

A comparison of resource use efficiency and constraints of wastewater and freshwater fish production system in West Bengal

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ABSTRACT

The study was carried out to find the profitability and resource use efficiency of two fish production system i.e. wastewater and freshwater in West Bengal, India. The study revealed that though the productivity of freshwater fish production system was higher by 74.5 kg/acre over the other system but the freshwater fish production farmers realized lower net returns of ₹ 1933.53/acre as compared to the wastewater fish production farmers. This was due to mainly two facts, firstly, higher rent of leased-in freshwater fish ponds and secondly, the locational advantage of wastewater fish ponds (proximity to the megacity Kolkata) which fetched higher price of the produce. The results of the study indicated that under both the system of fish production, fish seeds, area, and labour has greater influence on gross returns. Further, it was found that, fish seeds and labour were under-utilized in freshwater fish production system whereas fish seeds, labour and area were under used in wastewater fish production system. Theft and pilferages, non availability of quality fish seeds, lack of government support, lack of capital, lack of natural feed, labour crisis etc. were some of the major identified problems and constraints encountered during production of fish.

Keywords: Constraints, fish, freshwater, production, profitability, resource, wastewater.

Fisheries play an important role in the national economy, providing full or part time employment to more than 5.96 million people of the country. Constituting about 5.4 percent of the global fish production, India today is the second largest fish producing nation in the world after China. India is endowed with vast and varied resources for aquaculture and capture fisheries, both in the inland and marine ecosystem. Fish production of the country has increased from 41.57 lakh tonnes (24.47 lakh tonnes from marine and 17.10 lakh tonnes from inland fisheries) in 1991-92 to 90.40 lakh tonnes (33.21 lakh tonnes from marine and 57.19 lakh tonnes from inland fisheries) in 2012-13 (Annual Report, DAHD, 2013-14). The sector contributes about 1.3 percent to the overall GDP and 4.36 percent of the agricultural

GDP amounting ₹ 91,541 crores during 2012-13. Fish products export aggregated to 9,28,215 tonnes in volume and valued at ₹18,856.26 crores, recording a growth of 13.6% over previous fiscal (CSO, 2011).

The share of inland fisheries in total fish production of the country (63.30%) revealed a paradigm shift in the historical scenario of marine dominated fisheries to inland fisheries. Within inland fisheries, there is a shift from capture fisheries to aquaculture during the last two and a half decade. Freshwater aquaculture with a share of 34 percent in inland fisheries in mid-1980s has increased to about 80 percent in recent years. India's total potential area for fish production consisted of 6.12 million hectares of freshwater and 1.24 million hectares of brackish water aquaculture. West Bengal is the highest fish producing as well

as fish consuming state of India. The provisional estimates show that West Bengal produced 16.37 lakh tonnes of fish (17.36 % of India's fish production) during 2013-14 which was 9.84 percent higher than the fish production level of 2012-13 (14.90 lakh tonnes). Apart from the fact that they are mainly consumed in the state, a large amount of inland and marine fish is exported to Delhi, Uttar Pradesh, Madhya Pradesh, Bihar and other adjoining states. West Bengal occupies the 4th position in the country in terms of export of sea food products. Export of marine fish beyond boundaries of the country earned handsome revenue of ₹ 700 crore in the year 2009-10 (Anonymous, 2012). The average productivity of fish in West Bengal is 2694 kg/ha/annum which is quite higher than the national average of 1127 kg/ha/annum (Annual Report, DAHD, 2011-'12) although, the average productivity of fish from ponds in the country is 2160 kg/ha/year (Ayyappan and Biradar, 2004).

