



## **Measurement of Farm Productivity of Rice: A Case of Bangladesh**

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### **Authors' contributions**

*This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.*

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### **ABSTRACT**

The focus of this study is to assess rice production in the different category of farms in Bangladesh. The relevant data were 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, machinery cost, human labour cost, seed cost and herbicides cost had the positive and significant impact on the gross return of rice production and the coefficient of pesticide

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was negatively significant. So, there is a scope for increasing return from rice production by increasing human labour, seed, fertilizer, machinery and herbicide uses since the coefficients of these parameters were positive and significant. The study will help to policymakers for the development of all category rice farmers especially 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 labour force is employed in this sector [1]. There has been 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 of rice is produced by 200 million small farmers whose average land is less than 1 hectare.

Tonini and Cabrera [2] Bangladesh is 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 million smallholdings out of 15.3 million total farm holdings in the country, belongs to small farmers (0.05-2.49 acre) [1]. Therefore, small farmers still dominate the agricultural sector, especially 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 [3]. 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 raised serious concern in sustaining food-grain production [4].

Nasrin [5] evaluated the financial profitability of aromatic rice production and its impacts on farmers' livelihood in selected areas of Tangail district. He found total human labour, seed, fertilizer, power tiller and irrigation had a significant impact and insecticides had an insignificant impact on the per hectare output. Hyuha et al. [6] found that improvement in profit efficiency in rice production would require focused programs to increase access to

education and extension services. Tama [7] 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 et al. [8] showed that farmers were in the second stages of production that land, fertilizer and seed were being underutilized and labour and agrochemicals were being highly over-utilized. Kolawole [9] examined the determinants of profit efficiency among the small scale paddy rice farmers in Nigeria. Except for the unit cost of fertilizer/kg, all the inputs have positive signs 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 [10] carried out 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 [11] 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 policymakers in the formulation of policies regarding the efficient production of rice in all category of the farmer of Bangladesh. The objectives of this study are (i) to measure the profitability of rice in 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 the 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 user inputs on return in producing rice.

The following model was used in this study:

$$Y_i = aX_1^{b_1} X_2^{b_2} X_3^{b_3} X_4^{b_4} D_1^{b_5} D_2^{b_6} e^u \quad (1)$$

This was linearised in the logarithmic form as under:

$$\ln Y = \ln a + b_1 \ln X_1 + b_2 \ln X_2 + b_3 \ln X_3 + b_4 \ln X_4 + b_5 D_1 + b_6 D_2 + U \quad (2)$$

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;  
 $b_1, b_2, \dots, b_6$  = production coefficients of the respective variables; and  
 $U$  = Error term.

## 3. RESULTS AND DISCUSSION

### 3.1 Variable Cost

The variable cost item for rice production was fertilizers, machinery, organic materials, pesticides/fungicides, seeds, weedicides, hired labour and interest on operating capital. Variable cost for the 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 a 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 the same during the time. Variable cost for the 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 a 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 (Tables 2, 3, 4 and 5).

### 3.2 Fixed Cost

The fixed cost item for rice production was land use cost and family labour cost. For the 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 a 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 a 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 a 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 the other three categories of the farmer during the time (Tables 2, 3, 4 and 5).

### 3.3 Total Cost

For a 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 the small farmer, total cost was Tk. 57709.55, Tk. 49745.00, Tk. 55392.10 and Tk. 59048.45 per hectare in 2009, 2010, 2011 and 2012 respectively. For the medium farmer, total cost was Tk. 56160.57, Tk. 44567.54, Tk. 53056.82 and Tk. 50707.88 per hectare in 2009, 2010, 2011 and 2012 respectively. For a large farmer, total cost was Tk. 40188.80, Tk. 47621.25, Tk. 46796.95 per hectare in 2010, 2011 and 2012 respectively. Total cost was comparatively lower than other categories of farmers (Tables 2, 3, 4 and 5).

### 3.4 Gross Return (GR)

The 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).

### 3.5 Profitability of Different Category of the Rice Farmer

#### 3.5.1 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 was 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 was 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).

#### 3.5.2 Small farmer

Gross margin was estimated at Tk. 50844.49, Tk. 50897.62, Tk. 40809.15 and Tk. 46795.11 per hectare in 2009, 2010, 2011 and 2012 respectively. Net return was estimated at Tk. 31324.28, Tk. 29979.14, Tk. 25719.24 and Tk. 21776.97 per hectare in 2009, 2010, 2011 and 2012 respectively. Benefit-cost ratio was 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).

#### 3.5.3 Medium farmer

Gross margin was 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.

**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*

**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 Machinery	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 labour 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 Machinery	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 labour 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: Authors calculation, 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 Machinery	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 labour 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, 2011 and 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 Machinery	-	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 labour 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

56870.69, Tk. 31965.67, Tk. 23890.84 and Tk. 20074.89 per hectare in 2009, 2010, 2011 and 2012 respectively. Benefit-cost ratio was 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).

Table 6. Estimated values of the 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( $X_1$ )	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***	

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

### 3.5.4 Large farmer

Gross margin was 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 was 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 (Tables 2,3,4 and 5).

### 3.5.5 Major factors affecting the production of rice

Estimated values of the coefficient 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, machinery, human labour cost, seed cost and herbicides cost had a positive impact and only pesticide cost had the negative impact on the gross return of rice production during the time. All the variables were found significant in 2010 and 2012 at the different significant level which means there is an opportunity to increase gross return by using more quantity of those factors of production with decreasing pesticide cost. Fertilizer, human labour cost and seed cost were found significant in 2009 which means there is an opportunity to increase gross return by using more quantity of fertilizer, human labour cost and seed cost. Machinery, human labour cost, seed cost, pesticide cost and herbicides cost were found significant in 2011 which means by using more quantity of machinery, human labour cost, seed cost and herbicides cost; using less pesticide there is an opportunity to increase gross return. Fertilizer cost, machinery cost, human labour cost, seed cost, herbicides cost and pesticide cost were found significant in 2012 which means by using more quantity of fertilizer, machinery, human labour, seed and herbicides ; using less pesticide there is opportunity to increase gross return, which was also found for 2010 (Table 6).

The result of Rasyid et al. [12] was that seed, pesticide, fertilizer, labour were the significant

factors for 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 [13] 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, machinery cost, human labour cost, seed cost and herbicides cost. The reason is that these factors of production have a 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 especially marginal and small scale farmers of Bangladesh.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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