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## A cost efficiency analysis of boro rice production in Dinajpur district of Bangladesh

Md Shajedur Rahaman <sup>1\*</sup>, Sadika Haque <sup>2</sup>, Md Abdur Rouf Sarkar <sup>1</sup>, Mohammad Chhiddikur Rahman <sup>1</sup>, Md Salim Reza <sup>2</sup>, Mohammad Ariful Islam <sup>1</sup>, Md Abu Bakr Siddique <sup>1</sup>

<sup>1</sup>Agricultural Economics Division, Bangladesh Rice Research Institute, Gazipur 1701, Bangladesh

<sup>2</sup>Department of Agricultural Economics, Bangladesh Agricultural University, Mymensingh 2202, Bangladesh

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M Nahid Sattar

[nahidsattar@bau.edu.bd](mailto:nahidsattar@bau.edu.bd)

#### \*Corresponding Author

Md Shajedur Rahaman

[saju021@gmail.com](mailto:saju021@gmail.com)



### ABSTRACT

The size of the farm is an important factor that reflects the efficient utilization of resources in farming. Therefore, this paper aims to investigate how the farm size affects the cost efficiency of rice production during the Boro season in Bangladesh. In particular, the analysis aims to estimate the concentration of cost efficiency among the 240 small, medium, and large Boro rice growers sampled in the Dinajpur district. Descriptive statistics were used to evaluate the socioeconomic characteristics of rice farmers. A Cobb-Douglas type stochastic cost frontier model was employed to figure out how the rice farmers are cost-efficient. The sociodemographic factors that affect efficient investment in rice production also have been identified. The results of the study show a broad range of cost efficiency scores between 56.65 to 96.40% for the worse to the best rice-growing farmer, respectively with an average efficiency of 84.01%. The findings also show that the mean cost efficiency level of small, medium, and large farmers was 83.30, 85.58, and 94.43%, respectively. The land rental fees, human labor wages, irrigation prices, and pesticide prices are the key factors that contribute to the productivity of rice cultivation. The relatively higher level of cost efficiency among large farmers obviously demonstrates the notion that only large farmers in the study region are investing efficiently in rice growing. Irrespective of the farm size, the cost efficiency drivers found out that more efficient were the farmers who had more experience in farming, obtained training on rice production techniques, and better access to institutional credit. It is therefore recommended that rice farmers should be well trained, provided credit access along with developing rural set-up, and also provide extension services in order to increase the cost efficiency levels in Boro season.

**Keywords:** Cost effective, rice, farm size, stochastic frontier analysis, Bangladesh



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## 1 Introduction

The predominance of agriculture in Bangladesh is visible from its contribution to economic progress and the generation of employment (Sarker et al., 2019). The agriculture sector contributes almost 10.25% to the GDP and recruiting about 40% of the labor force

of the nation (BBS, 2020). There are three concurrent crop seasons in Bangladesh, where paddy is cultivated in about 42% of the land during Boro season and it accounts for the production of 19.56 million tons of clean rice, which is around 54% of the total production of the country (BBS, 2020). On the other

hand, by 2050 this country's population is estimated to exceed 215 million and the nation would have to grow additional 10.8 million tons of rice (Hussain, 2010). It is therefore a major challenge to provide sufficient food through diminishing land and many other scarce supplies to feed the future with the ever-growing population of the country (Rahaman et al., 2018). Hence, rice becomes the most vital crop in the political economy of Bangladesh (Rahman et al., 2020).

Moreover, agriculture is highly vulnerable to climate change (Rahman MC, 2015). Bangladesh agriculture suffers from several issues, such as limited and scattered land holdings, natural hazards, increasing temperatures, irregular and unpredictable rainfall, winter shortening, rising sea level, rice monocropping, and low profitability in rice cultivation (Mondal et al., 2012). In comparison to crop yields, on-farm and research stations vary because of variations in the operational conditions of farmer's field and research stations. According to FAO (2014), such wide inequalities are apparent from high inefficiency rates in the usage and allocation of farm capital at the farm stage. The significant yield variations are associated with environmental, social, and political influences, as well as a rising population causing difficulties for the re-allocation of competitive capital across farms (Norton et al., 2009).

