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# Comparative Profitability and Efficiency Analysis of Rice Farming in the Coastal Area of Bangladesh: The Impacts of Controlling Saline Water Intrusion

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***Abstract:*** *This comparative study was conducted within a selected coastal empoldered area of Bangladesh, with a view to comparing the profitability and technical efficiency of T. Aman rice growers between two locations with different level of salinity. Two unions (Pankhali and Tildunga) under polder 31 of Dacope upazila were selected to fulfill the intention of the study. It should refer that the farmers of the Pankhali union controlled saline water intrusion into the rice field by sluice gate management and followed rice-cum-golda pattern, where as the farmers of Tildunga union still practicing rice-cum-bagda with saline water. The study revealed that T. Aman rice production was profitable in both of saline water controlled and uncontrolled areas but the realistic favor viewed that economic return was reasonably in controlled area. The returns per taka investment in controlled and uncontrolled areas were 1.70 and 1.60, respectively. The estimated result showed that the average level of technical efficiencies of the sample farmers were about 70.70% and 87.50% for the uncontrolled and controlled areas' farms, respectively. That means, at the given technology and level of inputs, the output could be increased by 29.30% and 12.50%, respectively. Farmer's education and training had positive significant effect on T. Aman rice production. The age of the sampled farmers' had significant positive impact on farming efficiency in the controlled farms but it was negative on the uncontrolled area. The saline water controlling had significant impact on the farming efficiency of T. Aman rice farmers'. The farmers of the saline water intrusion controlled area were technically more efficient than the uncontrolled area which resulted higher net return from T. Aman rice farming.*

***Keywords:*** *Controlling saline water intrusion, T. Aman rice, profitability, technical efficiency.*

## I. Introduction

There is a considerably large coastal area in Bangladesh. It envelops 32 percent of the country's geographical area wherein 28 percent of the total population live at 6.85 million households. Out of 64, coastal area contains19 districts of the country (Rahman et al. 2013a).The area is also on the high risks of natural and man-made calamities. After the mid-1960s, the land was only a few feet above the normal high tide, the rich of water and land resources had already then attracted many people from other parts of Bangladesh for its economic importance. As it is rich in resources, the coastal zone can make a substantial contribution to achieve the national goals of accelerated poverty reduction and economic growth. Good Water governance and management, flood controls were highly required to make the coastal zone more viable in terms of economy and environment. Realizing the fact, in mid-1970s the government decided to establish the embankments in the coastal islands through the predecessor of the Bangladesh Water Development Board (BWDB).In Khulna district, BWDB and LGED (Local Government Engineering Department) initiated the construction of a number of large-scale polders and embankments. The aim was to protect the people and their property from cyclonic surges and create better conditions for agricultural production (rice and shrimp/prawn) by controlling intrusion of saline water and improving drainage of rainwater (Hossain 2007). However, the coastal area was suffering from salinity problem for rice cultivation. The farmers usually cultivated rice-cum-bagda pattern, using saline water. Because of salinity the productivity of rice was very much lower compare to the other areas of the country. Salinity is a problem for livestock's and forestry also. The marginal farmers' preferred cultivating rice-cum-golda to rice-cum-bagda as golda was a good alternative with fresh water and rice. The main obstacle of that substitution was the large farmers' who were devoted to bagda (*Penancus monodon*) culture with saline water.

