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Measurement of Farm Productivity of Rice: A Case of Bangladesh

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ABSTRACT: The focus of this study is to assess rice production in different category of farms of Bangladesh. The relevant data was collected from secondary source collected by International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) under the Village Dynamics Studies in South Asia (VDSA) project. A total of 280, 318, 365 and 349 sample farmers were selected for the years of 2009, 2010, 2011 and 2012, respectively and the selected farmers were categorized into marginal, small, medium and large categories. Descriptive statistics were used to measure the profitability of rice production. In the study areas, rice farming was profitable for the selected years for all category of farmers but large and medium scale farmers received more profit than small and marginal farmers. Per hectare net return from rice production by small farmers was Tk.31324.28 in 2009 and Tk. 21776.97 in 2012 which provides a decreasing picture of profit for them. Cobb-Douglas stochastic cost frontier analysis was used to measure economic efficiencies. The regression result shows that, estimated values of the relevant coefficients i.e., fertilizer cost, machineries cost, human labor cost, seed cost and herbicides cost had positive and significant impact on the gross return of rice production and the coefficient of pesticide was negatively significant. So, there is a scope for increasing return from rice production by increasing human labour, seed, fertilizer, machineries and herbicide uses, since the coefficients of these parameters was positive and significant. The study will help to policy makers for the development of all category rice farmers specially the small and marginal farmers of Bangladesh.

KEYWORDS: Rice, Productivity and Bangladesh.

1 INTRODUCTION

Agriculture is the single largest producing sector of the economy since it comprises about 16.77% Gross Domestic Product (GDP) and 45% of the total labor force is employed in this sector (BBS, 2013). There has been a remarkable progress in food production over the last three and a half decades in Bangladesh despite high pressure of population on land and other natural resources. Rice is the driving force of Bangladesh agriculture among all crops. In the world, 90 percent rice is produced by 200 million small farmers whose average land is less than 1 hectare.

(Tonini and Cabrera, 2011). Bangladesh being an agricultural country most of her food crops are produced from small farms. Small farmers still dominate the agricultural sector in Bangladesh and play a significant role in the country's economy. 84 percent of the total farm holdings as well as 12.7 millions small holdings out of 15.3 million total farm holdings in the country belongs to small farmers (0.05-2.49 acre) (BBS, 2013). Therefore, small farmers still dominate the agricultural sector, specially the rice sector in Bangladesh. Data indicate that, domestic rice production has never been adequate to meet the country's domestic demand except in 1993-94 and 2005-2006. As such, rice imports have continued, although the volume varied from year to year depending on domestic production (Alam, 2012).However, recent trends are alarming as the average yield of modern varieties of rice fallen from 3.8 ton/ha in 1968 to 2.9ton/ha in 2006 which raising serious concern in sustaining food-grain production (Rahman *et. al*., 2007).

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Nasrin (2013) evaluated the financial profitability of aromatic rice production and its impacts on farmers' livelihood in selected areas of Tangail district. He found total human labor, seed, fertilizer, power tiller and irrigation had significant impact and insecticides had insignificant impact on the per hectare output. Hyuha *et al. (*2007) found that improvement in profit efficiency in rice production would require focused programs to increase access to education and extension services. Tama (2014) found total costs, gross return, gross margin and net return for aromatic rice were Tk.64446.51, Tk. 114243.71, Tk. 59999.29 and Tk. 49797.20 per hectare. The aromatic rice production was profitable (BCR is 1.77). Nimoh e*t. al. (*2012) showed that farmers were in the second stages of production that land, fertilizer and seed were being underutilized and labor and agrochemicals were being highly over utilized. Kolawole (2006) examined the determinants of profit efficiency among the small scale paddy rice farmers in Nigeria. Except the unit cost of fertilizer/kg, all the inputs have positive sign on the profitability of rice farming in Nigeria. More than half of the farmers having profit efficiency of 0.61 and above with an average profit efficiency of 0.601 suggesting. Profit efficiency was positively influenced by age, educational level, farming experiences and household size. APCAS (2010) carried out a research on agricultural activity in Asia on small and marginal farms. It found that data classification and tabulation collected from agricultural surveys are not carried out to properly reflect the role played by small farmers. Mustafi and Saiful (2004) found that production cost for MV Boro was much higher (Tk. 28249.0/ha) than MV Aus and MV T. Aman rice. The yield of MV Aus, MV T. Aman and MV Boro rice were 353kg/ha, 4310 kg/ha and 4962 kg/ha, respectively. Higher gross return (Tk. 35719.0/ha) was obtained from MV Boro rice production while the gross return from MV T. Aman was Tk. 35221.0/ha. But the higher net return (Tk. 13012.0/ha) was obtained by the MV T. aman rice growers.

