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Efficiency of Rice Farms during Boro Period in Bangladesh: An Econometric Approach

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Dr. Mir Khaled Iqbal Chowdhury [α], Sherin Fatima Rumi [σ] & Dr. Md. Mushfiqur Rahman [ρ]

Abstract- Bangladesh is an agro-based economy. To achieve self sufficiency of food-grain production in Bangladesh, it is very important to increase the production of rice, particularly Boro rice. Production may be increased, firstly, by introducing modern technology in the long-run or secondly, by improving the efficiency of the farmers in the short-term. In this study, researcher is focusing to achieve the target by improving the efficiency of the farmers. Modern econometric tools, like Stochastic Frontier Approach (SFA) is used for measuring the efficiencies of the farmers. Empirical results of this study shows that average technical, allocative and economic efficiency of the farmers during Boro period are 86 per cent, 75 per cent and 64 per cent respectively. So, it is possible by making the farmers technically and allocatively efficient, production of Boro rice could be increased by 14 to 36 per cent without any increase in input use, technology is given. In this study, we also find some important inefficiency factors which affect the production of Boro rice in Bangladesh, such as, inadequate extension services, insufficient credit facilities, and land degradation. Importantly, we are trying to quantify them by using Tobit regression model. Study suggests that authority should address these inefficiency factors properly and take necessary action by increasing credit facilities and extension services and reducing land degradation by using more environment friendly fertilizers and pesticides. Therefore, it expected that inefficiency of the farmers decrease and eventually the target of self-sufficiency of food-grain production by 2013 may be achieved.

I. Introduction

Bangladesh is an agro-based country. Though the contribution of agricultural sector in Bangladesh economy is decreasing day by day, but its real impact on the whole economy is still comprehensive. Contribution of agricultural sector of GDP was 20.01 per cent in 2010-2011 and in 2011-2012 it was 19.29 per cent. Agriculture has also an indirect contribution to the GDP. About 43.6 per cent labour forces are engaged in agriculture directly or indirectly.

Serial food production is main agricultural product of it. Rice is dominated crop in agriculture. Boro is the major part of rice production in Bangladesh. Food-grain production in Bangladesh was 36.065 million metric tons in 2010-2011, of which Aus rice was 2.133 million metric tons, Aman rice was 12.791 million metric tons and Boro rice was 18.617 million metric tons. Total rice production was increased by 33 per cent in seven years during 2004-2005 to 2010-2011. Particularly, Boro rice production was increased by 35 per cent during that period. Food-grain import in 2010-2011 was 5.15 million metric tons, of which rice import was 1.554 million metric tons and wheat import was 3.596 million metric tons. So, by increasing the production of Boro rice, Bangladesh can reduce import of food-grain.

Bangladesh has settled a target of food sufficiency by the end of 2013. Total food deficit of Bangladesh is about 2.5 million metric tons. To ensure the food security of the country, it is essential to increase the food-grain production, particularly rice production. Boro is dominated among the rice production, so we may be given more emphasis to increase Boro rice production.

Production of Boro rice can be increased in two ways: Firstly, by increasing the efficiency of Boro rice producer which takes lesser time. Secondly, by introducing technological change, which takes longer time and as well as required huge amount of investment. In this study researcher focuses to increase Boro rice production by improving efficiency of the farmers, because Government of Bangladesh has settled to achieve self-sufficiency of crop production by the end of 2013. So, to take short-term but appropriate strategy to increase rice production is more justifiable.

II. Objectives of the Study

Find out the problems and subject matters, discussed above, we may select the objectives of the study are:

a) To measure the efficiency of the Boro rice producer;
b) To mention the ways of optimum utilization of resources during Boro rice production;
c) To identify and quantify factors which affect efficiency of Boro rice farmers;
d) To suggest some important and useful policies for improving the production of rice during Boro season.

III. Methodology of the Study

a) *The Survey Method*

This study is based on survey method. Researcher used primary data in this study for estimating the efficiency of Boro rice farmers. Data are

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collected by questionnaire method and face to face interview method. We have taken sample from different parts of Barind area of Bangladesh. Total 205 samples are selected from the study area. Both simple random sampling and purposive sampling techniques are used for selecting these samples. Three different districts from Barind area are selected. Then one upazella (sub-district) from each district is selected. Then three or four villages from each upazella are selected under the procedure of purposive sampling. Then 20-25 farmers from each village are selected by simple randon sampling.

b) Questionnaire Designing

In this study we have used both open-ended and structured closed type questionnaire. There are four sections in the questionnaire: personal and social status related questions in the first section; production and cultivation related question in the second section. The third section contains non-farm income and activities related questions and final section includes livestock related questions.

c) The Survey Data

In this study we used the primary data which are collected from three different upazell of three different districts in the High Barind area of Bangladesh. The survey data are collected for the Boro season from November to February in 2010-2011.

IV. The Conceptual Framework

a) Production Function

The concept of the production function is basic to the development of the theory of farm in microeconomics. In the classical non-stochastic theory of the farm a production function is defined as a schedule showing the maximum amount of output that can be produced from a specified set of inputs, giving the existing technology (Ferguson, 1966).

