

TECHNICAL EFFICIENCY OF RICE PRODUCING FARMS: A CASE STUDY OF CHAR- CHAPARI AREAS OF ASSAM

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The present study is designed to measure the level of technical efficiency and to identify the determinants of rice productivity and technical efficiency of rice producing farms in Char Chapari areas of Assam. The technical efficiency is measured by using a stochastic frontier production function. Multi-stage random sampling technique is used to select 210 rice farms of the char areas of Assam. The estimated production function reveals that Irrigation, chemical fertilizer, labour mandays, and farming experience of the farmers have significant positive impact on rice productivity. The estimated farm level technical efficiency is found to be ranging between 37.1 percent to 96.11 percent with mean efficiency of 82.05 percent. About 90 percent of the farms have a technical efficiency index of above 70 percent. The study also points out that with the resources/inputs available with the farmers, the farm's efficiency can still be increased by improving application of quality human resources engaged in agricultural pursuits, the services of experienced farmers and benefits of alternative occupations of the members of agricultural households in the Char Chapari areas of Assam.

Keywords: Char Chaparies, Productivity, IRI Variety of Rice.

INTRODUCTION

Rice (*Oryza Sativa*) is the main staple cereal in the diet of the people of Assam. The state has plenty of agricultural land and expertise in farm activities. But in spite of these, the growth of agricultural productivity has remained sluggish there. Paddy cultivation occupies 86.56 percent of the net cropped area and 61.16 percent of the gross cropped area in Assam. The normal paddy area of the state is 23.83 lakh hectares as in 2008-09. The yield rate of Autumn Rice was 999 kg/ha only and for Winter Rice it was 1380 kg/ha. On the other hand, for Summer Rice, the yield rate was 2267 kg/ha in the same year (Economic Survey Assam, 2008-09). The common variety of HYV rice which are popular among the rice farmers of the state of Assam are Mala, IR-36, Lachit, Masuri, Jaya, Ranjit, Ratna, China Boro, Biplov, Bahadur, Kaveri, Krishna, Iri etc. The Char Chaparis cover a vast portion of land in Assam and large numbers of people live in those areas. "Char" means a small isle surrounded by water in a river. "Chapari" means an area of sandy land in the bank of a river attached to the main land. The 'Char Chapari' in and by the sides of the mighty river Brahmaputra in Assam are extremely fertile and suitable for cultivation. According to "Socio-Economic Survey Report 2002-2003 of Char Chapari Areas of Assam", 4,34,754 families comprising 24,90,097 number of people live in 2251 Char Chapari villages in Assam which cover an area of 3609 sq.km. Barring Majuli and some other small Chars of upper Assam, almost all Char Chapari's are inhabited by people belonging to religious minority group, the Muslims. Near about two thirds of Assam's religious minority people, the Muslims, live in Char Chaparis. Char Chapari Areas account for 4.60 per cent of the State's total geographical area. These are spread over as many as fourteen districts of the state of Assam. The Char Chapari area is largest in the Dhubri district of Assam (35.7 percent of the district area) followed by Jorhat

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district (Socio Economic Survey Report 2002-03 of char areas of Assam; Govt. of Assam).

Near about 90 percent of the people of Char Chapari areas are associated with agriculture (Ismail Hussien, 2007). The agricultural land is extremely fertile in these areas. The cultivators are hard working and gifted with age old superior agricultural skill. However despite their toil, they are among the poorest of the poor, illiterate and neglected population group of Assam (Chakraborty, G. 2006). From the latter half of 90's, a new variety of seeds known as Iri has been introduced in large part of Char Chapari areas. Although the yield is higher, the Iri variety of paddy is coarse compared to other varieties of paddy grown by Char Chapari dwellers. As such the price as well as demand for Iri in the market is low. Iri needs high doses of chemical fertilizers, large number of labourers and substantial amount of water. It is undertaken by those cultivators who have a ready flow of cash (Chakraborty, G. 2006). However the high yielding Iri is popular among the poor Char Chapari dwellers as it satisfies their consumption needs.

The people living in the Char Chaparis of Assam are poverty afflicted. Since agriculture is their main occupation, one natural approach towards eradication of poverty from these areas would be to develop the agricultural sector of the area. The present study, therefore, focuses on measuring the technical efficiency with an objective to identify the proximate determinants of agricultural productivity and technical efficiency of rice producing farms of selected char Chapari areas of Assam.