In the past, there was no exclusive study on the production of rice with the factors affecting the profitability including all category of rice farmer of Bangladesh in different years. The findings of the study are likely to be helpful to the researchers and policy makers in the formulation of policies regarding efficient production of rice in all category of farmer of Bangladesh. The objectives of this study are as (i) to measure the profitability of rice of all category of rice producing farmer. (ii)To determine the key factors affecting the gross return of rice producing farmers.

2 METHODOLOGY

The study was conducted in eleven districts namely Chandpur, Comilla, Thakurgaon, Patuakhali, Bogra, Chuadanga, Jhenaidah, Mymensingh, Madaripur, Narsingdi and Kurigram. Secondary data was used which was collected from VDSA project of ICRISAT. A total of 280, 318, 365 and 349 rice farms were selected as a sample for the years of 2009, 2010, 2011 and 2012, respectively and the selected farms were categorized into marginal, small, medium and large farms.

Descriptive statistics were used to measure the profitability of rice production. Factor analysis to see the influence of factors on the profitability of rice was analyzed by Cobb-Douglas production function. The Cobb-Douglas production function was used to explore the relationship between production and input. Since the model proved superior on theoretical and econometric grounds, this function was chosen on the basis of the best fit and significant effects of using inputs on return in producing rice.

The following model was used in this study:

$$Yi = aX_1^{b1} X_2^{b2} X_3^{b3} X_4^{b4} D_1^{b5} D_2^{b6} e^{u} \quad (1)$$

This was linearised in the logarithmic form as under:

$$InY = Ina + b_1InX_1 + b_2InX_2 + b_3InX_3 + b_4InX_4 + b_5D_1 + b_6D_2 + U \quad (2)$$

Where,

Y = Gross return (Tk.);

X_1= Fertilizer cost (Tk.);

X_2= Machinery cost (Tk.);

X_3= Human labor cost (Tk.);

X_4= seed cost (Tk.);

D_1= Pesticides dummy;

D_1= 1 for pesticides user farms and 0 for no pesticide user farm;

D_2= Herbicides dummy;

D_2= 1 for herbicides user farms and 0 for no herbicide user farm;

ln =Natural logarithm;

a =Constant/Intercept;

b_1, b_2……b_6 = production coefficients of the respective variables; and

U=Error term.

3 RESULTS AND DISCUSSION

VARIABLE COST

The variable cost item for rice production was fertilizers, machineries, organic materials, pesticides/fungicides, seeds, weedicides, hired labor and interest on operating capital.Variable cost for marginal farmer was Tk. 45901.40, Tk. 38663.80 Tk. 43181.67 and Tk. 51559.39 per hectare in 2009, 2010, 2011 and 2012, respectively which was increasing during the time. For small farmer, the variable cost was Tk. 45827.22, Tk. 34591.83, Tk. 40302.20 and Tk. 40836.37 per hectare in 2009, 2010, 2011 and 2012 respectively which was almost same during the time. Variable cost for medium farmer was Tk. 80489.62, Tk. 55547.79 Tk. 63685.07 and Tk. 61601.03 per hectare in 2009, 2010, 2011 and 2012 respectively which was higher than marginal and small farmer during the time. The estimated variable cost for large farmer was Tk. 34031.84 Tk. 34078.40 and Tk. 36434.00 per hectare in 2010, 2011 and 2012 respectively which was lower than marginal, small and medium farmer during the time (Table 2, 3, 4 and 5).