In general, we may describe production function as a technical relationship between inputs and outputs of a production process. Alternatively, production function defines the maximum output attainable from a given set of inputs.

Following Battese and Taylor, (1985) we may take these assumptions for a simple production function:

a) The production process is mono-periodic,
b) All inputs and outputs are homogeneous,
c) The production function is twice continuously differentiable,
d) Output and input prices are known with certainty,
e) The goal of the farm is to maximize profit (or minimize cost for a specified output level).

Now, we consider a simple production process in which a farm utilizes two variable inputs (x¬1 and x2) and one or more fixed inputs in order to produce a single output (y).

The production functions are usually represented by a mathematical function as

$$y = f\left(x_1, x_2, \nu, \gamma\right) \tag{1}$$

where ν denotes returns to scale which refers to the long-run analysis of production, since it assumes change in the plant. γ means a efficiency parameter which refers to the organizational aspect of production.

f) Efficiency

Farrell's (1957) seminal article has led to the development of several techniques for the measurement of efficiency of production. The term 'efficiency' implies the success with which a farm best utilizes its available resources to produce maximum levels of potential outputs (Dinc et. al., 1998). A farm is efficient if and only if it is not possible to increase output (or decrease inputs) without more inputs (or without decreasing output) (Cooper, et. al., 1995). Any failure to obtain this potential maximum output results in inefficiency. The neoclassical theory of production defines the production function based on the notion of efficiency that gives the maximum possible output for given amounts of inputs. It is not realistic to recognize this 'maximum' output simply by observing the actual amount of output unless the observed output is assumed to be a maximum; different farms produce different output levels even if they utilize the same input vector (Kumbhakar, 1994).

Farrell (1957) proposed that efficiency of a farm consists of two components: technical efficiency and allocative efficiency. The concept technical efficiency, which represents the ability of a farm to obtain maximum output from a given set of inputs, or the ability to minimize input use in the production of a given output vector. Thus the production frontier is associated with the maximum attainable level of output, given the level of inputs, or the minimum level of inputs required to produce a given output. In other words, it is the locus of maximum attainable output for each input mix. Technical inefficiency is attributed to a failure of the farm to produce the frontier level of output, given the quantities of inputs (Kumbhakar, 1994).

Allocative efficiency reflects the ability of a farm to use the inputs in optimal proportions, given their respective prices. Alternatively, allocative inefficiency arises if farms fail to allocating inputs which minimize the cost of production of an output, given relative input prices. Failure in allocating resources optimally results in increased cost and decreased profit. In particular, a farm is said to be allocatively inefficient if the marginal rate of technical substitution between any two inputs is not equal to the corresponding ratio of input prices, that is, allocative inefficiency exists when the farm fails to use cost-minimizing input mixes. The distinction between technical and allocative efficiency provides four ways for explaining the relative performance of farms. Firstly, a farm might be technically and allocatively inefficient, secondly; it may be technically efficient, but allocatively inefficient; thirdly, it may show allocative efficiency, but technical inefficiency; finally, it may be both technically and allocatively efficient.

These two measures technical efficiency and *allocative efficiency* - are then combined to provide a measure of economic efficiency, which reflects the ability of a farm to produce output at minimum cost. Thus, either one of the efficiencies may be necessary but not sufficient conditions to ensure economic efficiency for a farm. The simultaneous attainment of both efficiencies gives the sufficient condition to ensure economic efficiency (Ellis, 1988).

V. Empirical Models and Results

a) *The Estimated Model*

In our study we apply a Cobb-Douglas frontier because it is self-dual and its dual cost frontier model forms the basis for computing technical, allocative and economic efficiency as follows:

$$\ln \tilde{y}_i = \beta_0 + \sum_{k=1}^{6} \beta_{ik} \ln x_{ik} + \xi_i - \zeta_i \quad \text{(i=1, 2, …, 205, number of farms)} \tag{2}$$

Now, subtracting from both sides of (2) yields:

$$\ln \tilde{y}_i = \ln \tilde{y}_i - \xi_i = \beta_0 + \sum_{k=1}^{6} \beta_{ik} \ln x_{ik} - \zeta_i$$

where $\tilde{y}_i$ now denotes the farm's observed output adjusted for the stochastic random noise captured by ξ_i. This equation constitutes the basis for obtaining the technically efficient input vector x_{ik}^T and algebraically deriving the dual frontier cost function which is the basis for calculating the economically efficient (technically and allocatively efficient) input vector x_{ik}^E . The dual frontier cost function model is analytically derived from the stochastic frontier production model as:

$$C(p_{ik}, \tilde{y}_i) = \alpha_0 \prod_{k=1}^{6} p_{ik}^{\beta_{ik}\alpha_{ik}} \tilde{y}_i^{\alpha_{ik}} \tag{3}$$

where $\alpha_0 = \left(\frac{1}{\beta_0^{\alpha_{ik}}}\right)\left(\sum_{k=1}^{6} \beta_{ik} \Big/ \prod_{k=1}^{6} \beta_{ik}^{\beta_{ik}\alpha_{ik}}\right)$ and $\alpha_{ik} = \frac{1}{\sum_{k=1}^{6} \beta_{ik}}$

