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# EFFICIENCY ANALYSIS OF BORO RICE PRODUCTION IN NORTH-CENTRAL REGION OF BANGLADESH

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## ABSTRACT

Data envelopment analysis (DEA) has been widely used in agricultural production efficiency analysis in recent years. Based on the existing state of DEA technology, this paper estimates technical, allocative, economic, and scale efficiency using field-level survey data from a sample of 199 Boro rice farmers in north-central part of Bangladesh for the year of 2010. The results of the study revealed that on average, the farms technical, allocative, economic, and scale efficiencies were 0.93, 0.82, 0.69, and 0.90 respectively. Their existing technical, allocative, economic and scale inefficiencies were 7%, 18%, 31%, and 10%, respectively. In addition, a second stage Tobit regression showed that the variation was also related to farm-specific attributes such as education, family size, seed type, land tenancy, extension services, irrigation machine type, and sources of energy. Although tremendous development has been achieved in crop production in Bangladesh, the evidence suggests that farmers in Bangladesh fail to exploit the full potential of technology, and that input uses might be reduced through the adaptation and spread of improved agricultural mechanization. Farmers in Bangladesh would also benefit from making sure that a better supply of electricity is delivered to them, and being exposed to new varieties of rice which would be more efficient to grow in their particular conditions.

**Key words:** Boro Rice, Efficiency, DEA Model, Tobit Analysis, Bangladesh.

## INTRODUCTION

Rice (*Oryza Sativa* L.) is the staple food crop for more than half of the world's population (Anonymous, 2009). Bangladesh is the fourth largest producer (FAOSTAT, 2012) and third largest (FAPRI, 2009) consumer of rice in the world. The economy of Bangladesh is primary dependent on agriculture, which contributes about 20.24% to the Gross Domestic Product, and about 43.53% of the labor force is employed in agriculture (BER, 2010). It has a population of about 142.3 million with a growth rate of 1.34%, giving a population density of 964 per square kilometer (BBS, 2011). The increasing rate of rice production has lessened slightly over the past few years compared to the rate of population increase. To meet the additional needs, the country imports rice every year. The country had to import 0.087 million MT of rice in 2009-2010 (BER, 2010). In Bangladesh, rice is grown in three distinct seasons: Boro (post-monsoon rice) from January to June, Aus (pre-monsoon rice) from April to August, and Aman (monsoon rice) from August to December. Of the three types of rice, Boro rice alone contributes about 55% of total food grains, and is also highest in productivity (3.84 MT per hectare) compared to Aus rice (1.76 MT per hectare) or Aman rice (2.16 MT per hectare) (BER, 2010). However, the average rice yield in Bangladesh was 2.81 tones/hectare in 2008-2009 (BBS, 2010), which is much lower compared to those of other Asian countries such as China, South Korea, Indonesia, Japan, and Vietnam (FAPRI, 2009).

Previous studies about Bangladesh (Wadud and White, 2000; Rahman, 2002; Balcombe *et al*., 2008) focused mainly on technical or economic efficiency except Coelli *et al.* (2002). Like Coelli *et al*. (2002), this study applies data envelopment analysis (DEA), so it is not necessary to assume a simplistic functional form. However, the measurement of the production efficiency in agricultural production is an important issue from the standpoint of agricultural development, since it gives pertinent information useful for making sound management decisions, resource allocations, and for formulating agricultural policies and institutional improvement. Therefore, the objectives of this research were twofold. First, we aim to investigate the individual Boro rice farm's technical, allocative, economic, and scale efficiency. Second, we aim to assess the effects of several explanatory variables on rice farming. To fulfill the objectives of this study, the DEA model is used to measure the efficiency level, and the Tobit model is estimated as a function of various attributes of the farms to figure out which aspects of a farm's investment of human and physical resources might change to improve efficiency.

## MATERIALS AND METHODS

DEA is a well-established linear programming approach for measuring the relative efficiency of peer decision-making units (DMUs) that have multiple inputs and outputs, proposed by Charnes *et al*. (1978) and extended by Banker *et al*. (1984). In this paper, we used the non-parametric DEA method to investigate the technical efficiency (TE), allocative efficiency (AE), economic efficiency (EE), and scale efficiency (SE) of the sample Boro rice farmers. There are a number of multiple-input single-output production units (Boro rice farmers) to be evaluated, which were taken as DMUs. In this study, we used input-oriented efficiency measures because they reflect local reality, where a decrease in scarce resources (input) makes use more relevant.

