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Research Note

Return to Scale and Resource Use Efficiency in Fish Production in Tripura

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Aquaculture is considered to be one of the vital sectors for economic development of Tripura and has witnessed an impressive growth from a traditional activity to a commercial activity. The State has 22,164 ha of water area under culture and 7,879 ha under capture fisheries (Govt. Tripura, 2011). Fish production in the State can be increased either by increasing water area under fish culture or by increasing productivity of fish culture or by both. Scope for horizontal expansion by means of expanding fish culture area is relatively less for the small hilly State like Tripura. Despite highest growth rate in fish production among all the North-Eastern States, fish culture has remained with small scale fish farmers having percapita water body holding of about 0.10 ha (Debnath, 2011). Over utilization or underutilization of resources results in inefficiency and lowering of productivity. The efficient use of resources through proper allocation and control will not only increase the productivity but also profitability of the farms. Since aquaculture is considered as an important sector in the state of Tripura, an attempt has been made in this study to estimate return to scale, elasticity of production and resource use efficiency so as to suggest some policy measures for productivity improvement through adjustment in use of resources. The findings of the study will help policy makers and Government of Tripura to take measures for improving fish production and productivity in the state.

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Multistage stratified random sampling technique was used to collect data for the study. West Tripura district, being the largest fish producer in the State was selected purposively. In this district, two sub-divisions, were selected and from each two blocks having highest area under fish culture were selected. From each of the selected block, two villages were selected. A sample of 20 farmers was selected from each of the selected villages which made a total sample size of 160. Primary data related to existing practices, input use pattern and output were collected from farmers through personal interview method using specially designed and pre-tested schedules during 2013-14.

Multiple regression was used to develop production function for fish production and was used to measure the resource use efficiency and return to scale as applied by Williams et al. (2012), Taru et al. (2008), Pradhan (2012), Emokaro & Ekunwe (2009) and Kumar (2000). The implicit form of the model is as follows;

$Y= f\ (X_1, X_2, X_3, X_4, X_5, X_6, X_7, X_8, U)$

Where,

Y= Fish production (kg ha^{-1} $year^{-1}$)

X_1= Stocking density (number of fry ha^{-1})

X_2= Feed used (kg ha^{-1})

X_3= Manure used (kg ha^{-1})

X_4= Fertilizer used (kg ha^{-1})

X_5= Lime used (kg ha^{-1})

X_6= Labour input (man-days ha^{-1})

X_7= Expenditure on fish health management (¹ ha^{-1})

X_8= Operational pond holding (hectare)

U= Stochastic error term

The production function was fitted using three functional forms *viz.*, linear, semi-log and Cobb-Douglas (double log). The best fitted equation from the three functional forms was chosen based on the prior expectation of the parameters, statistical as well as econometrical criteria. The best fit model was Cobb-Douglas production function and the model is expressed as follows;

$$LnY = \ln\beta_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + \beta_5 \ln X_5 + \beta_6 \ln X_6 + \beta_7 \ln X_7 + \beta_8 \ln X_8 + U$$

Where, β_0 = constant term; $\beta_1$to β_8 = Regression coefficient to be estimated and X_1 to X_8 are selected input variables.

Elasticity of production is the measure of response of output due to changes in variable inputs (Taru et al., 2008). Based on the best fit function, the elasticity of various inputs was determined by formula;

$$\sigma = \frac{dy}{dxi} X \frac{Xi}{Y}$$

Where, Y is the fish production; x_i's are the inputs used in production and X_i and Y are the mean of input and output respectively

The estimated regression coefficients are the elasticity of various inputs used in Cobb-Douglas production function.

The estimated coefficients were used to compute the Marginal Value Product (MVP) and its ratio with Marginal Fixed Cost (MFC) used to determine the economic efficiency of resources used. The model was estimated as follows;

r = MVP/MFC

Where, r is efficiency ratio; MVP is marginal value product of variable inputs and MFC is marginal factor cost (price per unit input)

Based on economic theory, a farm maximises profits with regards to resource use when the ratio of the marginal return to the opportunity cost is one (Taru et al., 2008). The values are interpreted as follows;

- If r<1; resource is excessively used or over utilized hence reduction in use of that resource will enhance the profitability from that resource.
- If r>1; resource is under-used or being underutilized hence increasing the use of that resource will enhance the profitability from that resource.
- If r= 1; resource is efficiently used, that is optimum utilization of resource and hence the point of profit maximization.

