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Financial profitability and resource use efficiency of boro rice cultivation in some selected area of Bangladesh

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The paper analysed the profitability and resource use efficiency of boro rice cultivation in Bogra district of Bangladesh using farm level survey data of April-May, 2016. In total 103 farmers were selected randomly from the study area. Result based on Farm Budgeting model showed that per hectare variable cost and total cost of production was BDT (Bangladeshi Taka) 57,583 and BDT 71,208 respectively. Average yield was found 4.112 ton which was more than the previous year's national average yield of 3.965 ton. The average gross return, gross margin, and net return were BDT 86,548, BDT 28,965 and BDT 15,340 respectively. Benefit-Cost ratio (BCR) was found 1.22 and 1.50 on full cost and variable cost basis. Cobb-Douglas production function analysis showed that the key production factors, that is, human labour, irrigation, insecticide, seed and fertilizer had statistically significant effect on yield. MVP and MFC ratio analysis showed that growers allocated most of their resources in the rational stage of production.

Key words: Benefit-Cost ratio (BCR), Cobb-Douglas production function, elasticity and resource use efficiency.

INTRODUCTION

Rice is the staple food of the people of Bangladesh. About 160 million peoples in Bangladesh depend on rice as main food and about 75.1% of agricultural land use to grow rice of which 42.40 was employed on boro crops (BBS, 2015). Boro is the single most crops in Bangladesh in the context of total volume of production. It has been persistently contributing over last successive years (BBS, 2015). In 2015, the area under boro crop was 48,40,222

ha which was 1.04% higher than the previous year. In FY 2014-15, average yield rate was 3.965 metric tons husked rice per hectare and total boro production was 1, 91,92,164 metric tons which was 55.29% of total production of rice (BBS, 2015). HYV boro was found more efficient among all other main rice varieties (Local Aman, HYV Aman and HYV Boro) in Bangladesh (Regmi et al., 2016). Although rice was considered as the main

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crop in Bangladesh and the country was ranked as the fourth largest rice producer in the world (IRRI, 2009), it is not produced with full efficiency. Labor, fertilizer, seed as well as irrigation were the significant factors, which affect the level of technical efficiency of rice production (Hasnain et al., 2015). Also, the ownership of key resources like land, labour, and draft animals significantly affect the efficiency of production (Rahman et al., 2009). Besides land and labour, irrigation was also found as significant determinants of modern rice productivity where decreasing returns to scale prevailed (Rahman, 2011). At the time of considering individual inputs, human labour was found as the largest contributor of expenses of HYV boro rice production in Bhola district (Majumder et al., 2009). Irrigation played a positive and vital role in the productivity of both conventional and HYV of rice cultivation in Rajbari district of Bangladesh (Bapari, 2016). Profitability of boro rice production also depends on the cost of irrigation (Nargis et al., 2009). In northwest part of Bangladesh, defects have been found on the current irrigation water management system. Although the area irrigated for dry season rice (*boro*) has increased about three folds during 1981-2014 (Dey et al., 2017). A study showed that 78.7% of the lifted water was important for boro rice production. This wastage of water increase irrigation as well as production cost (Dey et al., 2013). Efficiency measurement shows that there were higher degrees of inefficiency in the cultivation of modern rice. These efficiency differences were depicted by soil fertility, infrastructure, experience, extension services, tenancy and share of non-agricultural income (Rahman, 2003). Some studies revealed that farmers who borrowed capital used more inputs and attained higher returns in contrast to non-borrower (Sarkar et al., 2010). As efficiency and input use pattern varies with the socio-economic characteristics of farmer or manager (Islam and Sujan, 2016). For enhancing technical efficiency different strategies like ensuring better extension services and conducting farmers training programs, enhancing access to agricultural microcredit, reducing land fragmentation and raising awareness level of farmers were proposed by Backman et al. (2011). Efficient use of input through adaptation and spread of improved agricultural mechanization can be way of exploiting the full potential of technology (Nargis and Lee, 2013). Agricultural mechanization in cultivation was also poised to make a major difference in the future agriculture (Ahmed, 2001). Increased access to irrigation, tenurial reformation and assurance for higher price of rice can boost farm returns as well as offset the impact of uneven rise in labour wage. These will synergistically enhance the adoption of modern rice along with farm productivity (Rahman, 2011). For gaining higher profitability enhancement in labour productivity and formalization of the agricultural labour market should be more emphasized rather than mere input subsidization or price support (Selim, 2011). A review of existing literature