**Meaning of efficiency:** Efficiency or performance analysis is a relative concept (Coelli *et al*., 1998). It relates to production analysis and measures the production with a ratio. TE relates to the degree to which a farmer produces maximum output from a given bundle of inputs, or uses the minimum amount of inputs to produce a given level of output when the technology exhibits constant returns to scale, but is likely to differ otherwise. These two definitions of TE are known as output-oriented and input-oriented efficiency measures, respectively. AE or price efficiency reflects the ability of a farm to use the inputs in optimal proportions, given their respective prices. EE is distinct from the other two, even though it is the product of TE and AE (Farrell, 1957), and reflects the ability of a production unit to produce a well-specified output at minimum cost. An economically-efficient firm might be both technically and allocatively efficient. However, this is not always the case as Adesina and Djato (1997) pointed out. SE relates to the most efficient scale of operation in the sense of maximizing average productivity. A scale-efficient farm has the same level of total technical and pure technical efficiency.

**Model specification:** The efficiency measurement methods used in this paper are derived from those presented in Färe *et al*. (1994), which are based upon the work of Farrell (1957), Afriat (1972), and Charnes *et al*. (1978). The estimation methods used in this research are explained below.

Assume that farm *j* (*j*=1, 2,.. 199) produces a single output ($y_j$) using a combination of inputs $x_{ij}$ (*i*=land, seed, chemical fertilizer, organic fertilizer, pesticide, human labor) as defined in the data and variables section.

The DEA model used for calculation of TE are:

$$\begin{aligned} & Min_{\theta,\lambda}\ \theta, \\ & Subject\ to\quad -y_i + Y\lambda \geq 0, \\ & \qquad \theta x_i - X\lambda \geq 0, \\ & \qquad N1'\lambda = 1 \\ & \qquad \lambda \geq 0, \end{aligned} \qquad (1)$$

Where θ is a scalar, $N1$ is a $N \times 1$ vector of ones, and λ represent an $n \times 1$ vector of constants. The value of θ obtained is the TE score for the i[th] farm.

The EE and AE are obtained through solving the following cost minimization DEA model:

$$\begin{aligned} & \min_{\lambda, x_{ni}^*}\ w_i x_{ni}^* \\ & Subject\ \ to \\ & -y_i + Y\lambda \geq 0, \\ & x_i^* - X\lambda \geq 0, \\ & N1'\lambda = 1, \\ & \lambda \geq 0, \end{aligned} \qquad (2)$$

where $w_i$ is a vector of input prices for the $i^{th}$ farm and $x_{ni}^*$ (which is calculated by the model) is the cost minimizing vector of input quantities for the $i^{th}$ farm, given the input prices $w_i$ and the output levels $y_i$. The total cost efficiency (CE) or EE of the $i^{th}$ farm is calculated by comparing the minimum cost of the farm to its actual cost:

$$EE_i = \frac{w_i' x_i^*}{w_i' x_i} \qquad (3)$$

The AE is calculated residually by following the definition of Farrell (1957):

$$AE_i = \frac{EE_i}{TE_i} \qquad (4)$$

Given that the production technology is of the VRS type, SE measure can be obtained by using the following formulae (Coelli *et al.*, 2005):

$$SE_i = \frac{TE_{CRS}}{TE_{VRS}} \qquad (5)$$

**Identifying factors of efficiency:** The second step in the analysis is to identify the factors that influence farm TE, AE, EE and SE using a Tobit model. It is customary to regress the DEA efficiency scores on the relevant control variables (Fethi *et al*., 2000; Hwang and Oh, 2008). Since the dependent variable, efficiency, is a censored variable with an upper limit of one (Lockheed *et al*., 1981), it is pertinent to use the Tobit model, which is a censored regression model, applicable in cases where the dependent variable is constrained in some way. The Tobit model may be defined as:

$$Y = \begin{cases} y^*; & 0 <= y^* <= 1 \\ 0; & y^* < 0; \\ 1; & 1 < y^* \end{cases}$$

$$y^* = x_i + \varepsilon_t \qquad (6)$$

where

y is the DEA efficiency score; $\varepsilon_t$ ~ N(0, σ2);

y* is a latent (unobservable) variable;

β is the vector of unknown parameters which determines the relationship between the independent variables and the latent variable;

$x_i$ is the vector of explanatory variables.