Except a vast resource of freshwater aquaculture in West Bengal, there is huge domestic and industrial sewage water, especially in Kolkata that can be effectively exploited for fish production using techniques developed by the nearly 20,000 natural ecologists, i.e. the farmers as well as the fisherman of East Calcutta Wetland (ECW). It is because of them that sewage has taken on a new meaning for Kolkata. In Kolkata, raw wastewater-fed fish pond system - known as "Bheri" is frequently cited as showpieces of wastewater fish production. In India, there are over 130 sewage-fed fisheries covering a total area of 12,000 ha. The Calcutta Wetlands, which have been operational since about 1930, are the world's largest wastewater fisheries, comprising an area of approx. 3200 ha and providing employment for 4,000 families (Ghosh, 1990). The stocking density of such fisheries varies from 30,000 to 50,000 per hectare and production varies between 4 to 9 tonnes/ha. Local entrepreneurs are confident of raising productivity to 10 tonnes/ha given adequate management and technological support.

Although, the fish production of West Bengal is increasing over the year but the productivity of the fishery sector showed a very less increment due to over fishing, lack of quality fish seed in proper ratio, lack of marketing infrastructure, socio-economic and environmental constraints (Roy, 2008) and again the most farmers used to follow traditional technology

due to the absence of fishery extension services (Singh, 2001). Breaking up of joint family system, quarrel among legal owners, rivalry, theft, lack of renovation of existing ponds etc. have rendered large numbers of potential water bodies unproductive which could have play an important role in bridging the gap (Abraham *et al.*, 2010). In this context, the present study makes a modest attempt in assessing the resource use efficiency in fish production and identifying the production level constraints faced by the farmers.

Materials and Methods

Study area and sampling technique

The study was conducted to compare the major differences between two situation of inland aquaculture i.e., freshwater and wastewater. A total of 120 fish farmers were selected by simple random sampling without replacement (SRSWOR) technique, 60 samples from each of the two fish production system. For freshwater fish production system, data was collected from Bolpur and Nanur blocks of Birbhum district. For wastewater fish production system, primary data was collected from the farmers belonged to the area namely Belgharia, Chingrighata, Chaubegha and Bantala, which comes under the jurisdiction of Kolkata district.

Analytical techniques

For the analysis of data simple averages, ratio measures, percentages and proportions are computed in order to draw meaningful inferences. The costs and returns are worked out on per farm basis. To capture the ability of the farmer to achieve the maximum realizable output with given level of inputs under the existing situation and technology, careful examination of allocative efficiency of the farms are estimated. Cobb-Douglas production function is employed to work-out the output elasticities and resource use efficiency and is presented below.

$$Y = a x_1^{b_1} x_2^{b_2} x_3^{b_3} x_4^{b_4} x_5^{b_5} x_6^{b_6} u$$

Where,

Y = Gross returns (Rs)

a = Intercept

x_1 = Area (acres)

x_2 = Fish seeds (₹)

x_3 = Labour (₹)

x_4 = Feed (₹)

x_5 = Manures and fertilizers (₹)

x_6 = Chemicals (₹)

u = error term

The function was converted into linear form by making logarithmic transformation of all the variables.

$$\ln Y = \ln a + b_1 \ln X_1 + b_2 \ln X_2 + b_3 \ln X_3 + b_4 \ln X_4 + b_5 \ln X_5 + b_6 \ln X_6 + \ln u$$

Allocative efficiency defined as the ability of a farm to maximize profit by equating the marginal value product (MVP) of inputs to their respective marginal costs (MFC). In order to determine optimal use of a resource keeping the use of other resources constant, MVP and opportunity cost (factor cost) of their resource were compared. The marginal product (MP) is estimated from the parameters of the Cobb-Douglas production function and the geometric mean levels of the output and input. The MVP of each resource is calculated by using the following formula.

$$MVP(X_i) = b_i \frac{\bar{Y}}{\bar{X}_i} P_y$$

Where,

$MVPX_i$ = Value marginal product of i^{th} input

b_i = Elasticity of production of i^{th} input

\bar{Y} = Geometric mean of gross returns

\bar{X}_i = Geometric mean of input of i^{th} input

P_y = Price of output

For determining resource use efficiency of resource the following criteria was used

$MVP/MFC > 1$ under utilization of resource

$MVP/MFC = 1$ Optimum use of resource

$MVP/MFC < 1$ Excess use of resource

The fish producers faced multidimensional problems ranging from physical, socio-economical to ecological and environmental in production and marketing of fish. These problems and constraints

were ranked based on the realisation of the actual growers and have been prioritised using Garrett's ranking technique.