Differentiating (3) with respect to each input's price and applying Shephard lemma provide the system of input demand function as:

$$x_{ik}^E = \frac{\partial C(p_{ik}, \tilde{y})}{\partial p_{ik}} = x_{ik}^E(p_{ik}, \tilde{y}_i) = \alpha_0(\beta_{ik}\alpha_{ik}) \prod_{k=1}^{6} \frac{1}{p_{ik}} p_{ik}^{\beta_{ik}\alpha_{ik}} \tilde{y}_i^{\alpha_{ik}} \tag{4}$$

Alternatively:

$$x_{ik}^E = \frac{\partial C(p_{ik}, \tilde{y})}{\partial p_{ik}} = \frac{\partial C}{\partial p_{ik}} = C.\frac{\alpha_{ik}}{p_{ik}}$$

where C denotes $C(p_{ik}, \tilde{y})$ is cost function and $\alpha_{ik} = \beta_{ik} \Big/ \sum_{k=1}^{6} \beta_{ik}$ (i=1, 2, …, 205, number of farms). We also solve for the technically efficient input vectors x_{ik}^T using the results from the stochastic frontier production function in (2). Multiplying the observed input vectors x_{ik}, technically efficient input vectors x_{ik}^T and economically efficient input vectors x_{ik}^E by the input price vectors provides the observed, technically efficient and economically efficient costs of production of the ith farm equal to $p_{ik}x_{ik}$, $p_{ik}x_{ik}^T$, and $p_{ik}x_{ik}^E$ respectively which compute the TE , AE and EE indices for the ith farm as:

$$TE = p_{ik}x_{ik}^T / p_{ik}x_{ik} \; ;$$

$$AE = p_{ik}x_{ik}^E / p_{ik}x_{ik}^T \text{ and}$$

$$EE = p_{ik}x_{ik}^E / p_{ik}x_{ik} \text{ respectively.}$$

Pesticides, x_{i5} is the total quantity of pesticides used per acre of land and is measured also in kilograms. The price of pesticides, p_{i5} is the price of all pesticides per kilogram. Seeds, x_{i6} represents the amount of seeds used in per acre of land and is measured in kilograms. The seed price, p_{i6} means the average prices of seeds per kilogram (includes both HYV and traditional type of seeds).

To assess the role of human capital variables, extension services, irrigation infrastructure and environmental factors in technical, allocative and economic efficiency, the following inefficiency effects model is estimated separately by using Tobit Regression Model

$$IE_i = \delta_0 + \delta_1 z_{i1} + \delta_2 z_{i2} + \delta_3 z_{i3} + \delta_4 z_{i4} + \delta_5 z_{i5} + \delta_6 z_{i6} + w_i \tag{5}$$

where the z_i are the socio-economic and infrastructural variables which affect production and as well as efficiency of the farmers. The variable z_{i1} denotes the year of the schooling of the farmer; z_{i2} denotes the year of rice cultivation experience of the farmer; the variable z_{i3} represents the land fragmentation; z_{i4} denotes the extension services dummy which assumes the value one if the farmer takes extension services from the related officials and zero otherwise; z_{i5} indicates credit facilities dummy which assumes the value one if the farmer takes any kind of credit from government and non-government sources and zero otherwise and z_{i6} denotes the degradation dummy which takes the value one if the land is un-degraded and zero otherwise. The value one for z_{i6} implies that most of the lands of an individual farm household are un-degraded.

The model includes a random error term, w_i which is normally and independently distributed with a zero mean and variance σ_w^2. The Tobit model is used as inefficiency, IE_i, is a limited dependent variable. The value of IE_i falls between zero and one; some of the values of IE_i are likely to be zero.

Now, for empirical study, we have defined output, y_i as the observed rice production and are measured in kilograms (km). Land, x_{i1} represents the total amount of land used for rice production and the price of land, p_{i1} represents the price per acre of land. Labour, x_{i2} includes both family and hired labour engaged in rice production and the price of labour, p_{i2} indicates the wage per man-day (wages for family labour are imputed). Irrigation, x_{i3} is the total amount of land irrigated for rice production and the price of irrigation, p_{i3} represents irrigation price per acre. Fertilizer, x_{i4} includes all organic and inorganic fertilizer and is measured in kilograms. The fertilizer price, p_{i4} indicates the average price all fertilizer per kilogram.

b) The Cobb-Douglas Stochastic Frontier Results

The maximum likelihood estimates of the parameters of Cobb-Douglas frontier are estimated using the econometric software Frontier 4.1 (Coelli, 1996). These are presented in Table 1 for Boro season. We expect the signs of all of the coefficients are positive. We obtain positive coefficients for all six parameters. In field level survey, we have observed some significant behaviour for labour and seeds. It shows that there are already abundant supplies of labour in agriculture sector of Bangladesh, particularly in the study area of northern part of Bangladesh. In the case of seed, they used excessive amount of seed. Therefore, we have some unusual results and behaviours of both coefficients of labour and seeds. All the coefficients are significant except seeds.