FIXED COST

The fixed cost item for rice production was land use cost and family labor cost. For marginal farmer, the fixed cost was Tk.16546.99, Tk. 15889.75, Tk.22535.17 and Tk. 14753.70 per hectare in 2009,2010, 2011 and 2012 respectively.For small farmer, the fixed cost was Tk. 11882.34, Tk. 15153.17, Tk.15089.91 and Tk.18212.08 per hectare in 2009,2010, 2011 and 2012 respectively which was increasing during the time.For medium farmer, the fixed cost was Tk.15915.76, Tk.16793.65, and Tk.21214.28and Tk.19907.36 per hectare in 2009,2010, 2011 and 2012 respectively which was increasing during the time. For large farmer, the fixed cost was Tk. 6156.97, Tk. 13542.85 and Tk. 10362.95 per hectare in 2009, 2010, 2011 and 2012 respectively which were lower than other three category of farmer during the time (Table 2, 3, 4 and 5).

TOTAL COST

For marginal farmer, total cost was Tk.62448.39, Tk. 54553.55, Tk.65716.84and Tk. 66313.10per hectare in 2009,2010, 2011 and 2012 respectively.For small farmer, total cost was Tk.57709.55, Tk. 49745.00, Tk.55392.10and Tk. 59048.45per hectare in 2009,2010, 2011 and 2012 respectively. For medium farmer, total cost was Tk.56160.57, Tk. 44567.54, Tk.53056.82and Tk. 50707.88per hectare in 2009,2010, 2011 and 2012 respectively. For large farmer, total cost was Tk.40188.80, Tk. 47621.25,.82and Tk. 46796.95per hectare in 2010, 2011 and 2012 respectively. Total cost was comparatively lower than other category of farmer. (Table 2, 3, 4 and 5).

Gross Return (GR)

Average gross return was Tk. 97172.58, Tk. 80908.78, Tk. 82686.65 and Tk. 79119.61 per hectare in 2009, 2010, 2011 and 2012 respectively (Table 1).

Table 1. Table 1: Per hectare gross returns for producing rice in 2009, 2010, 2011 and 2012.

Farmer category/ Year	Value of main product (Taka/ha)	Value of by product (Taka/ha)	Gross return (Taka/ha)
2009			
Marginal	83929.67	5522.98	89452.65
Small	80284.33	8749.51	89033.84
Medium	108600.6	4430.71	113031.3
Large	-	-	-
Average			97172.58
2010			
Marginal	77673.92	7207.48	84881.4

Small	72799.37	6924.77	79724.14
Medium	70597.95	5935.26	76533.21
Large	78354.34	4142.01	82496.35
Average			80908.78
2011			
Marginal	74875	8363.85	83238.85
Small	73088	8023.34	81111.34
Medium	69832.09	7115.57	76947.66
Large	84730.46	4718.27	89448.73
Average			82686.65
2012			
Marginal	73224.9	10350.68	83575.58
Small	71652.64	9172.78	80825.42
Medium	63591.67	7191.1	70782.77
Large	74695.6	6599.07	81294.67
Average			79119.61

Note: Marginal farm (0.05-0.49 acres), small farm 0.50-2.49 acres), medium farm (2.50-7.49 acres) and large farm (7.50-above acres)
Source: Author' s calculation, based on VDSA data.

PROFITABILITY OF DIFFERENT CATEGORY OF RICE FARMER

MARGINAL FARMER

Gross margin obtained in 2009, 2010, 2011 and 2012 were Tk. 51201.48, Tk. 52661.57, Tk. 57254.12 and Tk. 32016.19, respectively. Net return were estimated at Tk. 27004.26, Tk. 30327.85, Tk. 17522.01 and Tk. 17262.49 per hectare in 2009, 2010, 2011 and 2012 respectively (Tables 5 and 6). Benefit cost ratio were estimated at Tk.1.43, Tk. 1.56, Tk. 1.27 and Tk. 1.26 per hectare in 2009, 2010, 2011 and 2012 respectively (Table 2).