Despite the fact that certain inefficiencies exist, it is impossible to ignore the function of agriculture in alleviating poverty and food protection. Also, the development in agriculture that involves rising farm productivity plays a major role in the battle against rural poverty and hunger (Valdes and Foster, 2010; Wiggins et al., 2010). Besides, due to the increasing scarcity of agricultural land, agriculture faces a new challenge of ensuring productivity with a comparatively limited resource. The World Bank's study illustrated that with growing land shortages and increasing population the sustainability of agriculture is fundamentally attached to the productive utilization of the capital at our disposal (Bank, 2007). Rice production is marginally profitable in Bangladesh. Nevertheless, the country already attained rice self-sufficiency (Jalilov et al., 2019). One of the drivers of this sufficient production is the government supports and input subsidy. However, foreign donors and international aid agencies have criticized certain Bangladeshi policies, including fertilizer subsidies and the price support program, owing to their ineffectiveness in achieving target levels of sustainable food security (Ahmed et al., 2009). An important question arises that how is the farmers efficient in rice cultivation under the subsidized cultivation. Most importantly, to clarify the argument of donors, it is important to investigate how the farmers are cost efficient in rice production and find out the factors that reflect the levels of efficiency.

Cost effective use of resources and its factors specific is essential to make the decision and better farming activities. For example, in Vietnam, Tung (2013) observed that farmers need to modify their farm plans and 'expand their output' owing to improved rice production. On the other side, farmers in Bangladesh not just need to become more efficient in agricultural practices though also have to be responsive to the factors of demand, so that limited assets are used effectively to increase both productivity and profitability and to provide the commercial market with supplies. In addition, productivity increases will have a major impact on increasing farm income.

Several preceding studies on assessing the rice farmers' efficiency in Bangladesh have been published, focusing narrowly on data coverage and concentrating primarily on measuring only technical efficiency (Rahaman et al., 2019; Siddique et al., 2020; Hasnain, 2015; Rahman MC, 2015; Rahman et al., 2012; Zahidul Islam et al., 2012; Wadud and White, 2000). Coelli et al. (2002) utilized a non-parametric approach to determine efficiencies in terms of technical, allocative, costs, and scale. The result indicates that for modern rice in Bangladesh, technical efficiency ranged from 74 to 82%, though allocative performance reported 81%. Rahman (2003) indicates that profit efficiency in modern rice processing is 77%, suggesting how a further 23% of benefits are wasted triggered by an amalgamation of technical, allocative, and scale inefficiency. Nargis and Lee (2013) used Data Envelopment Analysis to measure efficiencies and found technical efficiency 0.93%, allocative efficiency 0.82%, cost efficiency 0.69%, and scale efficiency 0.90%.

With this given context, the current research applied a parametric stochastic frontier approach (SFA) to evaluate the levels of cost efficiency of Boro rice-producing small, medium, and large farmers' in the Dinajpur district. As well as to test a hypothesis of whether the farm size has a significant influence on the farm the cost efficiency of the rice growers of the study area. This research also investigated the origins and causes of rice farmers' inefficiency in rice production of the small, medium, and large farmers' during the Boro season. The connections among the production, marketing information, and farmers' household features are important to make rice farming much profitable to enhance farm-specific cost efficiency, which has not been well investigated in the context of Bangladesh. Therefore, the findings of this study would guide the policymakers in designing policies that can contribute to the measures needed to improve the nation's potential for food production efficiently.