As rice takes the monopoly position in the staple food items of the country, the small farmers took initiative to restrict saline water intrusion into the rice field of coastal area. Finally, the people of the Pankhali union of polder 31 under Khulna district banned the intrusion of saline water and brought more land under the cultivation of T. Aman rice (Transplanted Aman rice, cultivation period is August – November), following rice-cum-golda pattern instead of rice-cum-bagda (Rahman et al. 2013b).Besides, the people of Tildunga union of same polder were practicing rice-cum-bagda as bagda was financially more profitable. The local people experienced some positive results from controlling saline water intrusion into the Pankhali union. From 2007 to 2012, there were emerging some grasses and some land became usable as grazing land. Some farmers reported that they were getting good output from vegetables production. These were the impact of reducing salinity due to the controlling of saline water intrusion into the empoldered area. In order to identify the impact of saline water controlling on the soil salinity level, the Soil Resource Development Institute (SRDI) measured the salinity of that controlled area and made a database to compare with other uncontrolled areas. The researcher used the dataset of SRDI to compare the salinity level of Pankhali and Tildunga unions. The comparative result showed that there became significantly difference of salinity between Pankhali and Tildanga unions although both unions are under polder 31. There prevails lower salinity during the months August to December and higher during the months March to June (figure 1). The average salinity of Pankhali and Tildunga were 7.85 dS/m and 12.34 dS/m, respectively. The lowest salinity (0.50 dS/m) of Pankhali union prevailed at September and that of Tildanga (1.95) was at November. The highest water salinity prevailed in Pankhali and Tildanga at the months April (19.75 dS/m) and May (26.50 dS/m), respectively (Table 1).

According to the SRDI (2012), the difference of salinity between two concerned unions was due to the control of saline water intrusion. And that was controlled mostly to facilitate better rice production in the Pankhali union. This study was designed to evaluate the impact of controlling saline water intrusion into the empoldered area,onthe basis of profitability and efficiency of rice farming.

## II. Review Of Literature

A number of studies have been conducted on profitability and efficiency analysis of various crops farming in Bangladesh and other countries. For instance, Rahman (2003) conducted a study to measure the profit efficiency among Bangladesh rice farmers. The analysis was done by using a stochastic profit frontier and inefficiency effect model. The results showed that there was 23% level inefficiency in modern rice cultivation. The efficiency differences were explained largely by infrastructure, soil fertility, experience, extension services, tenancy and share of non-agricultural income. Hyuha et al. (2007) analyzed the inefficiency in Uganda using stochastic profit and inefficiency function. The result showed that the rice farmers in Uganda were not in the profit frontier. The causes of inefficiency were low education and limited access to extension services. Rahman et al. (2014) studied about the technical efficiency of fresh water golda (*Macrobrachium rosenbergii*) farming in the coastal empoldered area of Bangladesh. The study used frontier production function and inefficiency model to analyze the cross-section data. The result showed that the inefficiency factors among the golda farmers were level of education, training and farm size. Rahman et al. (2013) conducted a study to estimate the technical efficiency of maize production in Bangladesh. The study used activity budgeting technique to calculate profitability and stochastic frontier production function model to measure the efficiency of maize farming. It showed that the farmers' age, education and training had positive significant impact on efficient maize production. Piya et al. (2012) conducted a case study in Nepal to compare the technical efficiency of rice farming in urban and rural area. The study estimated production function using maximum likelihood method and calculated the efficiency score of individual household by using stochastic frontier analysis. The result suggested that the degree of commercialization, farmers' age, education, share of agriculture in total household income and share cropping had significant impact on the efficiency of rice farming.

The mentioned studies used the stochastic frontier approach to measure the efficiency of various crop farming.

Some studies also analyzed the efficiency of rice farming in Bangladesh. However, this study was designed to show the impact of controlling saline water intrusion into the rice field in the coastal area of Bangladesh on the basis of profitability and technical efficiency of rice farming.

## III. Methodology

The area for this study was the Polder 31 in Dacope Upazila of Khulna district. Keeping in view, the objectives of the study two unions (Pankhali and Tildunga) of the Upazila were selected. The farmers of the Pankhali union were controlling saline water intrusion, so we called it the controlled area. On the other hand, the farmers of the Tildunga union were using saline water, and we called it uncontrolled area. A stratified random sampling technique was used to select 60 rice-cum-golda and 60 rice-cum-bagda farmers from the respected study areas. Primary data were collected using a structured interview schedule. The secondary data used in this study were from text books, journals, government papers, research reports, online materials and periodicals. Both descriptive statistics and activity budgeting were employed in analyzing the data and identifying the productivity and profitability of rice production. The stochastic frontier model using Cobb-Douglas production function was used to measure farm specific technical efficiency. Same analytical technique was used separately in different two areas.