Thus, the Tobit model used in this study may be specified as:

$$y^* = \sim + {}_1AG + {}_2ED + {}_3FS + {}_4LS + {}_5ST + {}_6OCU + {}_7LT + {}_8ES + {}_9IM + {}_{10}SE + {}_{11}WB + + {}_{12}LD + £_t \quad (7)$$

where

$y^*$ is the dependent variable (TE, AE, EE and SE of rice farms);

ε is the error term.

The full meaning of the abbreviated independent variables can be found in Table 4.

**Data and variables:** The data used in this study was based on a direct interview survey of 199 randomly-selected Boro rice farmers in three villages, namely Churkhai, Borobilarpar, and Choknojur, under Sadar upazila of Mymensingh district. The villages were purposefully selected for the study to represent some identical physical characteristics like land type, topography, soil and climatic condition in the north-central region of Bangladesh. This area is a major rice-growing area belonging to Agro-Ecological Zone (AEZ) number 9, known as the Old Brahmaputra flood plain. The data was for the 2010 Boro crop season and was collected from July 2011 to September 2011. The data was composed in Excel and analyzed using DEAP version 2.1 described in Coelli (1996). We also used STATA version 10 software to resolve the Tobit regression. The variables selected for use in this research are presented in Table 1. Additional variables like irrigation, power tiller, threshing, and capital were not included, because they were effectively uniform across the sample. Although, irrigation was lead input for Boro rice production, but per hectare charge of irrigation was near to similar. For the same reason, Coelli *et al*. (2002) was not included this variable in their DEA study in Bangladesh.

The table shows that the average land size for Boro rice production was 0.69 hectares. Land represents different types of land (own-cultivated land, sharecropping land, and rented/leased land) used for rice production, and the price of land represents rent per hectare of land for one season. Human labor is required for different farm operations like land preparation, transplanting, weeding, application of fertilizers and insecticides, supplying irrigation water, harvesting and carrying, cleaning, drying, storing, and everything else. This was computed by converting all women and children hours into man equivalent hours by assigning a ratio of 2 children = 1.5 women = 1 man (Ali, 2001). Both family and hired labors were used to cultivate Boro paddies in the study areas and were measured as the number of man-days for various activities, assuming that 1 day consists of 8 hours work. Seeds included all seeds used in rice production. Most of the farmers used three main types of chemical fertilizer, namely urea, tripple super phosphate, and murate of potash. Most of the farmers, however, used cow dung to increase soil fertility. Almost all of the farmers in the study areas used pesticides. In the study area, average irrigation cost per hectare was Taka 7,614 (1 US$: Bangladeshi Taka 80.69 as of May 29, 2012) and most of the farmers (about 87%) used electric deep tube well in the study area. The use of power tiller for land preparation has currently been increasing rapidly, and almost all farmers used hired power tillers. The average power tiller cost per hectare was Taka 3,952 for two-cross ploughing in Boro season.

## RESULTS AND DISCUSSION

**Results and discussion of DEA analysis:** Summary statistics for the measures of technical, allocative, economic and scale efficiencies are presented in Table 2. Under variable return to scale, the estimated TE was found to be 93%, which appears that the output per farm can be increased on average 7%. The mean AE was 82% indicated that these farmers could reduce costs by about 18%, by taking more become aware of relative input prices when selecting input quantities. The combined effect of TE and AE showed that the average EE score was 69%. This means, according to Farrell’s principle, the farmers can potentially reduce their overall cost of rice production, on average, by 31% while they still achieve the existing level of output. However, farmers’ objective and skill might influence their potential and desire to achieve overall EE. SE measures the optimality of the firm’s size, or when it operates where average and marginal products are equal (Forsund *et al*., 1980). The last result reported in Table 2 is the average level of SE was 90%, which indicate that the farm can reduce scale inefficiency by 10%.