## 2 Materials and Methods

### 2.1 Study location and data

The Northwestern (NW) part of Bangladesh is called the 'granary' and is one of the leading paddy growing areas. Dinajpur is a renowned district that is always surplus in producing quality rice in the NW region of the country (Siddique et al., 2020). Therefore, the Dinajpur district was purposively chosen to fulfill the objectives of this study. Through consultation with the regional agricultural extension offices, Birganj and Parbatipur Upazilas of the district were selected purposively for farm level data collection. In total eight Unions (four from each Upazila) were covered in the study for an intensive survey of the rice farm households. To measure the cost efficiency of Boro season rice production, the sample farm households were selected randomly. The random sample selection was performed from a comprehensive list of rice farmers provided by the Department of Agricultural Extension (DAE). The households' plot-level data of rice cultivation were collected using a standardized pre-tested questionnaire. Thirty farmers from different categories (farm size) from each Unions were interviewed in this study that comprises a total of 240 sample rice farm households. Rather than proportional, the sampling has considered the purpose of the study. The detailed sampling frame has been presented in Table 1.

### 2.2 Theoretical concept

Stochastic Frontier Approach (SFA) was employed to measure Cost Efficiency (CE). Because of its parametric nature and supremacy over other approaches, the methodology was selected. The SFA has been preferable above the non-parametric Data Envelopment Analysis (DEA) because it uses the maximum likelihood method, which delivers better results than the DEA focused on statistical programming (Coelli et al., 2005). In performance studies, Erkoç (2012), and Zhang and Garvey (2008) compared the Data Envelopment Analysis and Stochastic Frontier Approach were found a clear link between the two approaches output estimations. On the other hand, Coelli (1995) shows in comparison that SFA can handle the stochastic noise and allows hypothesis testing to measure inefficiency. Islam (2016) used the stochastic frontier cost efficiency model to calculate the cost efficiency of rice production in Bangladesh as it offers better results and explanations. Hence we have also selected the SFA to evaluate the cost efficiency of Boro season rice production. The stochastic cost function was used to measure cost efficiency. The stochastic cost function structure is laid out in equation (1):

$$C_i = F(Y_i, X_i, \beta) \exp(\epsilon_i) \quad (1)$$

where,  $i = 1, 2, \dots, n$  farms,  $C_i$  is the cost of rice cultivation for the  $i$ th farm,  $X_i$  is the input price and cost of  $i$  farm.  $Y_i$  is the output of the  $i$ th farm and  $\epsilon_i$  is the expression for the error that could be decomposed into  $v_i + u_i$ .  $U_i$  represents the parameter for inefficiency and  $v_i$  is the random stochastic variable. Whereas  $\beta$  is a vector of production-related parameters.  $F(\cdot)$  represents the functional association among price, costs, and production.

The equation (1) can be asserted by decomposing error term as:

$$C_i = F(Y_i, X_i, \beta) \exp(v_i + u_i) \quad (2)$$

The cost efficiency levels of a farm can be attained as a ratio of the minimum total cost of cultivation ( $C^*$ ) to the real total cost of cultivation ( $C$ ) measured as stated in equation 3.

$$CE = \frac{C_i^*}{C_i} \quad (3)$$

where  $CE$  = cost efficiency;  $C^*$  represents the cost of cultivation in an optimal situation where  $CE$  is attained and  $C$  signifies the real cost the particular farmer has sampled. Therefore it can be rewritten as:

$$CE = \frac{(Y_i, X_i, \beta) \exp(v_i + u_i)}{(Y_i, X_i, \beta) \exp(v_i)} = \exp(u_i) \quad (4)$$

which represents the  $i$ th farm's cost efficiency of rice production. Bravo-Ureta and Pinheiro (1997), and Ahmed and Melesse (2018) stated that like technical efficiency, cost efficiency also assumes values from 0 to 1, where cost efficiency of 1 implies a cost-effective farm. If  $C_i^* = C_i$ , then a farm can be efficient in costing. Whereas if  $C_i^* < C_i$ , means a farm running into inefficiency level.

The cost inefficiency level of a farm can be obtained from equation 5.

$$u_i = K_i \delta + w_i \quad (5)$$

where  $K_i$  is a vector of the cost inefficiency effect related response variables;  $\delta$  is an undefined parameter need to be assessed; and  $w_i$  is a random variable that is undefinable. The cost efficiency influence by the variables within  $K$  which represents the parameter. A positive effect on cost efficiency and vice versa is indicated by a negative value.