The profitability of rice production was measured by using the following algebraic equation:

$\pi = TR - TC$

$$\pi = \sum Q_y . P_y + \sum Q_b . P_b - \sum_{i=1}^{n} (X_i . P_{xi}) - TFC \quad \text{………… (1)}$$

Where, $\pi$ = Net returns from production (Tk/ha); $Q_y$ = Total quantity of product (kg/ha); $P_y$ = Per unit prices of the product (Tk/kg); $Q_b$ = Total quantity of the concerned byproduct (kg/ha); $P_b$ = Per unit prices of the relevant byproduct (Tk/kg); $X_i$ = Quantity of the concerned i$^{th}$ inputs; $P_{xi}$ = Per unit price of the relevant i$^{th}$ inputs; $TFC$ = Total fixed cost involved in production and $i$ = 1, 2, 3,…, n (number of inputs).

The Cobb-Douglas stochastic frontier production function was used to analyze technical efficiency of rice production. The functional (double-log) form of stochastic frontier was as follows:

$$\ln Y = \beta_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + \beta_5 \ln X_5 + \beta_6 \ln X_6 + V_i - U_i \text{ … … (2)}$$

Where, $\ln =$ Natural logarithm, $Y =$ Observed farm output (kg/ha), $X_1$ =Seed (kg/ha), $X_2 = \text{Human labor (man} - \text{days/ha)}$, $X_3 =$ Urea (Kg/ha), $X_4 =$ TSP (kg/ha), $X_5 =$ MoP (Kg/ha), $X_6$ =Insecticide/pesticide (kg/ha); $\beta_0$ = Constant and $\beta_i$ = Coefficients.

The technical inefficiency effects $U_i$ in eq (2) are defined as

$$U_i = \delta_0 + \delta_1 Z_1 + \delta_2 Z_2 + \delta_3 Z_3 + \delta_4 Z_4 + W_i \text{ … … (3)}$$

Where, $Z_1 =$ Age of farmer (year), $Z_2$ =Education of farmer (year of schooling), $Z_3$ =Training (Dummy: '1' if taken; '0' otherwise), $Z_4 =$ Farm size (total cultivable land of farmer in decimal).

V is two sided uniform random variable beyond the control of farmer having $N(0, \sigma_v^2)$ distribution, U is one sided technical inefficiency effect under the control of farmer having a positive half normal distribution ($U \sim |N(0, \sigma_u^2)|$) and $W_i$ is two sided uniform random variable.

The β and δ coefficients are unknown parameters to be estimated together with the variance parameters which are expressed in terms of

$\sigma^2 = \sigma_u^2 + \sigma_v^2$ and $\gamma = \sigma_u^2 / \sigma^2$

Where, γ parameter has the value between zero and one.

The technical efficiency of the i$^{th}$ farmer can be shown to be equal to

$$TE_i = \frac{\text{Observedoutput}}{\text{Maximumattainableoutput}}$$

$$= \exp(-u_i)$$

$$= \exp[-E\{u_i / (v_i - u_i)\}]$$

$= 1 - E\{u_i / (v_i - u_i)\}$, ignoring high order of exponential series

The mean technical efficiency can be defined by-

Mean $TE = E[\exp[-E\{u_i / (v_i - u_i)\}]] = E[1 - E\{u_i / (v_i - u_i)\}]$

It is important to note that the above model for the inefficiency effects (3) can only be estimated if the inefficiency effects are stochastic and have a particular distributional specification. Hence, there is interest to test the null hypotheses that the inefficiency effects are not present;

$H_0: \gamma = \delta_0 = \cdots = \delta_4 = 0$; and

The coefficients of the variables in the model for the inefficiency effects are zero,