Table 3 and figure 1 shows the frequency distribution of farm-specific technical, allocative, economic and scale efficiency have been estimated for Boro rice farmers. No farmer in the study areas operates the farm below 70% TE levels. About 71% of farmers operate their farms between 90-100% efficiency levels. A careful examination of the results reveals that only about 15% of farmers obtained outputs close to the maximum output estimated through the frontier (efficiency level is 90-100%) and the AE levels ranges from 50-100% for Boro rice farmers. The EE score ranges from 40-100% where only about 4% of farmers were fall under 90-100% efficiency level and about 17% farmers operate their farms below 60% efficiency level. In terms of scale economics, finally 173 farms were characterized by increasing return to scale, 21 farms had constant return to scale and five farms were characterized by decreasing return to scale. If all farms were using the same technology, then we would expect returns to scale to be increasing for farms with a relatively low output and decreasing return to scale farms with a relatively high output. Constant return to scale would be expected for farms with an output level equal to mean output (Silberberg, 1990). The above mentioned findings appear that approximately 54% of the farms had achieved less than 70% EE. In contrast, 100%, 96%, and 98% of the farmers achieved more than 70% TE, AE and SE, respectively. This shows the potentials for increase the productivity of the farms. The farmers operated farms under a high level of TE, which were almost similar with the findings of Khan *et al*. (2010). The main empirical result is that the TE and SE were quite higher, whereas the AE and EE were somewhat lower in all estimated models. Islam *et al*. (2011) also pointed out the same findings in their study.

**Results and discussion of Tobit analysis:** The results of the Tobit estimates using the STATA software are presented in Table 5. The estimates reveal some interesting findings, especially when compared to existing literature on Bangladesh rice farming. Education was found to be statistically significant and positively related to a farm being technically efficient. Farmers that are more educated are likely to be more efficient compared to their less-educated counterparts, perhaps because of their better skills, access to information, and good farm planning. Dhungana *et al*. (2004), Balcombe *et al*. (2008) and Khan *et al*. (2010) also reported similar results. Government and non-government organizations should give attention to educate the inefficient farmers using the best practices of their efficient counterparts, perhaps using extension tools such as field-level schooling or night school. Family size was statistically significant and positively related to SE measures. Farmers with a large pool of family labor might benefit from being able to use these labor resources at the right time, particularly at peak cultivation times. The seed type variable was found significantly and positively related to TE, while it was negatively related to AE and EE. It was positively related because modern varieties of seed indicated higher technical efficiency. On the other hand, negative relationship indicated that it increased the cost of farmers for producing the rice.

The land tenancy variable proved to be positively related to AE but negatively related to TE in a statistically-significant manner. Coelli *et al*. (2002) previously identified a positive relationship between owner-operators and efficiency, although in that study it was only in terms of cost efficiency. Nevertheless, in Balcombe *et al*. (2008) found positive but insignificant relationship between tenancy and TE. Banik (1994) also observed that owner-tenant/tenant farms were technically

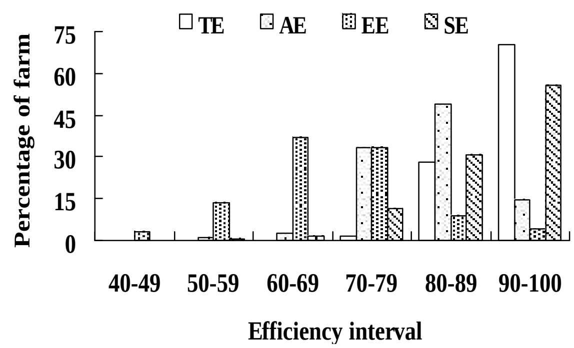


**Figure 1. Frequency distribution of technical, allocative, economic, and scale efficiency.** TE = Technical efficiency; AE = Allocative efficiency; EE = Economic efficiency; SE = Scale efficiency

**Table 1. Summary statistics of variables used in the data envelopment analysis model**

| Variables | Unit | Mean value | Standard deviation | Minimum value | Maximum value |
|---|---|---|---|---|---|
| Output variable | | | | | |
| Output value | Taka* | 105395 | 12763 | 65333 | 140496 |
| Input variables ( including missing values, zeros**) | | | | | |
| Land cultivated | Hectare | 0.69 | 0.58 | 0.07 | 5.06 |
| Land rent | Taka/hectare | 19169 | 4765 | 7936 | 44491 |
| Human-labour | Man-day/hectare | 104 | 25 | 31 | 183 |
| Labour wage | Taka/day | 264 | 26 | 225 | 325 |
| Seed/seedlings | Kg/hectare | 41 | 3 | 30 | 57 |
| Seed/seedlings price | Taka/kg | 76 | 25 | 40 | 100 |
| Organic fertilizer | Kg/hectare | 1145 | 953.18 | 0.00 | 3100 |
| Organic fertilizer | Taka/kg | 1.00 | 0.45 | 0.00 | 1.5 |
| Chemical fertilizer | Kg/hectare | 315 | 34 | 188 | 502 |
| Chemical fertilizer price | Taka/kg | 66.50 | 4 | 37 | 75 |
| Pesticide | Kg/hectare | 7.43 | 0.93 | 2.5 | 10 |
| Pesticide price | Taka/kg | 189 | 18 | 150 | 200 |

* = 1 US$: Taka 80.69 (as of May 29, 2012). ** = Zero represents the non-use of the corresponding input.

