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Research Note

RICE VERSUS SHRIMP FARMING IN KHULNA DISTRICT OF BANGLADESH: INTERPRETATIONS OF FIELD-LEVEL DATA*

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ABSTRACT

This study was designed to assess the relative profitability of rice and shrimp farming in two villages of Tildanga Union in Dacope Upazila of Khulna district in Bangladesh. In total, 120 farmers were randomly selected for the study. Descriptive statistics, activity budgets, Cobb-Douglas production function model were employed to achieve the objectives of the study. The study confirmed that both T. Aman rice and shrimp production were profitable. Shrimp production is more profitable than the rice production. Despite the fact, a large number of farmers prefer rice to shrimp due to environmental effects and welfare grounds of the common people. The results clearly indicated that farmers were producing in rational zone of a typical production function. Nevertheless, there is a scope to increase both Aman rice and shrimp by applying more doses of the concerned inputs under the present technology. It was concluded that all the farmers' opinions regarding crop cultivation were not same in the study area. The present study, of course, assessed the profitability of growing transplanted Aman rice and shrimp in Polder 31 and has given some important clues to make right decisions regarding better options for more environment-friendly profitable crop farming for individual farmers in Polder 31.

I. INTRODUCTION

Bangladesh's overall agricultural policy objective is to expand and diversify agricultural production and to maintain food security, especially with regard to sustaining near self-sufficiency in rice. Coastal areas in the Southern part of Bangladesh constitute a specific ecological zone having specific problems and possibilities of cyclones, tidal bores, salinity, etc (Hoque, 2001)**.** During the last few years, increasing proportions of land in the coastal areas have been devoted to shrimp and crop cultivation**.** Shrimp farming has proved a highly profitable business in Bangladesh, providing substantially higher incomes for the farmers.

Due to the high potential short-term economic benefits of shrimp farming and increased saline water intrusion in the field, many small and marginal farmers have been encouraged to switch from agriculture to aquaculture. There are apparent conflicts between subsistence agriculture

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and shrimp cultivation and conflicts over land rights and access to resources. According to the latest estimation made by BBS (Bangladesh Bureau of Statistics) 2010, per capita rice consumption is about 166 kg/year. Rice alone provides 76.0 percent of the calorie intake and 66.0 percent of total protein requirement and shares about 95.0 percent of the total cereal food supply (Alam, 2012). In 2009/10, cereal production of Bangladesh was 33.25 million tonnes and in 2010/11, this was 34.61 million tonnes which was 4.15 percent higher than previous years (BBS, 2010). In order to feed the increasing population, the present pace of foodgrain production needs to be sustained. Considering the situation emphasis should be given on the increase of production of T. Aman. Therefore priority should be given to bring more acreage under HYV (High Yielding Variety) of Aman cultivation rather than the cultivation of local varieties. Concurrently emphasis should be given on the other sectors such as fisheries sector. In the fisheries sector, shrimp plays a vital role in the economy. This sector has many potentialities to make the economy more viable by increasing the production and earning a lot of foreign exchange which is very essential for the country. One of the major exports earning industry of Bangladesh is shrimp. At present, Bangladesh is the seventh largest country of shrimp exporting to USA (United States of America) and Japan market.

Considering these issues a number of studies have been made on Shrimp and T. Aman rice. Islam *et al.* (2002) conducted a study on socioeconomic and environmental impacts of alternative shrimp-crop farming in Bangladesh. The study was designed to analyze the comparative profitability of alternate shrimp-crop farming and to determine the socioeconomic and environmental impacts of shrimp farming in coastal areas of Bangladesh. In year-round shrimp farming per hectare production of shrimp was higher compared to the production of shrimp under alternate shrimp-crop farming. The study revealed that the existing unplanned shrimp culture has adversely affected the production of cereal crops and vegetables, trees and plantation crops, poultry and livestock which was a major concern of famer to make decision over their enterprise. Uddin (1995) conducted a study on the shrimp farming of Khulna and Satkhira districts. Per hectare cost of shrimp was Tk. 62,613.26 in Satkhira district while it was Tk. 41,815.69 in Khulna district. He also found that per hectare net income in Satkhira district was Tk. 78,374.60 and in Khulna district it was Tk. 32,447.49 only. This indicated that net income in Satkhira district was much (i.e., 2.41 times) higher than that of Khulna district. In other words, shrimp farming in Satkhira district was more profitable compared to Khulna district.