### 2.3 Empirical model

The cost efficiency model specification used during the analysis contained eight inputs and production variables as the main determinants of the costs. These variables for the cost efficiency model were rental charge of the land, price of labor, seed, fertilizer, cost of pesticide, irrigation, land preparation, and threshing.



**Table 1.** Sampling distribution according to the farm size

Upazilas	No. of unions	Number of sampled farmers			
		Small	Medium	Large	Total
Birganj	4	18 × 4 = 72	8 × 4 = 32	4 × 4 = 16	120
Parbatipur	4	18 × 4 = 72	8 × 4 = 32	4 × 4 = 16	120

Source: Prepared by the authors

As proposed by [Aigner et al. \(1977\)](#), [Kumbhakar and Lovell \(2000\)](#), and [Coelli et al. \(2005\)](#), this analysis follows the approach of measuring cost function using SFA. The cost function is as set out below utilizing the double-log form in equation (6)

$$\ln C_i = \alpha + \beta_1 \ln Y_i + \beta_2 \ln X_1 + \beta_3 \ln X_2 + \beta_4 \ln X_3 + \beta_5 \ln X_4 + \beta_6 \ln X_5 + \beta_7 \ln X_6 + \beta_8 \ln X_7 + \beta_9 \ln X_9 + v_i + u_i \tag{6}$$

where  $C_i$  is  $i$ th farms observed production cost of Boro paddy,  $Y_i$  is  $i$ th farms production ( $\text{kg ha}^{-1}$ ),  $X_1$  is a land rental cost ( $\text{Tk ha}^{-1}$ ),  $X_2$  is the wage of human labor ( $\text{Tk man-days}^{-1}$ ),  $X_3$  is the price of seed ( $\text{Tk kg}^{-1}$ ),  $X_4$  is the price of fertilizer ( $\text{Tk kg}^{-1}$ ),  $X_5$  is the cost of irrigation ( $\text{Tk ha}^{-1}$ );  $X_6$  is the cost for land preparation ( $\text{Tk ha}^{-1}$ ),  $X_7$  the cost of threshing ( $\text{Tk ha}^{-1}$ ) and  $X_8$  is the cost of pesticide ( $\text{Tk ha}^{-1}$ ). Also  $v_i$  represents disturbance term while  $u_i$  is the  $i$ th farm characteristics attached to the farm-specific inefficiency.  $\beta_1$  to  $\beta_9$  are the parameters need to be estimated. The criterion of linearity of the homogenous degree 1 should be fulfilled in the cost frontier model. That is,  $\sum_{j=1}^9 \beta_j = 1$  ([Islam and Fukui, 2018](#)).

The Cobb–Douglas stochastic frontier approach was selected based on the assumption that, as the cost function case, it allows that the function is self-dual. Therefore, this presumption is the foundation of our research. The equation (6) was calculated by fitting the unrestricted production functions of the Cobb-Douglas (CD) form. The unrestricted CD output function was adopted to evaluate over 2 inputs used in the production process, due to its ease of measurement and the ability to be expanded easily ([Debertin, 2012](#)).

## 2.4 Inefficiency effect model

The consequences of cost inefficiency are believed to be linearly related to the characteristics of the producers. Some socioeconomic indicators were incorporated into the model to assess their possible impact on the inefficiency of farms. The following analytical expression was used to measure the Boro rice growing farmer’s inefficacy as follows:

$$\ln C_i = \delta_0 + \delta_1 Z_{1i} + \delta_2 Z_{2i} + \delta_3 Z_{3i} + \delta_4 Z_{4i} + \delta_5 Z_{5i} + \delta_6 Z_{6i} + \delta_7 Z_{7i} + \delta_8 Z_{8i} + w_i \tag{7}$$

where  $Z_1$  = Age of the farmers (yr);  $Z_2$  = Schooling of the farmer (yr);  $Z_3$  = Farming experience of the farmer (year);  $Z_4$  = Farm size (ha);  $Z_5$  = Extension service dummy (1 for received extension service and 0, otherwise);  $Z_6$  = Training dummy (1 for received training and 0, otherwise);  $Z_7$  = Credit dummy (1 for credit is taken for rice cultivation in Boro season and 0, otherwise);  $Z_8$  = Agricultural programs dummy (1 for watching and/or listening and 0, otherwise); and  $\delta_0, \dots, \delta_8$  are unknown parameters to be calculated and  $w_i$  = random errors.