reveals that so far the attention has been given by the researchers in investigating the efficiency of boro rice production in the study area are not adequate. Thus, the objective of the present study is to analyze the resource use efficiency of boro rice production in Bangladesh using data from boro rice farmers in April-May, 2016. Required data are collected from 103 boro rice producing farmers of Bogra district selected by using multistage sampling procedure. Note that, the weather condition for boro cultivation was favorable in the growing stage in 2016.

MATERIALS AND METHODS

A micro-level empirical study based on primary cross-section data was designed to attain the purposes of the study. The methodology of the study is mainly about the sampling procedure, collection of data and analytical framework.

Sampling technique

In this research, study area and respondent were selected by multistage random sampling procedure. In first stage of sampling, Bogra district was selected purposively. In the second stage, four upazilas named Bogra sadar, Dhunat, Shibganj and Sonatala were selected purposively. After that, a complete list of boro rice farmers was collected from each upazila. At the final stage, a total of 103 rice farmers were selected by random sampling technique. Among the 103 rice farmers 25 numbers of farmers were included from each one of first three upazila and 28 were included from Sonatala upazila. Since the study focuses on resources use efficiency, attempt was made to choose respondent from that areas, which had an average level of agricultural performance in their respective sub-regions.

Method of data collection

As per the conventional survey techniques, primary information on available resources and their use, prices of farm product and different inputs were collected by direct interviewing of farmers using a designed and pre-tested questionnaire in April-May, 2016.

Analytical framework

Different parameters of costs and return were analyzed to measure the profitability of boro rice cultivation on the study area. The following algebraic equation was developed to assess the costs and returns of rice production.

$$GR_i = \sum_{i=1}^n Q_{mi}P_{mi} + \sum_{i=1}^n Q_{bi}P_{bi}$$

- Where, GR_i = Gross return from i^{th} product (BDT/ha)
- Q_{mi} = Quantity of the i^{th} main product (kg/ha)
- P_{mi} = Average price of the i^{th} main product (BDT/kg)
- Q_{bi} = Quantity of the i^{th} by product (kg/ha)
- P_{bi} = Average price of the i^{th} by product (BDT/kg)
- $i = 1,2,3,\dots,n$

BDT = Bangladeshi Taka

Net return was estimated by subtracting both variable and fixed costs from the gross return. Return from by products also included with net return. To calculate the net return of boro rice production the following formula was used on the study:

$$\pi = P_y Y - \sum_{i=0}^n P_{xi} X_i - TFC$$

Where, π = Net return (BDT/ha)
 P_y = Per unit price of the product (BDT/kg)
 Y = Quantity of the product per hectare (kg)
 P_{xi} = Per unit price of i^{th} inputs (BDT)
 X_i = Quantity of the i^{th} inputs per hectare (kg)
 TFC = Total fixed cost (BDT)
 $i = 1, 2, 3, \dots, n$ (number of inputs).

Benefit-Cost Ratio (BCR) analysis

This ratio was measured in the study in two different ways:

$$BCR \text{ on } TVC = \frac{GR}{TVC} \quad BCR \text{ on } TC = \frac{GR}{TC}$$

Where, GR = Gross return, TC = Total Cost, TVC = Total Variable Cost and, the decision rules are that, when
 $BCR > 1$, the return from boro rice is economically satisfactory;
 $BCR < 1$, the return from boro rice is not economically satisfactory;
 and
 $BCR = 1$, there is economic breakeven point of boro rice production.