$H_0: \delta_0 = \cdots = \delta_4 = 0$

These null hypotheses are tested using the generalized likelihood-ratio statistic, λ, defined by

$\lambda = -2[\ln\{L(H_0)\} - \ln\{L(H_1)\}]$ ……………………… (4)

Where, $L(H_0)$ and $L(H_1)$ are the values of the likelihood function under the specifications of the null and alternative hypotheses ($H_0$ and $H_1$, respectively). If the null hypothesis is true then, λ has approximately a Chi-square (or a mixed Chi-square) distribution (Coelli, 1995).

A frontier 4.1 package was used to estimate the stochastic production function, which measures the inefficiency of the sample farms. Finally, the paired T-test was done to compare the level of technical efficiencies of individual farmers' between two different regions under the null hypothesis, $H_0$: Controlling saline water intrusion had no significant impact on farming efficiency of T. Aman rice.

## IV. Result And Discussion

### 4.1 Comparative Input Use Pattern and Productivity

Table 2 represents the comparative input use pattern and productivity of T. Aman rice cultivation between saline water controlled and uncontrolled areas. The rice farmers of both areas used considerably more seed than the recommended rate (30 kg/ha). Moreover, the use of seed in uncontrolled area was higher (59 kg/ha) than that of controlled one (51 kg/ha). Most of the rice growers used home supplied seed, whose germination rate was lower than quality seed. So, the farmers were prone to use more amounts of seeds than the recommendation. It divulges that there was significant mean difference at fertilizer application between the concerned areas. The application rate of fertilizers at the controlled area for T. Aman rice production were on an average 161 , 53 and 41 kg/ha of Urea, TSP and MP, respectively, while that of uncontrolled area were 116, 64 and 16 kg/ha, respectively. That means, controlled area's farmers used more amount of chemical fertilizers than that of uncontrolled area. The human labor used in the controlled and uncontrolled areas was 87 and 73 man-days/ha, respectively. It indicated that the saline water controlled farms were more human labor intensive in rice production. On an average, the yield of main product (rice) was 3845 and3177 kg/ha for the controlled and uncontrolled areas, respectively. The average return from by product (straw) was 6351Tk/ha and 5767 Tk/ha for the controlled and uncontrolled farms, respectively. So, the yield of rice in controlled area significantly differed (about 21.03% higher) from uncontrolled area.

**4.2 Comparative Cost and Return of T. Aman Rice Production**

The result of per hectare costs and returns of T. Aman rice production is presented in Table 3. Average hired human labor cost in saline water uncontrolled and controlled areas was estimated to be Tk. 10,750 and Tk. 15,000 per hectare, respectively which was the highest share (33.13% & 41.09%, respectively) of total cost. Cost of seedlings was higher in uncontrolled area (Tk. 3,744/ha) than that of controlled area (Tk. 3,212/ha).

Costs of fertilizer and insecticides were considerably higher in controlled area. That means, the controlled area's farmers were getting intension to use more inputs in rice cultivation. The farmers used exceptionally limited amount of manure for rice cultivation as there was only few numbers of livestock. It was manifest that there was no cost for irrigation as the farmers used flood, rain and drain water through sluice gate management and voluntary action of the gate committee. The farmers at the uncontrolled area used more family labor on rice cultivation than that of controlled area. The average family labor cost was Tk. 7,500/ha for uncontrolled area and that of controlled area was Tk. 6,750/ha. Per hectare total cost for T. Aman rice production in the controlled and uncontrolled areas were Tk. 36,504 and Tk. 32,452 where as total returns were Tk. 62,103 and Tk. 51,833, respectively. The gross margin and net return were estimated as Tk. 27,290/ha and Tk. 19,381/ha, respectively for uncontrolled farms and that were Tk. 32,837/ha and Tk. 25,599/ha for controlled farms. Farmers got Tk. 1.60 by investing Tk. 1.00 to T. Aman rice cultivation in the uncontrolled area and that of Tk. 1.70 in the controlled area as the benefit cost ratios (BCR) were 1.60 and 1.70, respectively.