OBJECTIVES OF THE STUDY

The objectives of the present study is to (i) measure technical efficiency of rice producing farms by using the stochastic frontier production function method. (ii) To identify the determinants of agricultural productivity and technical efficiency of rice producing farms. The study is conducted in selected Char Chaparies of Assam. Technical efficiency here refers to the ability and willingness of an economic unit (farm) to obtain the maximum possible output with a specified endowment of inputs (represented by a frontier production function) given the surrounding technology and environmental conditions.

Till date no study on technical efficiency of rice producing farms of Char Chapari areas of Assam has been carried out. It is also seen that some previous studies on agricultural productivity employed only the ordinary least squares (OLS) estimation technique which provides an average function and therefore, cannot determine farm level technical efficiency. The stochastic frontier production function technique overcomes this limitation of the OLS by providing numerical measures of technical efficiency of individual farms in a sample.

MATERIALS AND METHOD

The Theoretical Model: A stochastic production function is defined by

$$Y_i = f(X_i; \beta) \exp (V_i - U_i), \quad i = 1, 2, 3, \dots, n$$

Where, Y_i is output of the i -th farm, X_i is the vector of inputs used by the i -th farm, β is a vector of unknown parameters to be estimated, $f(\cdot)$ represents an appropriate function (e.g., Cobb Douglas, translog etc.). The term V_i is a symmetric error, which accounts for random variations in output due to factors beyond the control of the farmer e.g., weather, disease outbreaks, measurement errors etc., while the term U_i is a non negative random variable representing inefficiency in production relative to stochastic frontier. The V_i is assumed to be normally distributed with zero mean and constant variance $[N(0, \sigma_v^2)]$ while U_i has half normal distribution, a non-negative truncations of the $N(0, \sigma_v^2)$ distribution (i.e. half-normal distribution)

or have exponential distribution.

The stochastic frontier model was independently proposed by Aigner, Lovell, and Schmidt (1977) and Meeusen and Van den Broeck (1977). The technical efficiency of an individual farm is defined in terms of the ratio of the observed output to the corresponding frontier output, given the available technology. Therefore,

$$\begin{aligned}\text{Technical Efficiency (TE)} &= Y_i/Y_i^* = f(X_i; \beta) \exp(V_i - U_i) / f(X_i; \beta) \exp(V_i) \\ &= \exp(-U_i)\end{aligned}$$

Where, Y_i is the observed output and Y_i^* is the frontier output. TE ranges between 0 and 1.

The parameters of the stochastic frontier production function are estimated using the maximum likelihood method.

The Empirical Model

For the current study, the production technology of rice farmers in Char Chapari areas of Assam is assumed to be specified by the Cobb-Douglas frontier production function defined as follows:

$$Y = \beta_0 \text{IRR}^{\beta_1} \text{HYV}^{\beta_2} \text{CF}^{\beta_3} \text{MD}^{\beta_4} \text{PST}^{\beta_5} \text{MN}^{\beta_6} \text{EXP}^{\beta_7} \text{EDU}^{\beta_8} \text{FS}^{\beta_9} \text{AG}^{\beta_{10}} e^{U/V} \quad \dots\dots\dots(1)$$

Through log transformation, the nonlinear relationship in equation (1) is converted into linear ones:

$$\ln Y = \beta_0 + \beta_1 \ln \text{IRR} + \beta_2 \ln \text{HYV} + \beta_3 \ln \text{CF} + \beta_4 \ln \text{MD} + \beta_5 \ln \text{PST} + \beta_6 \ln \text{MN} + \beta_7 \ln \text{EXP} + \beta_8 \ln \text{EDU} + \beta_9 \ln \text{FS} + \beta_{10} \ln \text{AG} + U - V \quad \dots\dots\dots(2)$$

Where Y is yield of rice (kg/ ha), β_0 is constant or intercept term, IRR is the percentage area under irrigation, HYV is the percentage area of crop under HYV seeds, CF is the consumption of chemical fertilizers (N+P+K+DAP)(kg/ ha), MD is the use of total man days per hectare, PST is the use of pesticides (ml/ha), MN is the use of manure (kg/ha), EXP is the farming experience of the main farmer (in years), EDU is the level of education of the main farmer (in years), FS is the farm size (in hac.), AG is age of the head of the household (years) while U & V are as defined earlier. \ln is the Natural Logarithm and β_i 's ($i=1,2,\dots,10$) are the regression coefficients. The dependent variable yield per hectare (yearly yield of rice per hectare) represents agricultural productivity. The explanatory variables are also yearly estimates of inputs used for production of rice.