The present study was conducted to assess the relative profitability of rice and shrimp farming in selected areas of Khulna district and also to identify the nature of conflicts associated with making decision on crop and/or shrimp farming in the polder area. Although various institutional and non-institutional mechanisms usually followed by the community to resolve these conflicts, but these are not yet clearly documented. This study was therefore designed for seeking answers to this basic problem of the farmers in the polder area. This paper is organized into five sections. Following this introduction, Section II highlights the methods of data collection and analytical techniques used for the study. Main results and discussion of the study are presented in Section III. Farmers' decisions on T. Aman rice and shrimp farming in the polder area are discussed in Section IV. Finally, conclusion and recommendations of the study have been presented in the last section.

II. METHODOLOGY OF THE STUDY

A set of tools and techniques were followed to meet the aims and objectives of the study. Based on the objectives of the study Tildanga Union of Dacope Upazila under Khulna district (Polder No. 31) had to select purposively for the study. In fact, two adjacent villages namely Kaminibashia and Botbunia under Tildanga union have purposively been selected for the research investigation. In total 120 farmers have been selected for research investigation in which 80 farmers were selected from Kaminibashia and 40 farmers were selected from Botbunia village. Mainly three analytical tools were chosen to achieve the ultimate goals of the study. These are: (i) Descriptive statistics; (ii) Activity budgets; and (iii) Cobb-Douglas production function model. In the present study, the activity budgets (Dillon and Hardaker, 1993) were used to assess the relative profitability of rice and shrimp farming.

For T. Aman rice the following algebraic equation was used to prepare activity budgets:

$$\pi_1 = P_{F1}.Q_{F1} + P_{S1}.Q_{S1} - \sum (P_{xi1}X_{i1}) - TFC_1$$

Where,
π_1 = Profit of rice production (Tk/ha) ;
P_{F1} = Per unit price of rice (Tk/kg);
Q_{F1} = Quantity of rice (kg)/ha;
Ps_1 = Per unit price of straw (Tk/kg);
Qs_1 = Quantity of straw (kg/ha)/ha;
P_{xi1} = Per unit price of i-th inputs used for Aman rice production;
X_{i1} = Quantity of i-th inputs used for T Aman rice/ha;
i = (1,2,3,…,n); and
TFC_1 = Total fixed cost involved in producing per hectare rice.

For Shrimp the following algebraic equation was used to prepare activity budgets:

$$\pi_2 = P_{F2}.Q_{F2} - \sum (P_{xi2}X_{i2}) - TFC_2$$

Where,
π_2 = Profit from shrimp production (Tk/ha) ;
P_{F2} = Per unit price of shrimp (Tk/kg);
Q_{F2} = Quantity of shrimp (kg)/ha;
P_{xi2} = Per unit price of i-th inputs used;
X_{i2} = Quantity of i-th inputs used for shrimp farming/ha;
i = (1,2,3,...,n); and
TFC_2 = Total fixed cost related to the production per hectare shrimp production.

The specification of the Cobb-Douglas production function model for T. Aman rice was as follows:

$$Y = a X_1^{b1} X_2^{b2} X_3^{b3} X_4^{b4} X_5^{b5} X_6^{b6} X_7^{b7} u_i$$

It can be written in log linear form as follows:

$$\text{Ln } Y = \ln a + b_1 \ln X_1 + b_2 \ln X_2 + b_3 \ln X_3 + b_4 \ln X_4 + b_5 \ln X_5 + b_6 \ln X_6 + b_7 \ln X_7 + Ui.$$

Where,
Y = Return per hectare (Tk);
X_1 = Seedling cost (Tk/ha);
X_2 = Power tiller cost (Tk/ha);
X_3 = Human labour cost (Tk/ha);
X_4 = Urea cost (Tk/ha);
X_5 = TSP cost (Tk/ha);
X_6 = MOP cost (Tk/ha);
X_7 = Insecticide cost (Tk/ha);
a = Constant or intercept term;
b_1, b_2, . . . b_7 = Coefficients to be estimated; and
Ui = Error term.