Empirical model

For functional analysis of the data Cobb-Douglas production function is used. Logarithmic form of the function is linear and parsimonious which ease the estimation and interpretation of data (Beattie and Taylor, 1985). In general, the production of boro rice is mostly influenced by human labour, power tiller, seed, urea, TSP, MoP, insecticide and irrigation etc. The Cobb- Douglas regression function was as follows:

$$Y = AX_1^{\beta_1} X_2^{\beta_2} \dots X_n^{\beta_n} e^{U_i}$$

The production function was converted to logarithmic form so that it could be solved by Ordinary Least Square (OLS) method, that is,

$$\ln Y = \alpha + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \dots + \beta_n \ln X_n + U_i$$

The empirical production function was the following:

$$\ln Y = \alpha + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + \beta_5 \ln X_5 + \beta_6 \ln X_6 + \beta_7 \ln X_7 + \beta_8 \ln X_8 + U_i$$

Where, Y = Yield (BDT/ha)
 X_1 = Human Labor (BDT/ha)
 X_2 = Power tiller (BDT/ha)
 X_3 = Seed (BDT/ha)
 X_4 = Urea (BDT/ha)
 X_5 = TSP (BDT/ha)
 X_6 = MoP (BDT/ha)
 X_7 = Insecticide cost (BDT/ha)
 X_8 = Irrigation cost (BDT/ha)
 α = Intercept
 $\beta_1, \beta_2 \dots \beta_8$ = Coefficients of the respective variables to be estimated; and
 U_i = Error term.

In order to investigate the Resource Use Efficiency, the ratio of marginal value product (MVP) to the marginal factor cost (MFC) for each input was computed and tested for its equality to 1,

That is, $\frac{MVP}{MFC} = r$

Where, r = Efficiency ratio
 MVP = value of change in output resulting from a unit change in variable input (BDT)
 MFC = price paid for the unit of variable input (BDT)

Under this method, the decision rules are that, when:

$r > 1$, the level of resource use is below the optimum level, implying under-utilization of resources. Increasing the rate of use of that resource will help increase productivity.
 $r < 1$, the level of resources use is above the optimum level, implying over utilization of resources. Reducing the rate of use of that resource will help improve productivity.
 $r = 1$, the level of resource use is at optimum implying efficient resource utilization.

The most reliable, perhaps the most useful estimate of MVP is obtained by taking all input resources (X_i) and gross return (Y) at their geometric means (Dhawan and Bansal, 1977). All the variables of the fitted model were calculated in monetary value. As a result the slope co-efficient of those independent variables in the model represent the MVPs, which were estimated by multiplying the production co-efficient of given resources with the ratio of geometric mean (GM) of gross return to the geometric mean (GM) of the given resources, that is,

$$MVP (X_i) = \beta_i \frac{\bar{Y}(GM)}{\bar{X}_i(GM)}$$

Where, $\bar{Y}(GM)$ = Geometric mean of gross return (BDT)
 $\bar{X}_i(GM)$ = Geometric mean of different independent variables (BDT)
 β_i = Co-efficients of parameter
 $i = 1, 2, \dots, n$

RESULTS AND DISCUSSION

Cost of cultivation

For determining the cost of boro rice cultivation, all the variable costs e.g. human labour, power tiller, seed, organic manures, fertilizers, insecticides and irrigation were calculated as per hectare. The fixed cost of boro rice cultivation comprised land use cost and interest on operating capital. The cost on human labor was calculated by considering different charge for male and female labour and also for different time of the season. The land use cost was determined on the basis of per hectare lease value of land. Actual land use values for boro rice cultivation were calculated as per its agronomic lifespan of the year.