The Data

The Char Chapari areas are spread over the 14 districts of Assam. Out of these Dhubri district is purposively selected for the study as the district has the largest Char Chapari area and also high intensity of rice production. The Socio Economic Survey Report, 2002-2003 of Char Areas of Assam put the population of char Chapari area in Dhubri district at 6,89,909 persons. The Char Chapari areas of Dhubri district include 11 community development block areas out of 14 community development blocks of the district. Apart from rice, the char Chapari area produces jute, mustered, pulses and also vegetables in large quantities. A multistage sampling technique is used for data collection. Six community development blocks of Chapar, Nayeralga, Mahamaya, Devitola, Jamadarhatand Birshing Jaruah are randomly selected and 35 rice farms are selected at random from each of these selected Development Blocks. This gives a sample size of 210 farms for study. Data are collected with the help of structured questionnaires which contain information

on the socio-economic characteristics of the sample farmers and their rice production activities in terms of inputs and outputs from January to December 2009.

RESULTS AND DISCUSSION

Descriptive Statistics

The descriptive statistics of variables representing inputs, size of the farms and important characteristics of the farmers which are taken into consideration for specifying the production function in the present study, are presented in Table:1. The descriptions of the selected variables are also incorporated in the table for ready references. The Mean and Standard Deviation values are estimated from the sample data.

Table 1
Mean and Standard Deviation of the Selected Variables

Var.	Descriptions	Mean	S.D.
Y	Yield of rice in kg per hectare	3226.85	1031.24
IRR	Percentage area of rice crop under irrigation	89.08	20.54
HYV	percentage area of crop under HYV seeds	86.74	22.24
CF	Consumption of chemical fertilizers (N+K+P+DAP) in kg per hac.of rice crop.	421.79	196.47
MD	Use of total mandays per hac. of rice crop(1manday=8man/woman hours)	198.24	61.30
PST	Use of pesticides in ml per hac of rice crop	657.01	377.05
MN	Use of manure in kg per hac.of rice crop	1463.10	1099.70
EXP	Experience of the main farmer	26.73	13.70
EDU	Educational level of main farmer	4.53	4.977
FS	Farm size (in hac.)	1.24	1.26
AG	Age of the head of the household	46.97	12.16

Data Source: Field Survey, 2009

It is observed that the average farm yield per hectare is 3226.85 Kg of rice with SD value of 1031.24. There is wide variation in the yield rate across the farms and this leaves scope for further enhancing the agricultural productivity in the char-chapari areas of the state. On an average, a typical rice farmer is 46.97 years old with only 4.53 years of education, 26.73 years of farming experience operating on an average farm size of 1.24 hectares. The farmer produces an output of 3226.85 kg of rice per hectare by putting, in an average, 198.24 mandays of labour, 421.79 kg of chemical fertilizer, 657.01 ml of pesticides, and 1463.10 kg of manure per hectare. The average percentage area of crop under irrigation and HYV seeds is 89.08 and 86.74 percent respectively with SD value in between 20-22. There is apparently no deficiency of inputs applied for rice production. However, the average farm size is quite small and farmers have very low level of education.

Table 2
ML and OLS Estimates of the Stochastic Frontier Production Function Parameters for Rice in Char Chapari Areas

Variable	ML Estimate			OLS Estimate		
	Coefficient	Std. Error	t-Statistic	Coefficient	Std. Error	t-Statistic
C	5.091	0.401	12.695	4.334	.395	10.979
lnIRR	0.245*	0.044	5.568	.218*	.035	6.142
lnHYV	-0.068 ⁱⁿ	0.042	-1.624	-.047 ⁱⁿ	.033	-1.451
lnCF	0.145*	0.039	3.699	0.172*	.040	4.299
lnMD	0.197*	0.064	3.053	0.268*	.064	4.201
lnPST	0.012 ⁱⁿ	0.008	1.507	0.016 ⁱⁿ	.009	1.805
lnMN	-0.012*	0.005	-2.372	-.011**	.005	-2.056
lnEXP	0.029 ⁱⁿ	0.030	0.974	0.025 ⁱⁿ	.032	.793
lnEDU	0.048*	0.016	3.047	0.048*	.017	2.876
lnFS	-0.036 ⁱⁿ	0.022	-1.653	-0.026 ⁱⁿ	.024	-1.109
lnAG	0.079 ⁱⁿ	0.069	1.135	0.087 ⁱⁿ	.077	1.140
Sigma Squared	0.089			0.046		
Log Likelihood Function	37.64			30.64		
Sample Size	210			210		
R ²				0.749		
Adjusted R ²				0.737		
F-Value				59.493		

* = significant at 1%, ** = significant at 5%, ⁱⁿ = Insignificant.