Table 1 : Maxi mum-Likelihood Estimates of the Stochastic Frontier Model for Boro Season

Stochastic Frontier

Name of Variables	Parameters	Coefficients	t-ratios
Constant	β_0	0.4641	3.2048
Land	β_1	0.1448	4.2643
Labour	β_2	0.8898	2.2554
Irrigation	β_3	0.9092	5.1000
Fertilizer	β_4	0.3695	2.7491
Pesticides	β_5	0.4157	2.4813
Seeds	β_6	0.2788	0.3269
Inefficiency Model			
Constant	δ_0	0.136	9.501
Year of Schooling	δ_1	0.0011	1.021
Experience	δ_2	0.00176	3.735
Land Fragmentation	δ_3	-0.0108	-13.174
Extension Services Dummy	δ_4	0.0296	0.424
Credit Facilities Dummy	δ_5	0.00749	0.108
Land Degradation Dummy	δ_6	-0.0819	-8.081
Variance Parameters			
Sigma-squared	$\sigma^2 = \sigma_\xi^2 + \sigma_\zeta^2$	0.1437	5.9550
Gamma	$\gamma = \left(\sigma_\zeta^2 / \sigma^2 \right)$	0.5882	6.7013
	σ_ξ^2	0.0592	
	σ_ζ^2	0.0845	
Log likelihood Value		16.8526	

The estimates of the variance parameter and the parameter of are significantly different from zero. This indicates that the inefficiency effects are significant in determining the level and variability of output of farm households in Bangladesh. This result is consistent with Sharma et. al. (1997) and Coelli and Battese (1996). This shows that a conventional production function is not an adequate representation of the data.

c) Estimated Production, Cost and Input-Demand Functions

The estimated production function and its corresponding cost function are given below.

Now, we can derive the estimated production function and its corresponding dual cost function and input demand function for boro season.

Production Function for Boro Season is,

$$\ln y_i = 0.4641 + 0.1448 \ln x_{i1} + 0.8898 \ln x_{i2} + 0.9092 \ln x_{i3} + 0.3695 \ln x_{i4} + 0.4157 \ln x_{i5} + 0.2788 \ln x_{i6}$$

or, alternatively,

$$y_i = 0.4641\, x_{i1}^{0.1448}\, x_{i2}^{0.8898}\, x_{i3}^{0.9092}\, x_{i4}^{0.3695}\, x_{i5}^{0.4157}\, x_{i6}^{0.2788} \qquad (6)$$

(where i=1, 2, …, 205, number of farms)

The corresponding dual frontier cost function is analytically derived as follows:

$$C(p_{ik}, \tilde{y}_i) = \alpha_0 \prod_{k=1}^{6} p_{ik}^{\beta_{ik}\alpha_{ik}}\, \tilde{y}_i^{\alpha_{ik}}$$, notations are given earlier

$$C(p_{ik}, \tilde{y}_i) = 6.5195\, p_{i1}^{0.1448(0.3324)}\, p_{i2}^{0.8898(0.3324)}\, p_{i3}^{0.9092(0.3324)}\, p_{i4}^{0.3695(0.3324)}\, p_{i5}^{0.4157(0.3324)}\, p_{i6}^{0.2788(0.3324)}\, \tilde{y}_i^{0.3324}$$

Thus, the Cost Function for Boro Season is:

$$C_i = 6.5195\, p_{i1}^{0.0481}\, p_{i2}^{0.2957}\, p_{i3}^{0.3022}\, p_{i4}^{0.1228}\, p_{i5}^{0.1381}\, p_{i6}^{0.0926}\, \tilde{y}_i^{0.3324} \qquad (7)$$

(where *i*=1, 2, …, 205, number of farms) (7)

(where i=1, 2, …, 205, number of farms)

Input Demand Function for Boro Season:

Differentiating the cost function with respect to each input's price and applying Shephard Lemma provide the system of input demand function as follows:

$$x_{ik}^{E} = \frac{\partial C(p_{ik}, \tilde{y})}{\partial p_{ik}} = x_{ik}^{E}(p_{ik}, \tilde{y}_i) = \alpha_0(\beta_{ik}\alpha_{ik}) \prod_{k=1}^{6} \frac{1}{p_{ik}}\, p_{ik}^{\beta_{ik}\alpha_{ik}}\, \tilde{y}_i^{\alpha_{ik}},$$

For example, input demand function for input 1 in boro season is:

$$x_{i1} = \frac{\partial c}{\partial p_{i1}} = 6.5195(0.0481)\, p_{i1}^{(0.0481-1)}\, p_{i2}^{0.2957}\, p_{i3}^{0.3022}\, p_{i4}^{0.1228}\, p_{i5}^{0.1381}\, p_{i6}^{0.09268}\, \tilde{y}_i^{0.3324}$$

or, alternatively, $$x_{i1} = \frac{0.3135\, p_{i2}^{0.2957}\, p_{i3}^{0.3022}\, p_{i4}^{0.1228}\, p_{i5}^{0.1381}\, p_{i6}^{0.0926}\, \tilde{y}_i^{0.3324}}{p_{i1}^{0.9519}} \qquad (8)$$

(where i=1, 2, …, 205, number of farms).