The cost of boro rice production was approximated to be BDT 71,208 and BDT 57,583 per hectare on total cost and variable cost, respectively. The major share in total cost was human labour input cost (26.52%), followed by irrigation (17.43%), chemical fertilizers (17.36%) and land use cost (16.58%). On the 26.52% of labour cost 67% labours were family supplied and rest 33% were used on

Table 1. Production cost of boro rice in the study area (in BDT/ha).

S/No.	Items	Amount (BDT)	Percentage of total cost
	Variable Cost	57,583	80.87
	Human labour	18,883	26.52
	Family labour	12,566 (67%)	17.65
	Hired labour	6,317 (33%)	8.87
	Power tiller	4,404	6.18
	Seed	2,401	3.37
	Organic manure	2,986	4.19
A.	Chemical fertilizers:	12,360	17.36
	Urea	4,440	6.24
	TSP	4,357	6.12
	MoP	1,590	2.23
	Zipsum	1,973	2.77
	Insecticides	4,139	5.81
	Irrigation	12,409	17.43
	Fixed cost	13,625	19.13
B.	Land use	11,806	16.58
	Interest on operating capital	1,819	2.55
	Total Cost (A+B)	71,208	100.00

Data Source: Author's calculation based on field survey (2016).

Table 2. Profitability of boro rice cultivation in the study area.

S/No.	Items	Formula	Unit	Amounts
01	Yield from main product	Y_1	kg/ha	4,112
02	Farm gate Price of main product	P_1	BDT/kg	19.65
03	Return from main product (R_1)	$Y_1 * P_1$	BDT/kg	80,548
04	Yield from by product (R_2)		BDT/kg	6,000
05	Gross return ($R_1 + R_2$)	GR	BDT/kg	86,548
06	Total variable cost	TVC	BDT/kg	57,583
07	Total cost	TC	BDT/kg	71,208
08	Gross margin	$GR - TVC$	BDT/kg	28,965
09	Net return	$GR - TC$	BDT/kg	15,340
10	Benefit cost ratio			
	Full cost basis	GR/TC		1.22
	Variable cost basis	GR/TVC		1.50

Data Source: Author's calculation based on field survey (2016).

hired basis. More or less same percentage of contribution by labour and fertilizer were found by Bapari (2016). Estimated result tabulated below on Table 1.

Profitability of rice cultivation

The yield of boro rice was 4.1 ton/ha which was higher than the previous year's average yield (3.62 ton/ha) (BBS, 2015). Prevailing congenial atmosphere

throughout the season was the major cause of increasing yield. Including returns from both main product and by-product the gross return and gross margin of rice cultivation were BDT 86,548 and BDT 28,965 per hectare respectively. The net return of rice cultivation was BDT 15,340 per hectare which is significantly lower than the findings of Kazal et al. (2013). Prevailing lower price may be the cause of variant result. Estimated result tabulated on Table 2 showed that undiscounted benefit cost ratios (BCR) were 1.22 and 1.50 on full cost and variable cost

Table 3. Estimated parameters and other related statistics of boro rice production.

Explanatory variable	Parameters	Co-efficient	Sd. Error	t-values	P-values
Intercept	β_0	3.91***	1.15	3.40	0.00
Human labor (X_1)	β_1	0.29**	0.13	2.14	0.03
Power tiller (X_2)	β_2	-0.04 ^{NS}	0.04	-0.96	0.34
Seed (X_3)	β_3	0.18**	0.07	2.47	0.02
Urea (X_4)	β_4	0.14*	0.08	1.76	0.08
TSP (X_5)	β_5	0.02 ^{NS}	0.03	0.60	0.55
MoP (X_6)	β_6	0.02 ^{NS}	0.09	0.21	0.83
Insecticide (X_7)	β_7	-0.10***	0.03	-2.80	0.01
Irrigation (X_8)	B_8	0.30***	0.06	4.87	0.00
R^2		0.8253			
F-value		61.22***			
Return to scale		0.808			

***, ** and * indicate significant at 1, 5 and 10% level respectively. Data Source: Author's calculation based on field survey (2016).

basis. Estimated undiscounted BCR on full cost basis was almost similar with the findings of Kazal et al. (2013). More or less same result was found by Bapari (2016), Suresh and Reddy (2006) and Khan (2004). This ratio was found slightly different (1.41) in Mymensingh region by Ahmed et al. (2009).