SMALL FARMER

Gross margin were estimated at Tk. 50844.49, Tk. 50897.62, Tk. 40809.15 and Tk. 46795.11per hectare in 2009, 2010, 2011 and 2012 respectively. Net return were estimated at Tk. 31324.28, Tk. 29979.14,Tk. 25719.24 and Tk. 21776.97per hectare in 2009, 2010, 2011 and 2012 respectively .Benefit cost ratio were estimated at Tk. 1.54, Tk.1.60, Tk. 1.46 and Tk. 1.37 per hectare in 2009, 2010, 2011 and 2012 respectively (Table 3).

MEDIUM FARMER

Gross margin were estimated at Tk. 32541.64, Tk. 20985.42, Tk. 13262.59 and Tk. 9181.73 per hectare in 2009, 2010, 2011 and 2012 respectively. Net return was estimated at Tk. 56870.69, Tk. 31965.67, Tk. 23890.84 and Tk. 20074.89 per hectare in 2009, 2010, 2011 and 2012 respectively. Benefit cost ratio were estimated at Tk. 2.01, Tk. 1.72, Tk. 1.45 and Tk. 1.40 per hectare in 2009, 2010, 2011 and 2012 respectively (Table 4).

LARGE FARMER

Gross margin were estimated at Tk. 54136.48, Tk. 61050.07Tk. 44860.67 per hectare in 2010, 2011 and 2012 respectively. Net Return was estimated at Tk. 42307.54Tk. 41827.48, Tk. 34497.72 per hectare in 2010, 2011 and 2012 respectively. Benefit cost ratio were estimated at Tk. 2.05, Tk. 1.88, Tk. 1.74 per hectare in 2010, 2011 and 2012 respectively (Table 5).

The profitability of all categories of farmers was decreasing from 2009 to 2012. That means the farmers were going to become financially insolvent day by day. In the study area, marginal and small category farmers were gaining less profit than the medium and large category of farmers from the production of rice (Table 2, 3, 4 and 5).

Table 2. Activity budgets: Per hectare rice production of marginal farmers in 2009, 2010, 2011 and 2012 (Taka/ha))

Particulars	2009	2010	2011	2012
A. Gross Return	89452.65	84881.40	83238.85	83575.58
Variable Costs				
Cost of Fertilizers	7897.78	5628.44	6194.81	8021.83
Cost of Machineries	14322.64	9975.16	11841.11	11837.81
Cost of Organic Materials	1696.46	623.71	262.74	745.24
Cost of Pesticides/Fungicides	646.13	742.99	439.20	609.52
Cost of Seeds	2548.88	2180.76	2769.55	2136.08
Cost of Weedicides	213.92	120.02	91.33	191.92
Other Costs	1119.38	1791.74	2802.85	2601.35
B. Total Material Inputs Cost	28321.78	20777.82	24401.58	26143.74
C. Total Hired Labor Cost	9929.39	11442.01	11583.15	16822.42
D. Interest on Operating Capital	7650.23	6443.97	7196.94	8593.23
E. Total Variable Cost (B+ C+D)	45901.40	38663.80	43181.67	51559.39
Fixed Costs				
Land Use Cost	1501.73	1554.81	1858.82	1502.44
Total family labor cost	15045.26	14334.95	20676.34	13251.26
F. Total fixed cost	16546.99	15889.75	22535.17	14753.70
G. Gross cost(E+F)	62448.39	54553.55	65716.84	66313.10
H. Gross margin(A-E)	51201.48	52661.57	57254.12	32016.19
I. Net return(A-G)	27004.26	30327.85	17522.01	17262.49
J. Benefit cost ratio (A/G) (undiscounted)	1.43	1.56	1.27	1.26

Source: Author's calculation, based on VDSA data.