Utilizing likelihood-ratio we also check the existence of cost inefficiency, which is as follows:

$$\lambda = -\ln \left( \frac{H_0}{H_A} \right) \tag{8}$$

where  $\lambda$  is the likelihood ratio statistics estimated from the values of the likelihood ratio under the null hypothesis ( $H_0$ ) and the alternate hypothesis ( $H_A$ ). Microsoft Excel has been used to compile and edit the farm level data obtained from paddy growers. Finally utilizing the STATA program estimates the cost function and inefficiency model parameters.

## 3 Results and Discussion

### 3.1 Socioeconomic features of the rice farmers

[Table 2](#) provides a description of the sampled respondents’ socioeconomic and demographic details in the area of study. The table shows that most of the respondents belong to the age group 31 to 50. Farmer’s age performs a vital role in the management of their agricultural operations. Mostly younger farmers are embracing emerging technology more rapidly than their older peers. The average size of the family was 5.35, a bit higher than Bangladesh’s national average (4.30) ([BBS, 2016](#)). The most typical family size is 4 to 6 persons with 53.71% being male and 46.29% being female. It was reported that 43.75% of respondents

had primary education while 26.25% did not have formal schooling. Survey results also indicate that the respondents had 60% small, 27% medium, and 13% large farms; and the prime occupation of around 77% was farming in the study area. On average, farming experience ranged from 21 to 30 years for 42.25% of farmers. The extension service is a very important institutional feature in the agriculture sector. In the study area, about 65% of farmers received extension service. While only 15.35% of farmers receive rice production-related training. Results also indicate that 8.75% of farmers taken credit from different sources for rice cultivation. On average 21.50% of farmers of the study areas watching agricultural programs. Typically, around 11.25% of respondents have also been involved as members of various social organizations.

### 3.2 Estimation of the stochastic frontier cost function

The Cobb-Douglas stochastic cost frontier model parameter estimation is shown in Table 3. The results of the model show the variance parameters sigma squared ( $\sigma^2$ ) and gamma ( $\gamma$ ) statistically significant. The large and significant variance ratio parameter gamma ( $\gamma$ ) infers that roughly 95% of the gap between the observed production cost and maximum cost investment is induced by variations in the degree of cost efficiency of farmers as compared to typical random variability. This proves that amongst paddy growing farmers there is a high level of inefficiency. The significance of the  $\sigma^2$  (0.134 at 1%) is suggesting a better fit of the model (Rahman, 2003; Islam, 2016). The findings further suggest that the coefficients of output, land rent cost, the wage of human labor, cost of irrigation, and cost of pesticide were significant and positive, indicating that if a rise in the extent of such variables may result in a subsequent rise in the cost of Boro rice production. The findings of this study are very much consistent with Okello et al. (2019), Souleymane (2015), and Magreta et al. (2013).

### 3.3 Distribution of efficiency scores

The frequency distribution of the Boro rice-growing farmers' cost efficiency is presented in Table 4. The results show a broad range of cost efficiency between 56.65 to 96.40% for the worse to the best rice-growing farmers, respectively. Observing large variation is not unexpected in cost efficiency scores and comparable to the findings of Magreta et al. (2013), Souleymane (2015), and Backson et al. (2020).

The mean cost efficiency score is 84% suggesting that the average rice-growing farmers would improve efficiency further 16% by rising their technical and allocative efficiency. Even after a large deviation in

efficiency level, approximately 72.5% of Boro rice producing farmers driven closer to the CE level of 80% and beyond (Table 4). The least cost effective and average efficient Boro rice growers require an efficiency improvement of 41.23%  $[(1 - (56.65/96.4) \times 100)]$  and 12.86%  $[(1 - (84.006/96.4) \times 100)]$  respectively, to achieve the level of the foremost farmers' efficiency in the surveyed region. Around the other side, to be on the frontier, the best producer can improve efficiency by 3.60%  $[(1 - (96.4/100) \times 100)]$ .