**4.3 Estimates of Stochastic Frontier Production Function for T. Aman Rice Production**

The comparative maximum likelihood estimates of the parameters of the Cobb-Douglas stochastic production frontier of saline water controlled and uncontrolled areas for T. Aman rice are presented in Table 4. The coefficients of the variables in the frontier function are the elasticity of average output with respect to the different inputs used in the rice production as specified in the earlier equation (equation no. 2). However, the sign and magnitudes of the estimated coefficient in majority cases were consistent with prior expectation although some of them were statistically insignificant. The estimated coefficient of seed was negative and significant, irrespective of concerned areas. This implies that the amount of seed should reduce to get better production of rice. The coefficients of labor was positive and significant at 10% level in uncontrolled area only, which implies that if the application of labor increased by 1%, the yield of rice in uncontrolled area would be increased by 0.113%. The coefficient of Urea and TSP were anticipated at 5% and 10% level of significant only in controlled area, which means if the amount of Urea and TSP increased by 1%, the yield of rice in the controlled area would be increased by 0.008% and 0.021%, respectively. The coefficient of MoP and insecticides were positive and significant at both of controlled and uncontrolled areas which means, the farmers should increase the application of MoP and insecticides to get better production from T. Aman rice. Among the inefficiency factors, the coefficient of age of the farmers was positive in uncontrolled area and significant at 10% level. So, the age of farmers in uncontrolled area's farm had inverse relationship with farming efficiency.

But it had negative and significant coefficient in case of controlled areas. That means, if the age of farmers increase, the inefficiency of rice farming in uncontrolled area will be increased and decreased in case of controlled area. The coefficient of education and training were negative and significant, irrespective of concerned areas. So, it can be evident that if the farmers had higher education, their inefficiency would decrease meaning that their efficiency would be increased and the trained farmers were technically sounder than others. In other words, the level of the inefficiency effect of farmers tends to decrease with increase in training on farming of T. Aman rice farmers.

**4.4 Hypothesis Testing**

Table 5 presents the results of hypothesis testing. The null hypothesis was $H_0$: There was no inefficiency effect (gamma, $\gamma = 0$) or technical inefficiency in the model was absent. This hypothesis was strongly rejected for both of controlled and uncontrolled areas as the computed LR were greater than the tabulated $\chi^2$, indicating that there was presence of technical inefficiency effect in the production of T. Aman rice. Confirming this result further was the result of$\gamma$ (0.988 and 0.924 for the uncontrolled and controlled farms, respectively) of the preferred model in the lower part of Table 4. It ($\gamma$) was very close to one and significantly different from zero, thereby establishing the fact that high level of inefficiencies exist among the sample farmers. So, the MLE was the adequate estimation.

**4.5 Level of Technical Efficiency of T. Aman Rice Farmers**

It is evident from Table 6 that the mean value of technical efficiency was about 70.70% with a range from about 11% to 93% for the uncontrolled area's farms. About 31.67% (19 sample farmers) farms attained efficiency belongs to 81% - 90% category. In case of controlled area's farms the mean technical efficiency was about 87.50% with a range from about 54% to 96%. Near 51.67% (31 sample farmers) farms were belongs to efficiency level category 81% - 90%. The estimated result showed that there is a greater scope of increasing yield, breaking the frontier for T. Aman rice production in the study areas. The yield of T. Aman rice could be increased about 29% and 22% in case of uncontrolled and controlled areas, respectively even with the existing technologies if the management practices of the identified parameters are improved.