Land is the main resource base of the agricultural production process. The economic and social progress of farm households largely depends on the size of the operational holding. Keeping in view the importance of land resources for farming households, the size of land holding of sample households has been presented in Table 1. It was observed that the average agricultural land holding in the study area was 0.84 hectare. The average size of operational pond was 0.22 hectare per household and percentage share of operational pond size was almost 1/4th of the agricultural land holding by the households. This indicates that farms were having opportunities to make progress in aquaculture. It is advisable to have a minimum of 2 ponds which make it easier to prepare the ponds for stocking in every crop cycle without diminishing the whole lot of fish. One pond can be kept for seed production for fetching early return and another can be kept as grow-out pond.

Training helps to enhance skills, capabilities, and knowledge of farmers. Training and experience of the fish farmers are presented in Table 2. The majority of the farmers (63%) of the study area were trained in fish culture practices. Also they were well experienced (13 years) in fish culture and have attended on an average 7.2 days of training. This indicates that the farmers of the study area were better equipped with skill and experience in fish culture.

The resource use pattern is an indicator of production capacity of farm household. The resource use pattern of households was estimated and presented in Table 3. The stocking of fish seed in the study area was 13 889 numbers of fingerlings of mixed variety of different species *viz.,* Catla, Rohu, Mrigal, Kalbasu under composite fish culture which was well above the recommended number of stocking. Application of feed was only 1 459.18 kg ha^{-1} which is far below the recommended levels. Application of feed, manure, fertilizer, lime and expenditure on fish health management were found to be below the recommended level (Das, 2012).

Table 1. Land ownership pattern on sample farms

Particulars	Area in ha
Total agricultural land	0.84
Own pond area	0.17 (77.27)
Leased in pond area	0.06 (27.27)
Leased out pond area	0.01 (4.54)
Operational pond size	0.22 (26.19)

Figures in parenthesis indicate the percentage share of respected land holding

Table 2. Training and experience of the sample farmers in aquaculture

Particulars	Unit
Training attended in fish culture (%)	62.71
Training duration (days)	7.2
Experience (years)	12.59

Table 3. Operational cost and revenues of the sample fish farm

Inputs	Quantity	Cost (`)
Stocking (no. ha^{-1})	13,890	34,725
Feed (kg ha^{-1})	1,459.18	30,643
Manure (kg ha^{-1})	1,578.78	1,579
Fertilizer (kg ha^{-1})	144.12	1,874
Lime (kg ha^{-1})	43.65	262
Labour (Man-days y^{-1})	27.99	7,000
Transportation	—	4,000
Fish health management (ha^{-1})	78.95	79
Production (kg ha^{-1} y^{-1})	1,746.51	1,85,581

The Cobb-Douglas production function was applied to look into the explanatory behaviour of different inputs that are used into the production of the fish and presented in Table 4. The selection of best fit equation was based on the comparison of coefficient of multiple determinations (R^2), the prior expectation, the magnitude of standard error of the estimated parameter and statistical significance level of the estimated regression coefficient.

It can be observed from Table 4 that the R^2 value of the regression is 0.646 which indicates that 64.6% of the variations in fish production (output) are explained by the factors retained in production function. The 'F' value of 23.5 was significant which indicates the overall fitness of the regression model. The inputs like stocking density, manure used, lime and expenditure on health management had significant and positive impact on fish production. Hence these are the determinants of fish production in the study area. Stocking of seed and application of manure and expenditure on health management were significant at 1% whereas application of lime was significant at 5%. Other studies such as Das (2012), Wognaa (2013), Aderinola & Kolawole (1996) and Ojo (2000) had investigated the productivity of agricultural products *viz.*, fish, sugar cane, food crop and rice production respectively and they found out that seed and feed were significant determinants of agricultural production and profitability. But this study is not in consonance with those studies as feed was not found to be a significant determinant of fish production and profitability. This may be due to the fact that farmers are involved in a very small scale and also dependent on natural feeding due to which artificial feeding was not found to be a significant determinant. On the other hand, seeding, liming, application of manure and expenditure on health management were found as significant determinants of fish production and profitability.