The mean CE score of the rice farmers according to their farm size has been presented in Table 5. The findings show that CE is proportional to the size of the farm. The large farms on average achieved the highest CE (94.43%) followed by medium (85.58%) and small (83.30%) farms. This is because larger farms can allocate resources more efficiently in the production process. This is also supported by the findings of Blazejczyk-Majka et al. (2012) and Mburu et al. (2014).

### 3.4 Sources of inefficiency

The variables that are responsible for the cost inefficiency in rice farming have been presented in Table 6. It is noteworthy that as a result of the interpretation of the inefficiency model the sign of the coefficient is very substantial. Abu and Kirsten (2009), and Galawat et al. (2012) suggested that the decrease of the factors cost ineffectiveness can be identified by the negative sign of the coefficient, and conversely. Assa et al. (2012) further proposed that an opposite sign of the results interpreted the cost efficiency and not the inefficiency of the coefficients.

The age coefficient was positive and significant at the level of 10%, which implies that has no beneficial impact in increasing the cost efficiency of the farmers; it may also raise the inefficiency. The reason could be because the older farmer has less possibility of accepting modern approaches and new technologies. Besides that, youthful farmers having some institutional education thus could help to collect knowledge and exploring modern techniques that will potentially improve the efficiency of the rice growers. Whereas significant and negative coefficient of experience denotes that the experienced rice growing farmers tend to be highly productive. This means the inefficiency will decline as farm operators' experience grows. Therefore, increasing farmers' expertise leads to improve efficiency. That is because experienced farmers can handle and distribute resources more efficiently than less experienced farmers. It has been found that all trained farmers are more efficient than non-trained farmers. This is apparent from the significant negative coefficient of training obtained. The findings comply with the results of Backson et al. (2020), Konja et al. (2019), Trong and Napasintuwong (2015), Souleymane (2015), Munir et al. (2015), Sadiq and Singh (2015), Rahman (2012),

**Table 2.** Socioeconomic profiles of sampled farmers in the Dinajpur district

Features	Figure in percentage
Age of the respondents (years)	
<30	18.75
31 - 40	30.00
41 - 50	33.75
51 - 60	14.1
>60	3.4
No. of family member	
1-3	10.53
4-6	65.35
>6	24.12
Sex	
Male	53.71
Female	46.29
Schooling (years)	
No education	26.25
Primary	43.75
Secondary	20
Higher secondary	7.5
Graduation and above	2.5
Farm category* (acre)	
0.05 - 2.49	60.00
2.50 - 7.49	27.00
≥7.50	13.00
Profession	
Agriculture as main	76.61
Agriculture as secondary	23.39
Experience (years)	
0-10	11.25
11-20	29.15
21-30	42.25
31-40	14.85
Above 40	2.50
Average rice production (t/ha)	6.36
Received extension service	65.00
Received rice production training	15.35
Credit took to rice cultivation	8.75
Agricultural programs watching and/or listening	21.50
Organizational membership	11.25

\*Farm category small = 0.05-2.49 acre; medium = 2.50-7.49 acre; and large = 7.50 acre and above according to the BBS (2020). Source of the data: Field survey, 2018.