**4.6 T-test**

The paired T-test had been done under the null hypothesis, $H_0$: there was no difference between the farming efficiencies of controlled and uncontrolled areas' rice farmers'. The individual farmer's technical efficiencies from FRONTIER 4.1 package program were used to test the mentioned null hypothesis. The calculated value (12.995) at 99 percent confidence interval was highly significant. So, there was no enough evidence to accept the null hypothesis. That means, the technical efficiency of T. Aman rice farming significantly differs between the two conditions (saline water intrusion controlled and uncontrolled). So, Salinity had significant impact on farming efficiency of T. Aman rice farmers.

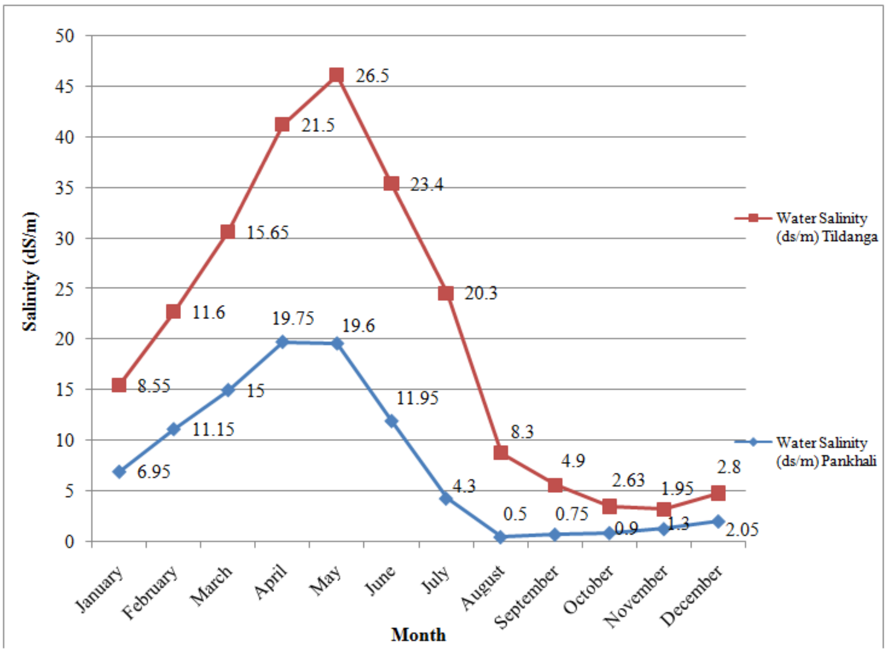
## V. Figures And Tables

**Table 1: Comparative Salinity of Pankhali and Tildanga Unions**

| Area (union) | Monthly water salinity (dS/m) | | | |
|---|---|---|---|---|
| | Minimum | Maximum | Mean | Std. Deviation |
| Pankhali | 0.50 | 19.75 | 7.85 | 7.39 |
| Tildunga | 1.95 | 26.50 | 12.34 | 8.85 |

Source: Soil Resource Development Institute (2012), author's calculation.

**Figure 1: Comparative salinity of Pankhali (controlled) and Tildanga (uncontrolled) unions.**




Data source: Soil Resource Development Institute (2012).

**Table 2: Use of Inputs for T. Aman Rice Production in Saline Water Controlled and Uncontrolled Areas**

| Items | Area | | Mean difference t-ratio |
|---|---|---|---|
| | Tildunga (Uncontrolled) | Pankhali (Controlled) | |
| Seed (kg/ha) | 59 | 51 | 8[ns] |
| Fertilizer (kg/ha): | 196 | 255 | -59*** |
| Urea | 116 | 161 | -45*** |
| TSP | 64 | 53 | 11** |
| MoP | 16 | 41 | -25** |
| Insecticides (No.) | 1.5 | 1 | 0.5[ns] |
| Human labor (man-days/ha): | 73 | 87 | -14** |
| Family | 30 | 27 | 2[ns] |
| Hired | 43 | 60 | -16*** |
| Yield performance | | | |
| Product | 3177 | 3845 | -668*** |
| By product | 5767 | 6351 | -584** |