Similarly, we solve the technically efficient input vector x_{i1}^{T} using the results in (8) in Boro season and observed input ratios $x_1/x_{i1} = k_1$ $(i \neq 1)$. Then multiply the observed input vectors x_{i1}, technically efficient input vectors x_{i1}^{E} and economically efficient input vectors x_{i1}^{E} by their input price vectors provides the observed, technically efficient and economically efficient costs of production of the 1st farm in boro season equal to $p_{i1}x_{i1}$, $p_{i1}x_{i1}^{T}$ and $p_{i1}x_{i1}^{E}$ espectively. Then we compute technical, allocative and economic efficiency for farm 1 in Boro season as:

$$TE = p_{i1}x_{i1}^{T} / p_{i1}x_{i1}\ ;\ AE = p_{i1}x_{i1}^{E} / p_{i1}x_{i1}^{T} \text{ and } EE = p_{i1}x_{i1}^{E} / p_{i1}x_{i1} \text{ respectively.}$$

d) Estimated Technical, Allocative and Economic Efficiency

Technical, allocative and economic estimates for Boro seasons are presented in Table 2.

Table 2 : Technical, Allocative and Economic Efficiency of Farms in Boro Season

Efficiency Index (%)	Stochastic Frontier					
	Number of Farms			Percentage of Farms		
	TE	AE	EE	TE	AE	EE
1.00-40	0	16	20	0	7.8	9.76
40-45	1	3	12	0.49	1.46	5.85
45-50	0	13	18	0	6.34	8.78
50-55	2	15	14	0.98	7.32	6.83
55-60	1	11	11	0.49	5.37	5.37
60-65	3	4	17	1.46	1.95	8.29
65-70	8	8	24	3.9	3.9	11.7
70-75	6	15	27	2.93	7.32	13.2
75-80	16	19	26	7.8	9.27	12.7
80-85	33	16	21	16.1	7.8	10.2
85-90	42	21	9	20.5	10.2	4.39
90-95	55	24	6	26.8	11.7	2.93
95-100	38	40	0	18.5	19.5	0
total	205	205	205	100	100	100

Table 3 : Summary Statistics of Efficiency in Boro Season

Statistics	Stochastic Frontier		
	TE	AE	EE
Mean	**86.82**	**75.00**	**64.13**
Minimum	41.95	30.49	30.01
Maximum	99.18	99.72	94.77
Std. dev	9.686	20.47	16.33
Skewness	-1.52	-0.59	-0.39
Kurtosis	3.164	-0.87	-0.82

Table 2 shows that 45 per cent farmers are 90 per cent or more technically efficient, 31 per cent farmers are more than 90 per cent allocatively efficient and only 3 per cent farmers more than 90 per cent economically efficient in Boro season.

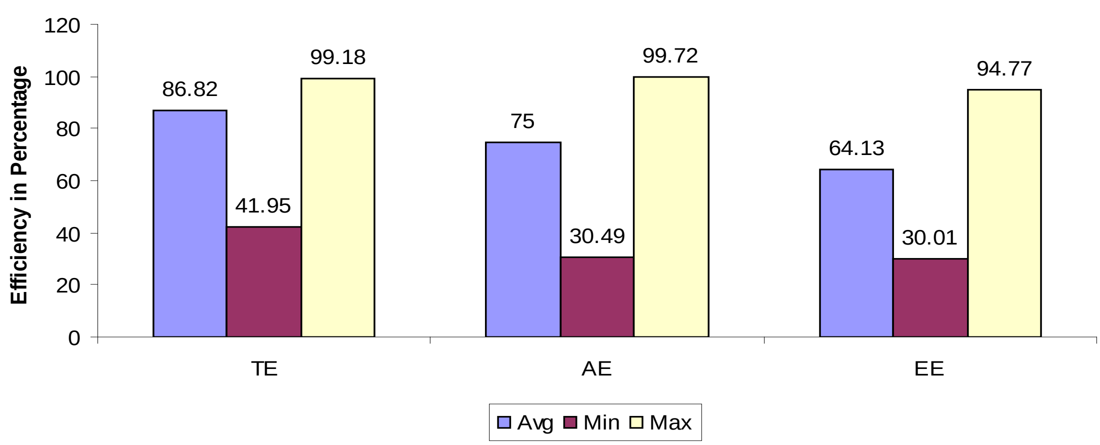

Figure 1 : Maximum, Average and Minimum Efficiency Scores of Farms in Boro Season

The average estimates of technical, allocative and economic efficiency for farms in Boro seasons are shown in Figure 1.