Data Source: Field Survey, 2009

ESTIMATED PRODUCTION FUNCTION

The linear multiple regression model as specified in (2) above, is estimated by applying both Maximum Likelihood method and OLS method. The Maximum Likelihood Estimates (MLE) and OLS estimates of the model are presented in Table: 2. All the estimated co-efficients of the regressors are positive except HYV, MN and FS. The variables IRR, CF, MD, MN and EDU have turned up statistically significant in both MLE and OLS results. The estimated coefficients

of the significant variables are more or less similar in OLS and MLE results. The following discussion will highlight the impact of the individual variables having significant effect on the yield of rice in both MLE and OLS results which reveal almost the same picture.

Irrigation (IRR)

The variable irrigation (IRR) is found to be exerting strong positive impact on the yield of rice. The variable has also turned up statistically significant at 1 percent level. The result is in conformity with the findings of many other studies which emphasized the importance of irrigation in enhancing agricultural productivity all over India.

Chemical Fertilizer (CF)

The regression co-efficient of variable representing chemical fertilizer is found to be have positive impact on productivity. It is also statistically significant at 1 percent level. The positive sign and significance implies that an increase of chemical fertilizers used, other factors being constant, would increase the productivity of rice.

Labour Mandays (MD)

The regression co-efficient of labour mandays is found to be significant at 1 percent level. The variable has positive impact on yield of rice per hectare. The result indicates that an increase in labour mandays, other factors being constant, can raise the productivity of rice significantly. The result is indicative of the fact that the rice crop production in Char Chapari areas is not yet overcrowded and further increase in labour man days employed in this area would increase rice productivity. This is, however, contradictory to the general phenomenon of the existence of surplus labour in agricultural sector of India.

Manure (MN)

The variable manure is also found to be statistically significant at 5 percent level in OLS and 1 percent level in MLE results. However, it exhibits negative impact on productivity. Manure is the traditional fertilizer and largely used by farmers in Char Chapari areas because of its easy availability and low cost. However, the result indicated that excess use of manures will have negative impact on yield.

Level of Education (EDU)

The level of education of farmers is a strong indicator of quality of human resources engaged in cultivation. The variable EDU representing level of education of the main farmer has statistically significant (at 1 percent level) positive impact on the yield of rice or rice productivity. The result confirms the intrinsic and instrumental values of education in developing agricultural sector into a modern one.

ESTIMATES OF TECHNICAL EFFICIENCY

The frequency distribution of the sample farms by level of technical efficiency is shown in Table-3.

The Individual technical efficiency indices of rice farmers range between 37.14 percent and 96.11 percent with a mean efficiency of 82.05 percent. In several studies conducted in less developed countries, technical efficiency of agricultural farms is observed to be varying in

between 0.22 to 0.87 (Ajibefun, I. A. ,2008), 17.19 percent to 93.13 percent with a mean of 65.06 percent technical efficiency. (Onyenweaku, C. E. and D. O. Ohajianya, 2007). However, in some other places like West Azarbayjan Province of Iran bordering Iraq and Turkey, mean efficiency in agricultural farm is found to be as high as 93.04 (Arsalanbod, M. 2005). In this light, the mean efficiency of 82.05 observed in Char Chapari is at best a moderate figure leaving enough scope for further improvement of the same. However, the mean technical efficiency of 82.05 percent obtained in the present study compares much higher with the 64 percent obtained by Kalirajan(1981) for rice in India and the 65 percent obtained by Kalirajan and Shand (1986) in Malaysia. The frequency distribution of technical efficiency shows that about 90 percent of the farmers have a technical efficiency index of above 70 percent and out of 210 farms, 22 farms have exhibited technical efficiency less than 70 percent. In West Azarbayjan (Arsalanbod, M. 2005),39 percent of farmers have efficiencies less than 80 percent, 7.89 percent of them have efficiency between 80 and 90 percent, and 91.72 percent of the farmers have efficiency more than 90 percent. This suggests that opportunities exist for increasing productivity through increasing efficiency in resource utilization by the rice farmers in Char Chapari areas of Assam.