***, ** and * indicate significant at 1%, 5% and 10% level, respectively. [ns] indicates not significant.

**Table 3: Per Hectare Costs and Returns of T. Aman Rice Production**

| Items of cost | Salinity uncontrolled area | Salinity controlled area |
|---|---|---|
| | Cost (Tk/ha) | Cost (Tk/ha) |
| Hired labor | 10,750<br>(33.13) | 15,000<br>(41.09) |
| Power tiller | 4,940<br>(15.22) | 4,940<br>(13.53) |
| Seedlings | 3,744<br>(11.54) | 3,212<br>(8.80) |
| Fertilizers cost | 3,984<br>(12.28) | 5,042<br>(13.81) |
| Manure | 234<br>(0.72) | 145<br>(0.40) |
| Insecticides/pesticides | 891<br>(2.75) | 927<br>(2.54) |
| Total variable cost | 24,543<br>(75.63) | 29,266<br>(80.17) |
| Family labor | 7,500<br>(23.11) | 6,750<br>(18.49) |
| IOC @ 10% for 4 month* | 409<br>(1.26) | 488<br>(1.34) |
| Total cost | 32,452 | 36,504 |
| Gross return | 51,833 | 62,103 |
| Gross margin | 27,290 | 32,837 |
| Net return | 19,381 | 25,599 |
| Undiscounted BCR | 1.60 | 1.70 |

Source: Field Survey (2012). Figures in the parenthesis represent the standard error.
*IOC= Interest on Operating Capital.

**Table 4: Maximum Likelihood Estimation of Stochastic Cobb-Douglas Production Frontier for Rice Production in Saline water controlled and uncontrolled Areas.**

| Name of variables | Parameters | Uncontrolled area | | Controlled area | |
|---|---|---|---|---|---|
| | | Coefficient | t-ratio | Coefficient | t-ratio |
| **Stochastic frontier** | | | | | |
| Constant | $\beta_0$ | 7.853*** (0.655) | 11.987 | 8.292*** (0.299) | 27.701 |
| Seed | $\beta_1$ | -0.099** (0.123) | -2.015 | -0.017*** (0.043) | -3.980 |
| Labor | $\beta_2$ | 0.113* (0.092) | 1.728 | -0.009 (0.045) | -0.220 |
| Urea | $\beta_3$ | -0.004 (0.104) | -0.041 | 0.008** (0.266) | 2.029 |
| TSP | $\beta_4$ | 0.114 (0.118) | 0.959 | 0.021* (0.015) | 1.944 |
| MoP | $\beta_5$ | 0.060* (0.036) | 1.789 | 0.005*** (0.016) | 3.224 |
| Insecticides/pesticides | $\beta_6$ | 0.271** (0.109) | 2.4976 | 0.120*** (0.033) | 3.692 |
| **Technical inefficiency model** | | | | | |
| Constant | $\delta_0$ | 2.308** (1.044) | 2.211 | -1.555** (1.208) | 2.287 |
| Age | $\delta_1$ | 0.398* (0.309) | -1.889 | -0.014** (0.013) | 2.092 |
| Education | $\delta_2$ | -0.125* (0.170) | 1.7362 | -0.112* (0.079) | 1.828 |
| Training | $\delta_3$ | -2.774** (2.160) | -2.284 | -0.884** (0.706) | -2.252 |
| Farm size | $\delta_4$ | 0.019 (0.013) | 1.423 | -0.002 (0.004) | 0.547 |
| Log likelihood value | | -55.19 | | 12.67 | |
| Mean technical efficiency | | 0.694 | | 0.875 | |
| **Variance parameter** | | | | | |
| Sigma-square | $\sigma^2$ | 5.415*** (1.289) | 4.200 | 0.110** (0.039) | 2.795 |
| Gamma | $\gamma$ | 0.988*** (0.010) | 96.682 | 0.924*** (0.112) | 7.121 |

***, ** and * indicate significant at 1%, 5% and 10% level, respectively.
Figures in the parenthesis represent the standard error.