The frequency distribution and summary statistics of the estimated technical, allocative and economic efficiency of farms in Boro seasons are presented in Table 3. The estimated mean technical, allocative and economic efficiency in Boro season are 87, 75 and 64 per cent respectively. This indicates that there is considerable inefficiency in Boro production in that region and therefore rooms for production gain through efficiency improvement. More specifically it can be said that farm households could reduce their production cost by 13, 25 and 36 per cent if they could operate at full technical, allocative and economic efficiency levels respectively.

Frequency histogram of technical, allocative and economic efficiency index for Boro season is given in diagrams from Figure 2 to Figure 4.

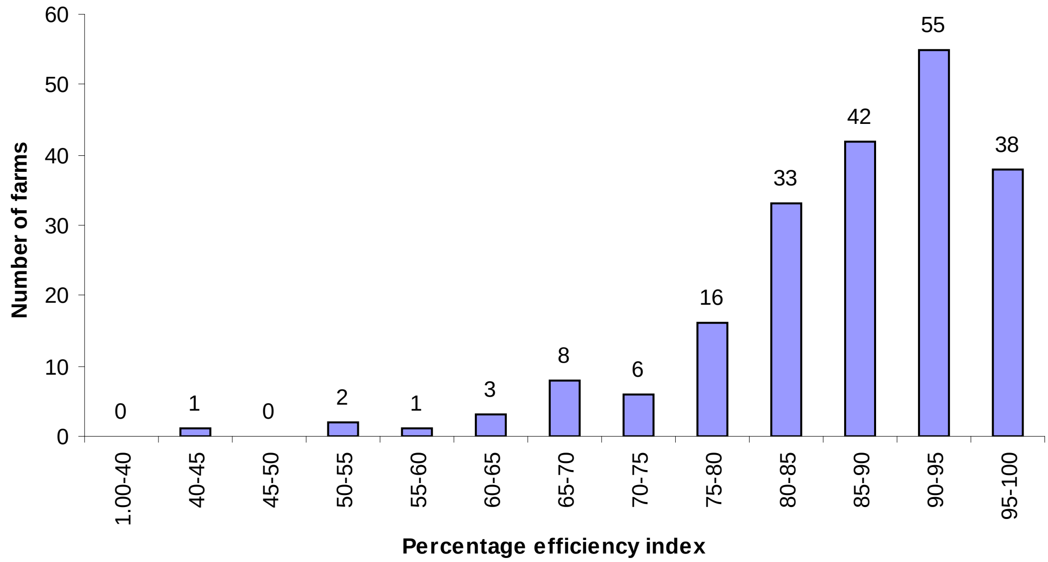

Figure 2 : Frequency Histogram of Technical Efficiency Index in Boro Season.

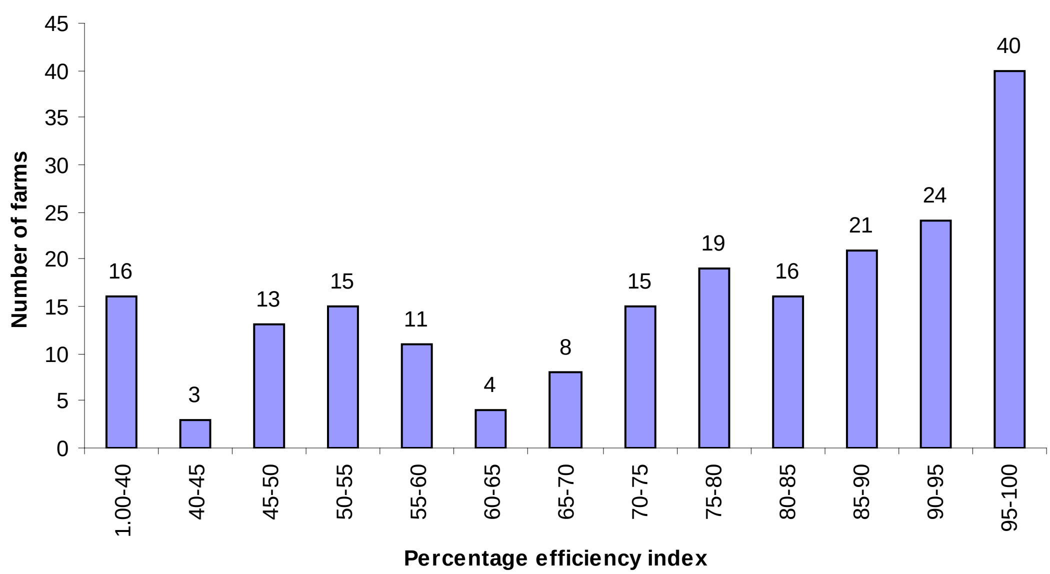

Figure 3 : Frequency Histogram of Allocative Efficiency Index in Boro Season.