Factors affecting yield of rice

In order to assess the individual effects of different inputs of boro rice production Cobb-Douglas production function model was used. Estimated parameters and other related statistics have been presented in Table 3. The co-efficient of irrigation and insecticide were significant at 1% level of significance. Where irrigation had positive impact but insecticide had reversed. Implying that gross return of rice would increase 3.0% and decrease 1.0% by 10% increasing the use of irrigation and insecticide respectively. Result might indicate that boro rice cultivation in Bangladesh is highly sensitive to timely irrigation. Negative parameters of insecticide might indicate the inappropriate use of that input. Underlying causes might be improper knowledge about the doses and effects of insecticide on rice cultivation. Improper quality of insecticide could be another reason behind it. The parameters of human labour and seed were significant at 5% level of significance implying 10% increase in the use of those inputs would increase the gross return of rice by 2.9 and 1.8% respectively. Highly significant effect of these two variables was also found by Ahmed et al. (2009). Highly labour intensive boro rice cultivation might be explained by the higher parameter of labour (0.29). Different level of productivity of different variety of rice was described by the parameter of seed (0.18). If seed cost had increased the productivity as well as cost of rice cultivation would increase. Same result for

seed also found by Majumder et al. (2009) and Ahmed et al. (2009). 1% increasing use of urea would increase the gross return of rice by 0.14% in facts its parameter was significant at 10% level of significance. Timely and properly application of urea had a positive effect on production might be revealed by the positive significant co-efficient of urea on gross return of boro rice cultivation. TSP and MoP had positive and power tiller had negative impact on the gross return of rice but the effects were insignificant. Insignificant effect annotated that these inputs had supportive not crucial effect on production.

Implication of R^2

The co-efficient of multiple determinations (R^2) were 0.8253, which indicate that about 82.53% of the variations in gross return of boro rice cultivation had been explained by the independent variables included in the model.

F-Statistics

The F-statistic of the model was found 61.22, which was highly significant at 1% level of significance. This result of F-statistic implies that all the independent variables included in the model were important for explaining the variations in gross returns of boro rice production.

Returns to scale

Returns to scale was calculated by summing up all the co-efficients of production. For boro rice production the ruminant of the coefficients was 0.808 indicating the production functions exhibit decreasing returns to scale.

Table 4. Resource use efficiency of different inputs under rice cultivation.

Variable	Geometric mean (GM)	$\bar{Y}(GM)/\bar{X}_i(GM)$	Co-efficient	MVP (X_i)	$r=MVP/MFC$	Decision rule
Yield (Y)	79595.64					
Human labour (X_1)	18762.09	4.242	0.287	1.220	1.220	Under-utilization
Power tiller (X_2)	4347.41	18.309	-0.038	-0.694	-0.694	Over-utilization
Seed (X_3)	2378.31	33.467	0.180	6.009	6.009	Under-utilization
Urea (X_4)	4397.79	18.099	0.139	2.522	2.522	Under-utilization
TSP (X_5)	4276.30	18.613	0.020	0.376	0.376	Over-utilization
MoP (X_6)	1584.33	50.239	0.020	0.984	0.984	Over-utilization
Insecticide (X_7)	4059.59	19.607	-0.097	-1.901	-1.901	Over-utilization
Irrigation (X_8)	12101.43	6.577	0.297	1.953	1.953	Under-utilization

MFC= BDT 1. Data Source: Author's calculation based on field survey (2016).