**Table 5: Generalized Likelihood Ratio Test of Null Hypotheses for Parameters of the Inefficiency Function**

| Test of null hypothesis | Uncontrolled | | | | Controlled | | | |
|---|---|---|---|---|---|---|---|---|
| | Test statistics $(\lambda)^a$ | Degrees of freedom | Critical values at 95% $(\chi^2_{0.01})$ | Conclusion | Test statistics $(\lambda)^a$ | Degrees of freedom | Critical values at 95% $(\chi^2_{0.01})$ | Conclusion |
| Farmers are completely efficient in producing rice ($\gamma = \delta_0 = \delta_1 = \delta_2 = \delta_3 = \delta_4 = 0$) | 29.14 | 5 | 15.09 | Reject $H_0$ | 30.22 | 5 | 15.09[b] | Reject $H_0$ |

Source: Frontier 4.1 package program, [a] $\lambda = -2\,[\ln\{L(H_0)\} - \ln\{L(H_1)\}]$. [b]Critical values (15.09 at 1% probability level with k +1 df, where k is the number of restriction) obtained from Kodde and Palm (1986).

**Table 6: Level of Technical Efficiency for T. Aman Rice Producers**

| Technical efficiency (%) | No. of farmers | |
|---|---|---|
| | Salinity uncontrolled area | Salinity controlled area |
| <60 | 15 | 2 |
| 61-70 | 6 | 2 |
| 71-80 | 17 | 3 |
| 81-90 | 19 | 31 |
| 91-100 | 3 | 22 |
| No. of farms | 60 | 60 |
| Minimum efficiency | 0.11 | 0.54 |
| Maximum efficiency | 0.93 | 0.96 |
| Standard deviation | 0.168 | 0.079 |
| Mean efficiency | 0.707 | 0.875 |

Source: Frontier 4.1 package program, author's estimation.

**Table 7: Paired Samples Test**

| | | Paired Differences | | | | | t | df | Sig. (2-tailed) |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | 99% Confidence Interval of the Difference | | | | |
| | | Mean | Std. Deviation | Std. Error Mean | Lower | Upper | | | |
| Pair 1 | uncont–cont | -.16767 | .09994 | .01290 | -.20201 | -.13332 | -12.995 | 59 | .000 |

Source: Individual efficiency score from FRONTIER 4.1 package program. Statistical Package for Social Science (SPSS) program was used for T-test.

## VI. Conclusion

This study was designed to examine the effect of controlling saline water intrusion into the coastal rice field in terms of resource profitability and technical efficiency of rice farmers in Bangladesh. There existed significant impact of saline water intrusion control on the profitability of rice farming in the concerned area. The net returns of T. Aman rice were Tk. 19,381/ha and Tk. 25,599/ha in the saline water uncontrolled and controlled farms, respectively. The farmers received higher return on investment in rice production in the controlled areas as BCR was higher (1.70) than the uncontrolled area (1.60).Urea and TSP had significant positive impact on rice production in the controlled area only. However, seed, labor, MoP and insecticides had significant impact on both areas rice farms. Technical efficiency of rice production also varied with the controlled of saline water intrusion. The average technical efficiencies for T. Aman rice farming were about 70.70% and 87.50% for the uncontrolled and controlled farms, respectively. This implies that the output per farm can be increased, on an average, 29.30% and 12.50% in uncontrolled and controlled areas, respectively without incurring any additional production cost. The coefficients of farmer's education and training had significant positive effect on efficiency for rice production. If the efficient management of the existing resources can be ensured and modern variety of seed and technology is available to the farmers, yield and production can be increased which may help to increase their income and ensure food security. However, the salinity had negative and significant impact on the efficiency of T. Aman rice farming. So, the saline tolerant varieties or salinity controlling technologies may be introduced to the saline prone areas for efficient rice production.

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