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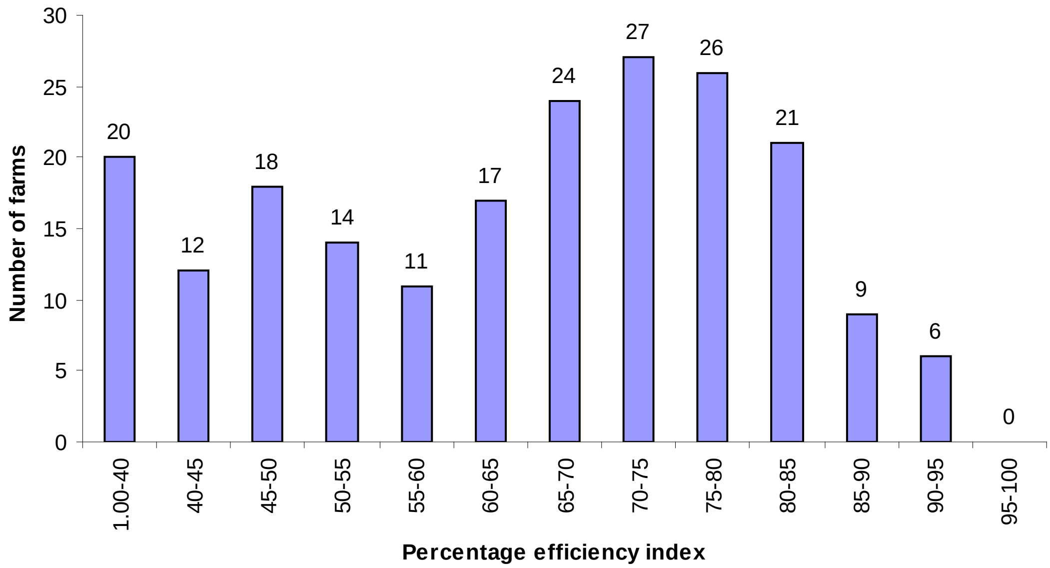

Figure 4 : Frequency Histogram of Economic Efficiency Index in Boro Season.

Highest numbers of technically efficient farms are found in 90-95 per cent efficiency class interval. In case of allocatively efficient farms, different results are found. Highest numbers of allocatively efficient farms are seen in 95-100 percent efficiency class interval. On the other hand, maximum economically efficient farms are in in 70-75 per cent efficiency class interval at boro season.

e) Factors Affecting Technical, Allocative and Economic Inefficiencies in Boro Season

We can assess the role human, socio-economic and environmental factors to explain the causes of inefficiency of farmers during Boro season. Results of Tobit regression model for factors affecting inefficiency during Boro season are presented in Table 4.

Table 4 : Factors Affecting Inefficiency during Boro Season

Boro Season	Factors					
	TI		AI		EI	
	Co-efficients	t-ratios	Co-efficients	t-ratios	Co-efficients	t-ratios
Constant	0.136	9.501	0.08893	2.401	0.212	6.839
Yrs. of Schooling	-0.0011	-1.021	0.00607	2.162	0.00639	2.723
Exp. of the Farmers	0.00176	3.735	-0.00057	-0.443	0.00092	0.897
Land Fragmentation	-0.0108	-13.174	0.01456	0.869	-0.00486	-2.746
Extension Service Dummy	0.0296	0.424	-0.137	-0.757	-0.0877	-0.580
Credit Facilities Dummy	-0.00749	-0.108	0.183	1.018	0.147	0.982
Land Degradation Dummy	-0.0819	-8.081	-0.0133	-0.508	-0.05615	-2.561
Log Likelihood	100.04		111.47		151.60	

The coefficient of year of schooling for TI is negative and significant. This means a positive effect on efficiency. In other words, more educated persons are technically more efficient in Boro season. In contrast, less educated persons are allocatively and economically more efficient in this season.

The coefficient of length of experience for technical and economic efficiency is positive, but allocative efficiency is negative. This means that relatively new farmers are technically and economically more efficient but experienced farmers can handle inputs more efficiently.

The coefficients of land fragmentation for all efficiencies are negative, except AI in Boro season. This indicates that greater land size provides more efficiency for the farmers. Because the farmers can easily apply modern technology in bigger size of lands and also it is more economic.

The negative coefficients of extension services and credit facilities imply that they have positive effects on efficiency of farmers. As we increase the quality extension services, farmers become able to allocate their inputs more efficiently and cost of production decreases. Similarly if we provide more credits in easiest way to the poor and marginal farmers, they become more efficient in production process.

The coefficients of environmental factor are negative in all cases. This indicates that less land degraded farmers have more and more efficiency. The coefficients of land degradation in TI and EI in Boro are significant.

VI. Conclusions

a) Findings of the Study

We have estimated technical, allocative and economic efficiencies of Boro rice farms using a cost decomposition technique specifying a self-dual Cobb-Douglas stochastic frontier production model. The model is estimated by the maximum likelihood method. The estimated parameters of the model are all positive, as expected. From this it is clear that there are plenty of rooms to enhance the productivity of Boro rice cultivation as far as efficiency is concerned. We have found average technical, allocative and economic efficiency scores are 86 per cent, 75 per cent and 64 per cent respectively. More specifically 14 per cent technical efficiency, 25 per cent allocative efficiency and 36 per cent economic efficiency could be improved in this season without changing or improving the cultivation technologies if the farmers operate at full efficiency scale. So, the policy makers could give more attention for improving the production and reducing the production cost of the farmer by increasing their efficiency levels.