The specification of the Cobb-Douglas production function model for shrimp was as follows:

$$Y = a X_1^{b1} X_2^{b2} X_3^{b3} X_4^{b4} u_i$$

It can be written in log linear form as follows:

$$\text{Ln } Y = \ln a + b_1 \ln X_1 + b_2 \ln X_2 + b_3 \ln X_3 + b_4 \ln X_4 + Ui.$$

Where,
Y = Return from shrimp (Tk/ha);
X_1 = Post larva (PL) cost (Tk/ha);
X_2 = Human labour cost (Tk/ha);
X_3 = Feed cost (Tk/ha);
X_4 = Lime cost (Tk/ha);
a = Constant or intercept term;
b_1, b_2, b_3, b_4 = Coefficients to be estimated; and
Ui = Error term.

III. RESULTS AND DISCUSSION

In order to estimate the average total costs per hectare, all the relevant costs of resources used in T. Aman rice production, as stated earlier, have been taken into account. Thus, per hectare total cost of T. Aman rice production was estimated at Tk 37,003.00. Gross return is the monetary value of crop produced in the concerned plots. Per hectare gross return from T. Aman rice production included the monetary value of physical produces obtained from T. Aman. Output from T. Aman included both the physical quantities of main product (i.e., paddy) and also by-product (straw). Per hectare total returns were calculated by multiplying the total amount of product and by product with their respective farm-gate prices. Per hectare yield of T. Aman rice was found to be 2945.00 kg. Gross margin is the difference between the gross return and total variable costs. Farmers of Bangladesh are more interested to know their return over variable costs and for this reason gross margin analysis was also done. In the present study, gross margin of Aman rice was estimated at Tk 21,642.00 per hectare (Table 1).

Table 1. Activity budgets: per hectare non-irrigated T. Aman rice production

Items of returns/costs	Quantity/ha	Per unit price (Tk)	Returns/Costs (Tk/ha)	% of total
A. Gross Returns				
Main product (paddy)	2945 kg	15.00	44,175.00	87.19
By-product (straw)	n.a	-	6491.00	12.81
Total	-	-	50,666.00	100.00
B. Gross Costs				
C. Variable Costs				
Seedlings	-	-	4341.00	11.79
Power tiller	2 times	10/decimal	4940.00	13.35
Hired labour	44 Man-day	250/Man-day	11000.00	29.72
Urea	186 kg	20/kg	3720.00	10.05
TSP	73 kg	22/kg	1606.00	4.34
MOP	12 kg	15/kg	180.00	0.49
Gypsum	-	-	120.00	0.32
Fertilizers cost	-	-	5626.00	15.20
Insecticides	-	-	3117.00	8.42
Total			29024.00	78.48
D. Fixed Costs				
Family labour	30 Man-day	250/Man-day	7500.00	20.27
Interest on OC	-	@10%	479.00	1.29
Total	-	-	7979.00	21.56
E. Total costs			37,003.00	100.00
F. Gross Margin (A-C)			21,642.00	
G. Net Return (A-E)			13,663.00	-
H. Undiscounted BCR			1.37	-

Source: Adapted from Fatema (2012).

Similarly, per hectare gross returns of shrimp were calculated and it can be seen that gross return for shrimp farming was Tk 210,915.00. The net return was Tk 147,771.00/ha and gross margin was estimated at Tk 157,386.00 per hectare for shrimp farming (Table 2).

Table 2. Activity budgets: per hectare shrimp production

Items of returns/costs	Quantity/ha	Per unit price (Tk)	Returns/Costs (Tk/ha)	Percentages of total
A. Gross Returns				
Shrimp	342.00 kg	550.00/kg	188,100.00	89.18
Other fish	-	-	22,815.00	10.82
Total	-	-	**210,915.00**	100.00
B. Gross Costs				
B.C. Variable costs				
Post larva	43886 pieces	0.5/piece	21,943.00	34.75
Hired labour	112 man-day	250/ man-day	28,027.00	44.39
Feed	86.2 kg	25/kg	2155.00	3.41
Lime	117 kg	12/kg	1404.00	2.22
Total			53,529.00	84.77
C.D. Fixed costs				
Family labour	34 Man-day	250/man-day	8500.00	13.46
Interest on operating capital			1115.00	1.77
Total			9615.00	15.23
D.E. Total costs			63144.00	100
F. Gross Margin (A-C)			157,386.00	
E. G. Net Return (A-E)			147,771.00	
E.H. BCR (undiscounted)			3.34	