**Table 3.** Estimation of Maximum-likelihood of the cost frontier model

Variables	Coefficient	Standard Error
Intercept	3.843***	0.789
Production	0.826**	0.338
Land rent cost	0.184***	0.048
Wage of human labor	0.197***	0.073
Price of seed	0.147	0.139
Price of fertilizer	0.103	0.069
Cost of irrigation	0.078*	0.032
Cost of land preparation	0.081	0.081
Cost of threshing	0.108	0.143
Cost of pesticide	0.112*	0.058
Variance parameter		
Sigma squared $\sigma^2$	0.134***	0.028
$\gamma$	0.952***	0.0004
Log-likelihood	-274.45	
Likelihood ratio <sup>†</sup>	45.05***	
Homogeneity test <sup>‡</sup>	1.54	
N	240	

<sup>†</sup>  $H_0 = \sigma_u^2 = 0$ ; <sup>‡</sup>  $H_0 = \sum_{j=1}^8 \beta_j = 1$ ; Source: Author's calculation. \*, \*\*, and \*\*\* indicates significance at 10, 5, and 1% levels, respectively.

**Table 4.** Boro rice-producing farmer's cost efficiency frequency distribution

Cost efficiency (percentage)	Number of farms	Percentage
51-60	3	1.25
61-70	20	8.33
71-80	43	17.92
81-90	104	43.33
91-100	70	29.17
Total	240	100
Mean		84.07
Maximum		96.4
Minimum		56.65

**Table 5.** Mean Cost Efficiency scores by farm size

Farm size	CE scores (%)
Small	83.3
Medium	85.58
Large	94.43
Overall	84.07

**Table 6.** Determinants of cost inefficiency effect

Variable	Coefficient	Standard Error
Intercept	1.990**	0.829
Age	0.008*	0.004
Education	0.342	0.245
Experience	-0.748**	0.312
Farm size	0.002	0.021
Extension service	0.011	0.024
Training received	-0.053***	0.019
Credit taken	-0.062***	0.020
Agricultural programs watching or listening	0.019	0.024

Source: Author's calculation. \*, \*\*, and \*\*\* indicates significance level at 10, 5, and 1% respectively.

and Rahman (2003). By delivering adequate and effective training, the management capability of farmers can be improved for the efficient functioning of farming activities. Shang et al. (1998) proposed that the right combination of inputs and the most appropriate method of cultivation should be decided primarily by available resources, cost, and farmers' management capability. Backson et al. (2020), Temesgen and Franklin (2017), Dang (2017), and Trong and Napasintuwong (2015) also drawn similar conclusions. The credit coefficient also has a negative significance level of 1%. The farmers face a shortage of operating expenses mostly during the peak input price of Boro season. Farmers generally have to buy inputs at higher prices, even though the officers have low market price information. This reason is supported by the significant negative credit coefficient, which implies that the greater the availability of credit the higher the cost efficiency. This is confirmed by Backson et al. (2020), Wongnaa et al. (2018), Saysay et al. (2016), Biam et al. (2016) and Magreta et al. (2013).

## 4 Conclusion

The study utilized stochastic cost frontier functions to analyze the rice farmers' cost efficiency in the Boro season. The average efficiency level in Boro season for modern rice farming is 84.01%, which means that substantial potential remains to improve cost efficiency by increasing the efficient utilization of resources. The study also found that the large farms on average achieved the highest CE (94.43%) followed by medium (85.58%) and small (83.30%) farms. This is because larger farms can allocate resources more efficiently in the production process. Furthermore, this result revealed that the major contributing factors to the costs of rice cultivation are land rental charges, human labor costs, irrigation costs, and pesticide costs. The socioeconomic and farm-specific factors utilize to characterize inefficiencies clearly show that growers with greater experience, greater access to credit, and training on rice cultivation techniques appear to be-

come more efficient. The credit facilities for farming should make it more affordable and simplify the criteria for loan approval and delivery. They should also consider electronic banking, and implement a modern, cost-effective distribution system. Farmers used this to purchase the necessary agricultural supplies for crop cultivation, including modern and approved seeds, fertilizers, farming equipment, and pesticides, which may increase efficiency. Farmers must therefore be provided with training, as training allows farmers to acquire practical know-how for emerging technologies and technical information. Training attendance has had an important and beneficial impact on increasing the efficiency of rice farming more cost effectively. Furthermore, improving rural infrastructure and reinforcing extension services would influence the efficiency of Boro rice cultivation significantly.

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## Conflict of Interest

The authors declare that there is no conflict of interests regarding the publication of this paper.

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