The inefficiency effects models are assumed by Tobit regression analysis. The results of human, socio-economic and environmental factors are reported. More educated farmers are more technically efficient. On the other hand, less educated but more experienced farmers are capable of managing inputs efficiently. Fragmentation is one of the major problems to increase production of rice in our country. This study suggests that less fragmented land gives more opportunity to use modern technology. Better and appropriate land tenure policy, for example, cooperative farming, giving government khash land to the landless but genuine farmers, will be helpful for the farmers to improve efficiency. Finally, land degradation hampers the efficiency of the farmers. So, policy makers could think to improve the environment of the soil by reducing erosions and deforesting of land and also improving the working condition of the area.

VII. Recommendations

The average scores of technical, allocative and economic efficiency for Boro season are 86, 75 and 64 per cent respectively. So, there is an opportunity to increase the technical efficiency of farmers by 14 per cent, allocative efficiency by 25 per cent and economic efficiency by 36 per cent without any change or improve in cultivation technologies if the farmers operate at the full efficiency scale.

Results of Tobit Regression Model shows that inefficiency effects in production are influenced by many factors. One of the major inefficiency effect factors in production is land fragmentation, that is, smaller plot sizes. So policies should be targeted in such way that the existing land tenure and land management system can reduce land fragmentation. Evaluating factors related to inefficiency suggests that extension services, credit facilities, land degradation and irrigation infrastructure are statistically most significantly associated with technical, allocative and economic inefficiency.

Tobit Regression Model results also show that extension services are directly related to efficiency of the farmers. Field survey to the study area also indicates that in this region we have seen very poor extension service facilities to the grass-root level farmers. So, if the agricultural department authority gives appropriate effort to improve the extension services, it would be expected that farmer's efficiency in Boro rice cultivation will improve. Therefore, policies should be targeted to increase quality and regular extension services for the grassroots and marginal farmers.

Credit facility is one of the important factors which related to the efficiency of the farmers. Credit facility particularly agriculture credit facility in this study area as well as in Bangladesh is not so organized. Empirical results suggest that credit facility factor is directly related to the efficiency. At the same time during the field level survey we have seen that there are lots of difficulties for the farmers to get agriculture credit. For example, government financial institutions like Bangladesh Krishi Bank (Bangladesh Agriculture Bank), Rajshahi Krishi Unnayan Bank (Agriculture Development Bank of Rajshahi) and other institutions have lots of formalities and processes which discourage the rural and low educated farmers to go there for loans. On the other hand, non-government organizations and other institutions which have credit programs especially micro credit programs are generally not interested to agriculture. Even they have some credit program for agriculture; the interest rate is so high that farmers were not benefited by taking that kind of credits. Another serious problem should be noted here that the marginal farmers sale their products or crops in advance to get credit from local Mahajans (village micro-credit providers). Therefore, they do not get appropriate price for their crops. It is one of the major obstacles for the farmers to operate at the maximum level of efficiency. So, policies should be targeted to improve the credit facilities for the farmers. Credit system should be simple and disciplined and formalities should be minimized, so that target people can get credit as easiest way as possible.

Irrigation infrastructure is another prime factor to influence efficiency of the farmers in Bangladesh. Irrigation infrastructure has developed sufficiently in the Barind region by the help of Barind Multipurpose Development Authority (BMDA). Moreover, Rural Electrification Board (REB) supplies power to the Deep Tube-wells. So, policies should be to keep this irrigation infrastructure and also can introduce by under ground drainage system. Electricity supply should be widening to every Deep Tube-well and uninterrupted at the time of irrigation.

Land degradation is considered as an environmental factor. Results show that it decreases technical, allocative and economic efficiency. So, it implies that land degradation decreases farmers' ability to utilize the existing technology in full capacity and also creates problems for the allocation of inputs in a cost minimizing way. On the other hand, results indicate that human factors such as, age and cultivation experience of farmers during Boro period and duration of formal education i.e., years of schooling are more or less affect the efficiency of the farmers.

Government of Bangladesh, in recent time, is giving more emphasis on agriculture sector. For these purpose, they might have continued the agriculture subsidy, so that the farmers can survive and maintain their living standard. But the government should strictly supervise that the benefits of the subsidized money have gone to the targeted and marginal farmers of the country. This study suggests that if the policy makers give more attention to the inefficiency factors which are identified in this study, then it will be easier to help the rural level farmers as far as efficiency is concerned. Production and new technology related to education and training program should be extended by the Thana (sub-district) extension agriculture offices. So the target people could be educated and proper trained. Therefore, they will be capable to operate the existing technology more efficiently and can easily adapt the new technology to come. So, policies to reduce land-degradation and to use more environment friendly fertilizer and pesticide will decrease technical, allocative and economic inefficiency and hence eventually increase Boro rice production and welfare of the farm-household of the country.

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