Table 3. Activity budgets: Per hectare rice production of small farmers in 2009, 2010, 2011 and 2012 (Taka/ha)

Particulars	2009	2010	2011	2012
A. Gross Return	89033.84	79724.14	81111.34	80825.42
Variable Costs				
Cost of Fertilizers	7086.41	4772.04	6614.22	5708.68
Cost of Machineries	11772.67	8175.51	9302.89	10457.16
Cost of Organic Materials	2168.64	670.02	815.36	695.03
Cost of Pesticides/Fungicides	699.87	568.49	531.90	402.66
Cost of Seeds	2396.30	1998.98	1850.13	1984.34
Cost of Weedicides	214.53	99.74	124.35	148.32
Other Costs	2057.41	2046.27	2108.39	2976.82
B. Total Material Inputs Cost	26378.53	18331.06	21347.25	22336.20
C. Total Hired Labor Cost	11810.82	10495.46	12237.91	11694.11
D. Interest on Operating Capital	7637.87	5765.30	6717.03	6806.06
E. Total Variable Cost (B+ C+D)	45827.22	34591.83	40302.20	40836.37
Fixed Costs				
Land Use Cost	1190.65	1315.73	1584.44	1831.55
Total family labor cost	10691.69	13837.44	13505.47	16380.53
F. Total fixed cost	11882.34	15153.17	15089.91	18212.08
G. Gross cost(E+F)	57709.55	49745.00	55392.10	59048.45
H. Gross margin(A-E)	50844.49	50897.62	40809.15	46795.11
I. Net return(A-G)	31324.28	29979.14	25719.24	21776.97
J. Benefit cost ratio (A/G) (undiscounted)	1.54	1.60	1.46	1.37

Source: Author'scalculation, based on VDSA data.

Table 4. Activity budgets: Per hectare rice production of medium farmers in 2009, 2010, 2011 and 2012 (Taka/ha)

Particulars	2009	2010	2011	2012
A. Gross Return	113031.26	76533.21	76947.66	70782.77
Variable Costs				
Cost of Fertilizers	7998.95	4618.34	5480.78	6236.84
Cost of Machineries	12704.56	6927.66	8964.69	8321.92
Cost of Organic Materials	2706.85	927.49	680.87	717.29
Cost of Pesticides/Fungicides	1138.67	459.91	337.28	525.77
Cost of Seeds	2978.09	1645.34	1815.06	1640.55
Cost of Weedicides	428.98	211.90	235.78	215.15
Other Costs	845.35	2040.64	3327.35	2440.79
B. Total Material Inputs Cost	28801.45	16797.07	20841.68	20098.32
C. Total Hired Labor Cost	11443.36	10976.82	11000.85	10702.20
D. Interest on Operating Capital	40244.81	27773.90	31842.54	30800.52
E. Total Variable Cost (B+ C+D)	80489.62	55547.79	63685.07	61601.03
Fixed Costs	988.12	1178.72	1522.52	1481.17
Land Use Cost	6878.68	10060.15	13323.26	12266.09
Total family labor cost	8048.96	5554.78	6368.51	6160.10
F. Total fixed cost	15915.76	16793.65	21214.28	19907.36
G. Gross cost(E+F)	56160.57	44567.54	53056.82	50707.88
H. Gross margin(A-E)	32541.64	20985.42	13262.59	9181.73
I. Net return(A-G)	56870.69	31965.67	23890.84	20074.89
J. Benefit cost ratio (A/G) (undiscounted)	2.01	1.72	1.45	1.40

Source: Author's calculation, based on VDSA data.

Table 5. Activity budgets: Per hectare rice production of large farmers in 2009, 2010, 2011and 2012 (Taka/ha)

Particulars	2009	2010	2011	2012
A. Gross Return	-	82496.35	89448.73	81294.67
Variable Costs				
Cost of Fertilizers	-	4361.95	5193.97	6153.58
Cost of Machineries	-	6786.49	8730.32	8108.71
Cost of Organic Materials	-	1112.71	981.13	614.38
Cost of Pesticides/Fungicides	-	399.92	350.75	305.26
Cost of Seeds		1702.95	1581.28	1403.94
Cost of Weedicides	-	247.73	196.76	290.29
Other Costs	-	2019.31	3045.53	2710.45
B. Total Material Inputs Cost	-	16606.07	20079.73	19586.62
C. Total Hired Labor Cost	-	11753.79	8318.94	10775.05
D. Interest on Operating Capital	-	5671.97	5679.73	6072.33
E. Total Variable Cost (B+ C+D)	-	34031.84	34078.4	36434
Fixed Costs				
Land Use Cost	-	795.85	1174.09	1386.69
Total family labor cost	-	5361.12	12368.76	8976.27
F. Total fixed cost	-	6156.97	13542.85	10362.95
G. Gross cost(E+F)	-	40188.8	47621.25	46796.95
H. Gross margin(A-E)	-	54136.48	61050.07	44860.67
I. Net return(A-G)	-	42307.54	41827.48	34497.72
J. Benefit cost ratio (A/G) (undiscounted)	-	2.05	1.88	1.74

Source: Author's calculation, based on VDSA data.