Source: Adapted from Fatema (2012)

The summary results of producing T. Aman and shrimp per hectare are also presented in Table 3. The gross margin was estimated at Tk 21,642.00 per hectare for T. Aman production and this was estimated at Tk 157,386.00 per hectare for shrimp farming. Per hectare net return of T. Aman rice was Tk 13,663.00, while this was Tk 147,771.00 for shrimp. The undiscounted BCRs (benefit-cost ratios) of T. Aman and shrimp farming were 1.37 and 3.34, respectively. These results indicate that T. Aman rice and shrimp cultivation are profitable from the viewpoints of individual farmers. The result showed that shrimp farming was more profitable than that of T. Aman rice production. However, per hectare operating capital required for shrimp production was much higher than that of T. Aman rice cultivation.

Table 3. Per hectare costs, return, gross margin, net return and BCR of shrimp and T. Aman rice farming.

Items	Shrimp farming	Aman rice farming
A.Gross returns (Tk/ha)	210,915.00	50666.00
A.B. Variable costs (Tk/ha)	53,529.00	29024.00
B.C. Gross margin (A-B) (Tk/ha)	157,386.00	21642.00
C.D. Fixed costs (Tk/ha)	9615.00	7979.00
D.E. Total costs (B+D) (Tk/ha)	63,144.00	37003.00
E.F. Net returns (A-E) (Tk/ha)	147,771.00	13663.00
G. BCR (Undiscounted)	3.34	1.37

Source: Adapted from Fatema (2012).

In the study area, farmers practiced alternate shrimp and T. Aman farming. They cultivated T. Aman in the rainy season and shrimp from mid February to end of June. Total costs and returns per year from both shrimp and T. Aman farming were summarized and presented in Table 4.

Table 4. Total per hectare costs, return, gross margin and net return of alternate shrimp and T. Aman rice farming

Items	Amount (From shrimp and Aman) (Tk/ha/year)
A. Gross returns	261,581.00
B. Variable costs	82,553.00
C. Gross margin (A - B)	179,028.00
D. Fixed costs	17,594.00
E. Total costs (B + D)	100,147.00
Net returns (A - E)	161,434.00

Source: Adapted from Fatema (2012).

The result showed that farmers get per hectare gross return, gross margin and net return of Tk 261,581.00, Tk 179,028.00 and Tk 161,434.00, respectively from alternate shrimp and T. Aman rice farming per year. If farmers cultivate only shrimp in the study areas for eight months then the return from T. Aman rice have to be forgone and they have to spend some extra money for one more harvest of shrimp. Based on the last harvesting data an estimated costs and returns were calculated by the researcher herself to assess the profitability of cultivating only shrimp in the study area. Were the farmers made a plan of one extra harvest of shrimp, the return would not be much higher amount than the existing one time harvest of shrimp. Because, the rainy season will be started from July and also they will not bear more costs for one extra harvest. The estimated costs and returns from only shrimp farming are presented in Table 5.

Table 5. Estimated gross costs and returns of per hectare shrimp production

Items of returns/costs	Quantity/ha	Per unit price (Tk)	Returns/ Costs (Tk/ha)	Percentages of total
A.A. Gross Returns				
Shrimp	387.00 kg	550.00/kg	212,850.00	88.41
Other fish	-	-	27,900.00	11.58
Total	-	-	**240,750.00**	100.00
B. Gross Costs				
C. Variable costs				
Post larvae	48886 pieces	0.5/piece	24,443.00	31.27
Hired labour	132 man-day	250/ man-day	33,000.00	42.22
Feed	106 kg	25/kg	2650.00	3.39
Lime	127 kg	12/kg	1524.00	1.94
Total			61,617.00	78.82
D. Fixed costs				
Family labour	60 Man-day	250/man-day	15000.00	19.19
Interest on operating capital			1540.00	1.97
Total			16540.00	21.16
E. Total costs			78157.00	100
F. Gross Margin (A - C)			1,79,133.00	
G. Net Return (A - E)			1,62,593.00	
H. BCR (undiscounted)			3.08	

Source: Adapted from Fatema (2012).