Garrett's ranking technique

$$\text{Percentage position} = \frac{100 (R_{ij} - 0.50) / 100}{N_{ij}}$$

where,

R_{ij} = Rank given for the i^{th} item by the j^{th} individual and

N_j = Number of items ranked by the j^{th} individual.

In this method, respondents are asked to rank the specific problems faced by them according to their own perception. The assigned rank is converted into percentage position which is subsequently transferred into Garrett score using Garrett's table. For each constraint, scores of individual respondents are added together and then divided by total number of respondents. Thus, mean score for each constraint has been ranked by arranging them in descending order.

Results and Discussion

General features of aquaculture units

The freshwater fish culture units have an average area of 5.75 acres with the average depth of 7.41 feet as compared to the wastewater fish production system with an average pond size of 14.72 acres and average depth of 4.74 feet (Table 1). In both the systems of farming, farmers' rear almost same species of fish like, catla, rohu, mrigel, common carp, silver carp, grass carp etc. whereas, the wastewater fish producing farmers grow some other fish like Nylon tekka, Magur, Japani puti, Briket, Bata, Pangas etc. Average present value of a pond is ₹ 6,07,304 per acre and generally 70 to 90 mandays per acre per year are required for fish production on an average. Most of the medium and large farmers availed credit amounting ₹ 16971.73 and 38554.54 per acre on an average respectively, from different cooperative societies and scheduled commercial banks. The wastewater fish farmers are sanctioned with more

Table 1. General information on pisciculture unit under freshwater and wastewater fish production system

Particulars	Unit	Freshwater fish producing farmers (n=60)	Wastewater fish producing farmers(n=60)
Average pond area	acre	5.75	14.72
Rent paid for leased in pond per acre	rupees	8901.94	4817.96
Depth of water	feet	7.41	4.74
Average Lifespan of a pond	year	20	50
Average no. of labours employed/year	manday	69.60	92.00
Source of water		Ground water, precipitation, run-off water, canal, river	Domestic and cottage industries sewage water, precipitation, ground water.
Species of fish reared by sample respondents		Catla, rohu, common carp (mrigel, silver carp, and grass carp).	Catla, rohu, common carp, (mrigel, silver carp, and grass carp), Nylon tekka, Magur, Japani puti, Briket, Bata, Pangas.
Size of finance per acre	rupees	16971.73	38554.54

credit due to their better financial condition, greater asset holding capacity and also for their ease of access to the financial institutions.

Costs and returns structures of freshwater and wastewater fish production systems

The costs and returns structure for two different situations of fish rearing presented in Table 2 discerns that the freshwater fish farmers' receive a net return of ₹36756.92 by incurring a total cost of ₹ 57,413.94 per acre whereas the corresponding figures are ₹ 38690.50 and ₹ 57,180.51 per care for wastewater fish production system. The returns per rupee of investment for these two sample group farmers were estimated to be 1.64 and 1.67 in the same order. It is worthwhile to note that the rate of return to investment for both the group of farmers' are almost same in spite of higher production to the tune of 74.5 kg per acre in freshwater fish production system because of the fact that though, the effluent water fish production farmers incur more cost for inputs but the rent for leased in effluent water aquaculture unit is almost half of the freshwater unit. The wastewater fish farmers also fetch a higher price ₹4.49/kg of fish due to their advantage of geographic position i.e. its proximity towards the megacity Kolkata and its suburban areas.