MAJOR FACTORS AFFECTING PRODUCTION OF RICE

Estimated values of co-efficient and related statistics of Cobb-Douglas production function is presented in Table 6. The result showed that, most of the coefficient i.e. coefficient of fertilizer, machineries, human labor cost, seed cost and herbicides cost had positive impact and only pesticide cost had negative impact on gross return of rice production during the time. All the variables were found significant in 2010 and 2012 at different significant level which means there is opportunity to increase gross return by using more quantity of those factors of production with decreasing pesticide cost. Fertilizer, human labor cost and seed cost were found significant in 2009 which means there is opportunity to increase gross return by using more quantity of fertilizer, human labor cost and seed cost. Machineries, human labor cost, seed cost, pesticide cost and herbicides cost were found significant in 2011 which means by using more quantity of machineries, human labor cost, seed cost and herbicides cost; using less pesticide there is opportunity to increase gross return. Fertilizer cost, machineries cost, human labor cost, seed cost, herbicides cost and pesticide cost were found significant in 2012 which means by using more quantity of fertilizer, machineries, human labor, seed and herbicides ; using less pesticide there is opportunity to increase gross return, which was also found for 2010 (Table 6).

Table 6. Estimated values of coefficient and related statistics of Cobb-Douglas production function of rice production in 2009, 2010, 2011 and 2012.

Explanatory variables	2009		2010		2011		2012	
	Estimated Coefficients	t-value	Estimated Coefficients	t-value	Estimated Coefficients	t-value	Estimated Coefficients	t-value
Intercept	1.55	5.80	3.32	19.21	1.23	6.85	1.54	6.03
Fertilizer(X_l)	0.24***	3.90	0.20***	6.23	0.009	0.24	0.18***	4.27
Machineries (X_2)	0.07	1.34	0.28***	5.92	0.33***	8.42	0.13*	2.67
Human labor cost (X_3)	0.66***	10.13	0.13***	5.02	0.56***	9.92	0.51***	8.42
Seed cost (X_4)	0.06**	1.66	0.34***	7.97	0.15***	3.49	0.22***	5.26
Pesticides cost (dummy variable) (X_5)	-0.003	-0.07	-0.17***	-3.63	-0.09**	-2.42	-0.21***	-4.34
Herbicides cost (dummy variable) (X_6)	0.08	1.58	0.12***	2.69	0.18***	4.84	0.41***	7.64
R^2	0.84		0.88		0.94		0.88	
Adjusted R^2	0.83		0.88		0.94		0.88	
Return to scale	1.03		0.95		1.04		1.04	
F-value	228.59***		434.50***		755.49***		373.38***	

Source: Author's estimation, 2015.
*Note: *** significant at 1% level and*
***significant at 5% level.*

The result of Rasyid et. al., 2016 was that seed, pesticide, fertilizer, labour were the significant factors for the rice production which is similar to this study. Another study found that seed cost, human labour cost, power tiller cost, urea cost, TSP cost, MP cost, irrigation cost, insecticide cost were also found significant to the profitability of rice production (Islam et. al., 2017) and the result is similar to this study.

4 CONCLUSION

Rice production is profitable in the study area and small farmers earned higher profit compared to medium and large farmers. However, the benefit cost ratio which indicates the profitability of rice farmers was decreasing during the period. The rice farmers require great concern on fertilizer cost, machineries cost, human labor cost, seed cost and herbicides cost. The reason is that, these factors of production have significant impact on the production of rice during the time. Thus the present study might be helpful for the researcher, policy makers and to other concerned authorities for conducting further comprehensive research or to plan for the development of the rice farmers specially marginal and small scale farmers of Bangladesh.

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