It can be shown from Table 5 that per hectare gross cost, gross return and net return of shrimp production would be Tk 78157.00, Tk 240,750.00 and Tk 1,62,593.00, respectively. If farmers produce only shrimp they could earn a little bit more return than alternate shrimp and T. Aman farming, which is not so significant. Despite the fact, a large number of farmers prefer rice to shrimp because rice is their staple food and if they cultivate rice their basic needs of life and other necessaries could easily be met. Although shrimp farming is slightly profitable but there is a high risk involve in producing shrimp due to sudden break out of unknown diseases or viruses attack to the shrimp. As a consequence, shrimp farming often becomes highly risky and unprofitable to the farmers. On the other hand, rice production is more environment-friendly and there is an ample scope to produce more diversified crop-farming than that of the shrimp cultivation.

In this study, an attempt has been taken to estimate the contribution of key inputs to the production processes of T. Aman rice and shrimp. This will give a greater scope and better opportunity for making efficient use of the key inputs in the production processes of T. Aman and shrimp or shrimp farming. To achieve one of the important objectives of the study, Cobb-Douglas production function model was chosen on the basis of best fit and significant effects of using various inputs on returns of producing T. Aman rice and shrimp. From the results of Cobb-Douglas production function model, it was observed that the coefficients such as seedlings cost, power tiller cost, human labour cost, urea, TSP, MOP and insecticides costs

had significant impacts on returns of T. Aman rice production and it was found that the coefficient of parameters such as post larvae costs and feed costs had significant impacts on returns of shrimp production.

The results of Cobb-Douglas production function analyses presented in Tables 6 and 7 as well as the interpretations of individual coefficients clearly indicate that the included variables of the models have significant effects on the production process of both T. Aman rice and shrimp farming. The results of the analyses also clearly indicate that farmers are now producing in rational zone (i.e., in the Stage II in a typical production function) of production. Nevertheless, there is a scope to increase both Aman rice and shrimp by applying more doses of the concerned inputs in this present technology.

Table 6. Estimated values of coefficients and related statistics of Cobb-Douglas production function model for T. Aman rice production

Explanatory variables	Values of coefficients	Standard error	t-value
Intercept	5.923	0.891	6.647
Seedling cost (X_1)	0.166*	0.086	1.932
Power tiller cost (X_2)	0.153***	0.055	2.780
Human labour cost (X_3)	0.142***	0.045	3.181
Urea cost (X_4)	0.036	0.158	0.231
TSP cost (X_5)	0.836***	0.061	13.634
MOP cost (X_6)	-0.090***	0.034	-2.649
Insecticide cost (X_7)	0.250***	0.031	8.121
F-value	58.968		
R^2	0.926		
Returns to scale ($\sum$ bi)	0.683		

Note: *** = Significant at 1% level
** = Significant at 5% level
* = Significant at 10% level
Source: Adapted from Fatema (2012).

Table 7. Estimated values of co-efficient and related statistic of Cobb-Douglas production function for shrimp farming

Explanatory variables	Values of coefficient	Standard Error	t-value
Intercept	3.847	1.877	2.05
Post larva (X_1)	-0.304**	0.136	-2.242
Human labour (X_2)	0.040	0.204	0.196
Feed (X_3)	0.941***	0.159	5.919
Lime (X_4)	0.214	0.162	1.319
F- value	18.31		
R^2	0.80		
Returns to scale ($\sum$bi)	0.89		

Note: *** = Significant at 1% level
** = Significant at 5% level
* = Significant at 10% level
Source: Adapted from Fatema (2012).