**Table 2. Summary statistics of TE, AE, EE, and SE of rice farmers**

| | Farmers efficiency | | | |
|---|---|---|---|---|
| | **TE** | **AE** | **EE** | **SE** |
| Mean | 0.93 | 0.82 | 0.69 | 0.90 |
| Standard deviation | 0.06 | 0.07 | 0.10 | 0.08 |
| Minimum | 0.79 | 0.59 | 0.45 | 0.57 |
| Maximum | 1.00 | 1.00 | 1.00 | 1.00 |

TE = Technical efficiency; AE = Allocative efficiency; EE = Economic efficiency; SE = Scale efficiency

**Table 3. Frequency distribution of efficiency scores**

| **Efficiency interval** | Frequency (number of farms) | | | |
|---|---|---|---|---|
| | **TE** | **AE** | **EE** | **SE** |
| 40-49 | 0 | 0 | 6 | 0 |
| 50-59 | 0 | 2 | 27 | 1 |
| 60-69 | 0 | 5 | 74 | 3 |
| 70-79 | 3 | 66 | 66 | 23 |
| 80-89 | 56 | 97 | 18 | 61 |
| 90-100 | 140 | 29 | 8 | 111 |
| IRS (%) | - | - | - | 173 |
| DRS (%) | - | - | - | 5 |
| CRS (%) | - | - | - | 21 |

TE = Technical efficiency; AE = Allocative efficiency; EE = Economic efficiency; SE = Scale efficiency; IRS = Increasing return to scale; DRS = Decreasing return to scale; CRS = Constant return to scale

**Table 4. Variable definitions for factors associated with efficiency**

| **Variables** | **Symbol** | **Definitions** |
|---|---|---|
| Age | AG | Age of farmers. |
| Education | ED | Years of schooling completed by the farmer. |
| Family size | FS | Number of people in household. |
| Land size | LS | Land used for Boro rice production. |
| Seed type | ST | Farmers used both local and modern varieties seed. Dummy variable for seed type. The value is 1 if the farmer used local varieties seed and 0 otherwise. |
| Household head occupation | OCU | Primary occupation of household head. The value is 1 if agriculture was the main occupation and 0 otherwise. |
| Land tenancy | LT | Dummy variable for tenure status. The value is 1 if the farmer was owner operator and 0 otherwise. |
| Extension services | ES | Dummy variable to measure the influence of agricultural extension on efficiency. Value is 1 if the farmer has had contact with an agricultural extension officer in the past year, and 0 otherwise. |
| Irrigation machine type | IM | Farmers used two types of irrigation machine, such as: Shallow tube well (STW) and Deep tube well (DTW). Dummy variable for machine type. If the farmer used DTW then the value is 1, and 0 otherwise. |
| Sources of energy | SE | Dummy variable for machine operating system. The value is 1 if the farmer used electricity operated irrigation machine and 0 otherwise. |
| Water buyer | WB | Dummy variable for water buyer. If the farmers buy water then the value is 1, and 0 for otherwise. |
| Land degradation | LD | Dummy variable for land degradation. The value is 1 if the farmer said that he had to use more fertilizer but production is lower than previous years and 0 otherwise. |

more efficient than owner farms. Extension service was statistically significant and positively related to a higher level of TE in this study. This conforms to results obtained by Balcombe *et al*. (2008). Rahman (2003) concluded that extension services had a positive impact on the profit efficiency of modern rice farming in Bangladesh. The demand for irrigation is increasing, as the cropping pattern in Bangladesh has shifted from Aman to Boro, which requires more irrigation. The results indicated that this type of irrigation machine had an important impact on TE. It was positively related to TE and EE and was also statistically significant. The area had low potentiality for groundwater exploitation, and the over-use of DTW results in shallow tube wells drying up.

Therefore, as the number of DTW increases, efficiency also increased in the study area. Irrigation management and infrastructure are differentiated by whether they use diesel or electricity. In this study, we found that electricity operated machines were statistically significant to EE, and SE, but there was a negative relationship among them because of an irregular supply of electricity. Other factors such as farmer age, land size, household head occupation, water buyer, and land degradation were insignificant in this model.