The coefficients of other variables like feed, fertilizer and labour were positive and in accordance with the expected sign meaning that the quantity of fertilizer and labour applied was directly related to the fish production while the statistical insignificance of these two variables implies that they are not the determinants of fish production in the study area. The coefficient of farm size was negative and statistically insignificant which implies that farm size is not directly related with fish production and

Table 4. Regression coefficient of Cobb-Douglas production function

Variables	Coefficient	t-value
Constant term	4.681	10.059
Stocking density (No. ha^{-1}), X_1	0.171*	3.629
Manure (kg ha^{-1}), X_3	0.359*	4.065
Lime (kg ha^{-1}), X_5	0.172**	2.011
Fish health management (` ha^{-1}), X_7	0.006*	2.822

*Indicates significant at 1% level of significance
**Indicates significant at 5% level of significance

thus it not a determinant of fish production. Oladejo (2010) and Williams et al. (2012) studied the resource use efficiency among selected fish farmers of Lagoes State of Nigeria and found that the farm size is negatively related with the fish production. This may be due to the fact that increase in farm size demands better management capabilities.

The regression coefficient derived from the production functions are elasticity of the independent variables with which the coefficient are associated (Table 4). The fish production is inelastic with respect to all the input variables. This implies that a change in the level of use of any of these variables will result in less than proportionate change in fish production.

The return to scale refers to the effect of a change in all the factors by same proportion upon output and it is indicated by sum of the regression coefficient estimated in the Cobb-Douglas production function. When the sum of regression coefficients is greater than, equal to or less than unity, the return to scale is increasing, constant or diminishing respectively (Kumar, 2000). The summation of the regression coefficient (partial elasticity coefficient of Cobb-Douglas function) of the independent variables considered for the study (Table 4) is found less than unity indicating the fact that decreasing return to scale is prevailing in the study area. This implies that if the inputs are increased by same proportion, the increase in output is not proportionate with the input valuable and vice versa.

The economic efficiency of resource use in fish production was determined by using the ratios of their Marginal Value Product (MVP) to the Marginal Factor Cost (MFC) and has been presented in Table 5. The MVP of inputs was calculated at their geometric mean level. Since all the inputs and output except expenditure on health management are expressed in quantity, the MFC was taken as price of each commodity separately. The results presented in Table 5 shows that efficiency ratio for application of lime, use of manure and expenditure on health management was greater than one which indicates that these inputs have been used below optimum level and therefore increase in use of these inputs will increase fish production. The efficiency ratio of stocking of fish seed used is less than one indicating that this input is being over utilized. Hence, reducing the stocking density of fish will increase the fish production. The results of resource use efficiency analysis clearly indicate that resources are not efficiently utilized for fish production in the study area.

The study has examined resource productivity, return to scale of production and resource use efficiency of fish farming. Several factors like stocking of fish seed, application of manure, application of lime and expenditure on health management are determinants of fish production in the study area. As per the findings of MVP/MFC ratio, it can be inferred that the quantity of certain inputs *viz.,* application of lime, use of manure and expenditure on fish health management need to be increased and some other resources *i.e.* the stocking of fish seed have to be reduced in order to achieve optimum output. It means strategic resource adjustment measures have to be taken care of in the farms of study area to arrive at optimum input-output combination. Lastly, the decreasing return to scale implies that there is an urgent need of use of resources at optimum levels to have higher fish production to make the state self-sufficient in fish production by vibrant utilization of the resources and effective productivity management strategies.

Table 5. Efficiency of resource use and elasticity of fish farmers in the study area

Resource inputs	Estimated regression coefficient	Mean output	Mean input	MVP (B.C/D)	MFC	Efficiency ratio (E/F)
A	B	C	D	E	F	G
X_1	0.171	1546.51	13131	0.02013961	2.50	0.00805584
X_3	0.359	1546.51	432.16	1.28470263	1.00	1.28470263
X_5	0.172	1546.51	38.23	6.95787791	6.00	1.15964631
X_7	0.006	1546.51	1.77	5.24240678	4.53	1.15726419

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