Table 2. Costs and returns structure under freshwater and wastewater fish production system

(₹ /acre/annum)

Particulars	Freshwater Fish producing Farmers (n=60)	Wastewater Fish producing Farmers (n=60)
Gross Returns	94170.86	95870.96
Yield (kg)	1497.39	1422.84
Costs		
Average total variable cost	47799.61	51502.04
Average total fixed cost	9614.33	5678.47
Average Total Costs	57413.94	57180.51
Net Returns over variable cost	46371.25	44368.90
Net Returns over total cost	36756.92	38690.50
Return per Kg of fish	62.89	67.38
Cost per Kg of fish	38.34	40.19
Net Returns per Kg of fish	24.55	27.19
Return per rupee investment	1.64	1.67

Resource use efficiency of freshwater and wastewater fish production systems

The Cob-Douglas production function was fitted to find out the extent of effective utilization of

resources under these two fish production systems and presented in Table 3. The estimated coefficient of multiple determination (adjusted) under fresh water fish production system is 0.77, implying that 77 percent of variation in the gross returns is explained by the independent variables included in the model. The estimated coefficients provide direct estimates of the elasticity of production with respect to the independent variable in question and the estimated values for the variables such as fish seeds (0.39), and human labour (0.49) are positive and significant at one percent level. Area has a positive coefficient of 0.01 and is significant at ten percent level. Though the coefficients of other variables included in the model, like feed, fertilizer and chemicals are positive and not significant but they fitted in the model well. The estimates of production function for wastewater fish production system indicates that the coefficient of multiple determinations is 0.79 (adjusted). This implies that the variables included in the model explained 79 percent of variation in the gross returns. Positive and statistically significant coefficients of fish seeds and labour indicates that for every one percent increase in the use of fish seeds and labour results in increase gross returns by 0.27 and 0.47 per cent respectively over and above the geometric mean level.

Table 3. Elasticity coefficients of per farm using Cobb-Douglas Production Function for freshwater fish production farmers

Variables	Freshwater fish production		Wastewater fish production	
	Coefficients	t-Statistic	Coefficients	t-Statistic
Intercept	2.48	3.63	2.73	4.32
Area (acre)	0.01	2.47*	0.18	1.83*
Fish Seed (₹)	0.39	3.39***	0.27	2.84***
Labour (₹)	0.49	3.48***	0.47	3.12***
Feed (₹)	0.03	0.99	0.01	0.03
Fertilizer and Manure (₹)	0.01	0.29	0.03	1.80
Chemical (₹)	0.02	1.21	0.01	0.67
R ² Value	0.80		0.81	
Adjusted R ²	0.77		0.79	
F – value	27.86		21.07	

*** Significant at 1 % level,** Significant at 5 % level, * Significant at 10% level

Note: Dependent variable Y is gross returns in ₹ per farm

In order to study the resource use efficiency, the Marginal Value Product (MVP) of each input has been compared with marginal factor cost (MFC). The resource use efficiency of freshwater and wastewater fish production system was presented in Table 4. Under freshwater fish production system the ratio of MVP to MFC for fish seeds (1.55) and human labour (1.84) showed more than unity indicating further scope for enhancement of profit with the increase in input. The input area (1.01), feed (1.03), fertilizer (1.04) and chemicals (1.02) have shown a value around unity implying almost optimal utilization of these inputs. The analysis for determining resource use efficiency of wastewater fish production system revealed that area (1.16), fish seeds (1.37) and human labour (1.81) showed a positive value of more than unity implying the opportunity of earning more profit by employing more units of these inputs. Estimated values of fish feeds (1.01), fertilizer and manures (1.06) and chemicals (1.02) were shown a value of somewhat around one indicating their optimal utilization.