Almost same result was found by Majumder et al. (2009) and reversed result was found by Ahmed et al. (2009) for boro rice production.

Resource use efficiency

Resource use efficiency implies how efficiently the farmer can use their resources in production process. Efficient use of resource is deeply concerned for ensuring their sustainability. For determining resource use efficiency eight input factors namely human labor, power tiller, seed, urea, TSP, MoP, insecticide, and irrigation were considered.

Higher MVP indicates increasing productivity of resources whereas negative MVP implies unproductive use of it (Utamakili, 1992; Olayemi, 1998; Mbanasor and Obioha, 2003; Emokaro and Erhabor, 2006). The results are presented in Table 4. From the table it was found that the MVP for seed, urea, irrigation and human labour were 6.009, 2.522, 1.953 and 1.220 respectively. The MVP values for all the variables were greater than one which indicated that farmers had chances of increasing per hectare output by utilizing more seedling, urea fertilizers, irrigation and human labour. Majumder et al. (2009) reported a similar result for owners and tenant operators, the MVP of seedlings and insecticides were higher than one while for cash tenants MVP of seedlings, insecticides and fertilizers were greater than one. Greater than one MVP ratio to MFC for seed, chemical fertilizers, plant protection chemicals and human labour was also found by Parasar et al. (2016). Same ratios for fertilizer, labour and land were reported to be greater than one by Sani et al. (2010). Over-utilized labour and planting material were also found by Onyemauwa et al. (2013). Ratio analysis of MVP to MFC for TSP and MoP fertilizer showed that the MVP of all of these factors were found to be lower than their respective cost which suggest to decrease the use of these inputs. Same ratio for insecticide and power tiller was -1.901 and -0.694, respectively. Negative efficiency ratio for these input showed that additional input of these

two factors bring no benefit but loss. So use of these two inputs must be decreased for maximizing outputs of rice production.

Elasticity of production

Percentage change in output due to the percentage change in input is defined by the elasticity of production. Elasticity concept can be applied to the production function for determining the stage in which farmers are allocating their resources (Table 5).

The summations of all the co-efficients of Cobb-Douglas production function express the direct measure of returns to scale which indicate the stage of production. Calculated elasticities for all farmers were less than one implying the allocation of resources on the *stage-II* of production functions where farmers get diminishing returns from their resources. Same result also found by Majumder et al. (2009) in similar study in Bhola district.

CONCLUSION AND POLICY RECOMMENDATIONS

The principal finding of the study is that the boro rice cultivation in Bogra district was a profitable venture. All of the factors namely human labour, seed, urea, insecticide and irrigation were very important for the cultivation. Function analysis implied that the farmers employed their scarce resources in boro rice production inefficiently. Resource use efficiency analysis also provided an alarm that most of the resources used in the production were not economically optimal. Improvement in irrigation system is the key recommendation for improving productivity of boro rice in the study area. Providing proper training to farmers for making them aware about different strategies of cultivation and taking necessary steps for increasing the quality of pesticide can also be policy implication. HYV boro seed should be made available to farmers in the production season within affordable cost. Agricultural labour should be made

Table 5. Elasticities of boro rice production.

S/No.	Input	Elasticity	Stage	Returns to scale
01.	Human labor (X_1)	0.29	Stage-II	Diminishing
02.	Power tiller (X_2)	-0.04	Stage-III	Diminishing
03.	Seed (X_3)	0.18	Stage-II	Diminishing
04.	Urea (X_4)	0.14	Stage-II	Diminishing
05.	TSP (X_5)	0.02	Stage-II	Diminishing
06.	MoP (X_6)	0.02	Stage-II	Diminishing
07.	Insecticide (X_7)	-0.10	Stage-III	Diminishing
	Irrigation (X_8)	0.30	Stage-II	Diminishing
	Total	0.81	Stage-II	Diminishing

Data Source: Author's calculation based on field survey (2016).

available when necessary and agricultural mechanization should be encouraged.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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