marketing cost of producer	2.12	1.4	2.12	1.3
Net price received by producer	147.8	98.6	134.15	85.3
Marketing cost of vendor			11.38	7.2
Net marketing margin of vendor			9.7	6.2
Consumer's price	149.9	100.0	157.35	100.0
Price spread (₹ kg ⁻¹)	2.12		23.2	
Total marketing cost (₹ kg ⁻¹)	2.12		13.5	
Total marketing margin (₹ kg ⁻¹)	0.0		9.7	
Marketing efficiency	69.7		5.8	

received from consumers. But for every 10 kg of fish, the vendor (forcibly) took an extra kilo from the farmer since this was considered as a practice by the vendors based on the argument that the farmer could not have sold the 10 kg of fish directly to the consumers on his own and this bulk sale was effected only because of the intervention of the vendor in the sale process.

Marketing channel-I for disposal of *chaur* fish was most efficient, as producers share in consumers' rupee (99%) and marketing efficiency (70) was highest in this channel. Kumar *et al.* (2008) estimated marketing efficiency that varied from 31.75 to 57.39 in different marketing channels at Howrah market for Indian major carps which is in conformity with the present study. However, Kumar *et al.* (2008) found 34.5-63.8% producer's share in consumer's rupee and Alam *et al.* (2010) in Bangladesh also estimated 30-40% producers share in consumer's rupee which is contrary with the present study. This may be due to shorter marketing channel in the present study than others. Jayaraman *et al.* (1993) estimated producers share in consumer's rupee which varied from 36 to 72%. The reason behind higher share of producers in consumer's rupee observed in the present study may be attributed to shorter marketing chain operating in the *chaur* and also because most of the fishes were being sold either to the vendors or the ultimate consumer whereas marketing chain in Alam's study was longer leading to higher share to middlemen.

Results of this study clearly revealed economic superiority of aquaculture over agriculture along with culture based fisheries in *chaur*. However, aquaculture requires much more resources in comparison to agriculture along with culture based fisheries. Therefore, small holders may require financial support for adopting such practices. Also, in the absence of environmental impact assessment, adoption of aquaculture in *chaur* for increasing income and employment, needs greater caution. Again, as farmers are mostly small holders and there is need to encourage them for collective marketing of their produce at distant markets for realising higher price of their produce and to get more profit.

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