Table 4. Resource use efficiency under freshwater and wastewater fish production system

Variables	MVP/MFC (freshwater fish production)	MVP/MFC (wastewater fish production)
Area (acre)	1.01	1.16
Fish Seeds (₹)	1.55	1.37
Labour (₹)	1.84	1.81
Feed (Rs)	1.03	1.01
Fertilizer/manure (Rs)	1.04	1.06
Chemical (Rs)	1.02	1.02

Problems and constraints faced by the farmers

Out of twenty one identified problems and constraints confronted by the freshwater fish farmers, only twelve problems which scored more than 10.00 in Garrett score were listed in Table 5 in descending order. It reveals that the incidence of theft and pilferages are the most important factor causing huge loss and a potential threat against the survival of fish farming occupation. The fish growers placed this problem in the top of the list having Garrett score of 41.17. The second place is assigned to the problem of non-availability of quality fish seed in right time leading to

low production and thereby less income. These two dominant problems are far ahead of other nineteen identified constraints. Scarcity of natural feed arising out of continuous rearing forces growers to depend on costly artificial feed. Most of the fish growers used to borrow money from village moneylenders at high interest rate varied from 24 to 48 percent per annum. So, financial support from government has an urgent need to save the farmers from the clutches of usurious moneylenders. According to Garrett score these problems occupy the next three positions in the list. The need for extensive extension programmes for pursuing farmers to adapt modern techniques to make the occupation more remunerative comes next with Garrett score of 14.80.

Table 5: Problems and constraints faced by the farmers in freshwater fish production system

Sl. No.	Problems and constraints	Garrett score	Rank
1	Theft and pilferages	41.17	I
2	Non availability of quality fish seeds	30.13	II
3	Lack of natural feed	17.67	III
4	Lack of government support	16.10	IV
5	Lack of capital	15.53	V
6	Lack of extension services	14.80	VI
7	Gas formation during rainy and summer season	14.50	VII
8	Quarrel and Litigation among the owners of the pond	14.07	VIII
9	Distance from the house	11.58	IX
10	Adaptability of fish seed is very low in new environment	11.47	X
11	Diseases of Fish	10.87	XI
12	Productivity of the soil of the pond	10.83	XII

Among the twenty four identified problems and constraints in wastewater fish production system, only ten problems were tabulized in table 6 following the same criteria. The source of water itself cause the major problem due to the effluents carried with it. The sewage water carries natural feed in one hand; on the other hand it carries heavy metals which

affect the productivity of soil underneath the pond. The adaptability of fish seed into new environment is also a big problem faced by the farmers placed second with Garrett score 33.80. The other important problems are non availability of quality fish seed (Garrett score 33.20), presence of predators, birds, cost of desiltation etc. were ranked 3rd, 4th and 5th, respectively.

Table 6: Problems and constraints faced by the farmer in wastewater fish production system

Sl. No.	Problems and constraints	Garrett score	Rank
1	Productivity of the soil of the pond	37.13	I
2	Adaptability of fish seed is very low in new environment	33.80	II
3	Non availability of quality fish seeds	33.20	III
4	Predators, birds eat small fish	23.40	IV
5	Desiltation incurs huge cost	17.03	V
6	Lack of Government support	16.67	VI
7	Ergonomics or work culture is not good among labourers	15.83	VII
8	Limited supply of sewage water	14.57	VIII
9	Labour crisis	13.23	IX
10	Lack of extension services	11.83	X

Conclusion

Being the highest fish producing state of India, the fish production of West Bengal is far behind in meeting the huge demand of its fish consuming population. To narrow down the demand—supply gap the requirement of augmentation in fish production is inevitable from the states resource endowment. This is possible only through improvement in productivity, which can be increased through one or more combination of technological factors i.e. the quantities and types of resources used and the efficiency with which they are utilized (Singh, 1994). An underlying premise behind efficiency estimation is that, if the farmers are not making efficient use of the existing technology, their efforts designed to improve efficiency would be more cost effective than

introducing brand new technologies as a means of increasing output (Bravo-ureta and Evenson, 1994). The resource use efficiency of both the production system showed more or less under utilization of resources. With judicious resource management, government support and technical know-how, the fish production can be manifold, making the state self-sufficient in meeting the demand of its people.

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