IV. RICE VERSUS SHRIMP FARMING

In the selected study area, there has been a long standing conflict between the farmers of shrimp and rice within the polder area in making decisions regarding shrimp and rice farming. The main reason behind this conflict was that shrimp requires saline water and rice requires freshwater. Shrimp farms need to replenish saline water and create saline inflows through pipes, gates, pumps etc., to let in saltwater. A group of farmers in this polder are interested to cultivate shrimp while others are willing to grow rice. In Polder 31, there are 82 sluice gates among them 16 were already broken, two gates were in bad condition and there was one wooden gate. Shrimp culture was very much popular in the area during 1985. Then people used those sluice gates for intrusion of saline water mainly for shrimp cultivation (Shushilan 2012). The severity of salinity problem in that area increased with the dehydration of the soil. As a result, the production of rice decreased and farmers were cultivating shrimp in their field. But during the period of shrimp farming farmers faced a lot of problems such as saline water, residual effects of shrimp feed, and other chemicals used for shrimp gradually reduced the soil fertility. As a consequence, cultivation of crops such as rice, wheat, vegetables etc., became very difficult in the polder area. Finding no other solutions, in 2009 the general people of the area along with the concerned officials of two NGOs *Bela* and *Nijera kori* went to the court for stopping the saline water intrusion from the river. The sluice gate in Botbunia Bazar under Polder 31 has been closed by the authority and by the existing gate committee. However, Union Parishad Chairman re-excavated the canals. After realizing the negative impacts of '*Gher*' farming on usual agricultural activities, people of the study area recently divided into three groups (Table 8). Some of them wanted to cultivate only rice, some of them wanted to cultivate only shrimp and the third group wanted to cultivate both shrimp and rice. It is evident from the survey results presented in Table 8 that 42.0 percent farmers are still interested to cultivate shrimp, while the rest 58.0 percent farmers are willing to grow single rice and/or rice and shrimp. Thus, it has become a crucial problem for the farmers in the polder area for making right decisions on rice and shrimp farming. However, a broad-based socioeconomic study taking into account a larger sample size could possibly be given the solution of this long standing problem of the farmers of the study area.

Table 8. Willingness of farmers' to grow crops in Polder 31

Farmers' groups in crop cultivation	Number of respondents	% of total
In favour of rice production	31	26.00
In favour of shrimp cultivation	51	42.00
In favour of Aman rice (in rainy season) and shrimp (February to June) farming	38	32.00
Total	120	100.0

Source: Adapted from Fatema (2012).

V. CONCLUSION AND RECOMMENDATIONS

This study provided some valuable information regarding the profitability of rice and shrimp production in the polder area. It is evident from the overall findings of the study that both the rice and shrimp farming are profitable. However, the study confirms that per hectare yield of T. Aman rice in the polder area is much lower than other parts of Bangladesh. Thus, there is an ample scope to increase rice production in the polder area by adding the most appropriate inputs under the existing technology and/or also by introducing some new modern varieties of rice such as some saline tolerant varieties of rice developed by BRRI and BINA. Despite the high financial profitability of shrimp cultivation from the viewpoints of individual farmers, a group of people in the polder area were not interested to shrimp cultivation due to its negative long-term effects on soil, water and overall environment. In other words, whether one should grow only rice or shrimp is still one of the biggest dilemmas for the farmers in the study area, since both are profitable crops.

On the other hand, shrimp is more profitable and give an enormous opportunity to earn foreign currency for this low-income country almost every year, but in practice, it is highly risky business for individual farmers due to frequent attacks of unknown diseases to the shrimp, which is beyond the control of general farmers of the study area. As a consequence, shrimp farmers often had to fetch tremendous losses from shrimp farming. It was observed in the study area that rice was a staple food for the people of all walks of life and its production was not only environment-friendly but also it was relatively less risky than the cultivation of shrimp. The recent soaring price of rice (in 2007 and 2008) all over the World has had different effects across the countries and population. In fact, farmers of Bangladesh have given special attention for growing more rice for the household food security.

For the greater interest of future generation as well as welfare ground of the vast majority people of the country, environment-friendly rice production could be given the top most priority in the polder area. Instead of shrimp farming, Golda and rice cropping pattern could be an innovative system to mitigate the on-going problem of shrimp and rice farming dilemma in the polder area. This pattern may allow growing environment-friendly more diversified high value crops, vegetables and fruits together with livestock (cattle, goat. sheep, poultry and other fisheries) farming. Thus, soil health of the polder area could be improved from its further deterioration; and income generation of the households, sustainable food and nutrition security of the people could be ensured for the greater interest of the present and future generation of Bangladesh.

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