**Table 5. Estimate the effects of farm-specific variables on rice farming efficiency by using Tobit model**

| Variables | TE | AE | EE | SE |
|---|---|---|---|---|
| Constant | 1.1470*** | 1.2172*** | 1.7912*** | 1.2772*** |
| | (0.0568) | (0.0619) | (0.1532) | (0.0859) |
| Age | 0.0001 | 0.0008 | 0.0009 | -0.0004 |
| | (0.0005) | (0.0006) | (0.0014) | (0.0008) |
| Education | 0.0033** | 0.0002 | 0.0049 | 0.0010 |
| | (0.0017) | (0.0018) | (0.0045) | (0.0025) |
| Family size | 0.0004 | -0.0045 | 0.0082 | 0.0108** |
| | (0.0035) | (0.0038) | (0.0094) | (0.0053) |
| Land size | 0.0214 | -0.0061 | 0.0508 | 0.0246 |
| | (0.0123) | (0.0132) | (0.0328) | (0.0184) |
| Seed type | 0.0591*** | -0.1313*** | -0.1011*** | -0.0161 |
| | (0.0118) | (0.0128) | (0.0317) | (0.0177) |
| Household head occupation | 0.0031 | 0.0195 | 0.0563 | 0.0334 |
| | (0.0175) | (0.0188) | (0.0467) | (0.0261) |
| Land tenancy | -0.0342* | 0.0393* | 0.0138 | 0.0059 |
| | (0.0215) | (0.0230) | (0.0570) | (0.0320) |
| Extension services | 0.0974* | 0.0383 | 0.1962 | 0.0223 |
| | (0.0617) | (0.0627) | (0.1553) | (0.0859) |
| Irrigation machine type | 0.0472* | 0.0248 | 0.1349* | 0.0658 |
| | (0.0286) | (0.0309) | (0.0765) | (0.0437) |
| Sources of energy | -0.0254 | -0.0109 | -0.0968* | -0.0663* |
| | (0.0229) | (0.0244) | (0.0604) | (0.0353) |
| Water buyer | 0.0187 | -0.0037 | 0.0543 | 0.0114 |
| | (0.0352) | (0.0380) | (0.0941) | (0.0532) |
| Land degradation | 0.0013 | -0.0159 | 0.0545 | 0.0593 |
| | (0.0268) | (0.0294) | (0.0729) | (0.0407) |
| Log likelihood | 133.94 | 199.83 | 20.20 | 103.18 |

***, **, and * indicate significant at 1% ($P<0.01$), 5% ($P<0.05$), and 10% ($P<0.10$) level respectively. Standard errors are in parentheses. TE = Technical efficiency; AE = Allocative efficiency; EE = Economic efficiency; SE = Scale efficiency

**Conclusion:** Production efficiency is an important factor of productivity growth in the agriculture-based economy of a developing country. The result indicates the average TE, AE, EE and SE for Boro rice farms were 93%, 82%, 69%, and 90%, respectively. Accordingly, there is a certain degree of production inefficiency, and the result shows that the TE and SE were quite high whereas the AE and CE were somewhat lower in the estimated models. Given the available technology, farmers could increase their rice production by only 7%. Tobit regression shows the variation of TE was also related to farm-specific attributes such as education, seed type, land tenancy, type of irrigation machine, and extension services. All of these factors provide a positive impact, but land tenancy shows a negative impact. Farmers could bring down the costs of production by 18% with greater efficiency. Land tenancy positively related, and seed type negatively related, were the main factors for this inefficient allocation. The economic inefficiencies were 31%, and from Tobit analysis it was found that seed type, source of energy, and type of irrigation machine were the core factors for this. The scale inefficiencies were 10% for Boro rice production, and the factors family size and sources of energy were accountable for scale inefficiencies in the studied areas. Most of the farmers used electric machines because of high diesel prices, but electric machines did not work properly because of the irregular supply of electricity. Therefore, the study suggested that the existence of some inefficiency may be reduced through policy interventions, adoption, and spread of improved agricultural mechanization and continues electricity supply. In addition, as farmers were technically efficient from the existing rice seed varieties, so new varieties of rice should be introduced and disseminated among the farmer to meet the increasing rice demand for increased population. All together, it would be possible to feed the teeming millions of people, to reduce rural poverty, and to raise the standard of living by establishing rice production as a profitable economic sector.

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