Table 3

Frequency Distribution of Technical Efficiency in Rice production in Char Chapari Areas of Assam

Technical Efficiency Range %	Frequency	Relative Frequency
< 40	1	0.47
40-50	2	0.95
50-60	8	3.81
60-70	11	5.24
70-80	42	20
80-90	111	52.86
90-100	35	16.67
Total:	210	100

Data Source: Field Survey, 2009

Mean Technical Efficiency: 82.05%

Minimum Technical Efficiency: 37.14%

Maximum Technical Efficiency: 96.11%

TECHNICAL EFFICIENCY FUNCTION/ REGRESSION MODEL

In order to find out the proximate determinants of technical efficiency, the technical efficiency function / Regression Model has been specified as below and estimated by applying OLS method since the model is linear and OLS estimates are easier to interpret.

$$TE_i = \beta_0 + \beta_1 AVEDU + \beta_2 AVEXP + \beta_3 ALTOCCU + \beta_4 INDTNS + \beta_5 FS + e_i$$

Where,

TE = technical efficiency in Percentage

AVEDU = average education of the household (except 5years of age)

AVEXP = average experience of the household agricultural labours (years)

ALTOCCU = household have subsidiary income (Yes = 1, No = 0)

INDTNS = indebtedness of the farm households (Rs)

FS = farm size (in hectares)

β_i = parameters to be estimated and

e_i = error term.

The OLS estimates of determinants of technical efficiency of rice producers in the area are presented in Table 4. The results indicate that, the coefficients of average years of schooling (education) of the household (except 5years of age), average experience of the household agricultural labourers (years) and alternative occupation of the farm household have positive signs and also significant at 1% level. The result corroborates the findings of other important studies conducted in other countries (Revilla-Molinai, I. M. et. al, 2001; Idiong, I. C.,2007; Ajibefun, I. A.,2008). However, the coefficient of farm size and farm indebtedness is insignificant and the farm size also exerts negative influence on the technical efficiency in the present study. Empirical result on the contrary (that there are significant possibilities to increase efficiency levels by increasing farm size.) is not scanty in the literature on determinants of technical efficiency (Krasachal, W.,2000). Broadly the results of the study imply that, in char chapari areas, the rice farmer's efficiency will increase with increase in proper utilization and application of education, experience in farming activities, and benefits of alternative occupation of the farm household. On the other hand farm size has a negative impact on technical efficiency, but its impact is not significant.

Table 4

OLS estimates of the determinants of Technical Efficiency in Rice Farming in Char Chapari areas of Dhubri District

Variables	OLS Estimates		
	Coefficients	Std. Error	t-value
(Constant)	64.657*	2.034	31.790
AVEDU	1.396*	.248	5.626
AVEX	0.501*	.108	4.657
ALTOCCU	3.796*	1.441	2.634
INDTNS	0.00006 ⁱⁿ	0.000	0.567
FS	-1.895 ⁱⁿ	2.781	-0.681

Data Source: Estimated from Field Survey Data, 2009

*=Significant at 1%, in =insignificant

Dependent Variable: TE

R Square = 0.275 Adjusted R Square= 0.257

Coefficient of indebtedness of the farm family has positive sign but it is not significant. This means that indebtedness of farmer is not a significant factor vis-a vis higher levels of efficiency with given technology.

CONCLUSIONS

The important factors directly related to yield of rice are irrigation, chemical fertilizer, labour mandays and education. Policies aimed at improving irrigation facilities, level of education of the farmers and proper distribution of chemical fertilizers will be useful in increasing rice productivity. Development of small irrigation projects and greater investment in formal and informal education, as well as in distribution system of fertilizers are required to be emphasized at policy formulation level. Policies directed at health status of the farmers in order to increase the labour mandays performed by the farmers will also be helpful in increasing rice productivity in the study area.

The result of the present study shows that the mean technical efficiency of farms in the poverty-stricken Char Chapari areas of Dhubri district is a modest 82.05 percent. There is only one farm which has technical efficiency less than 40 percent. Although the overall result is little bit unexpected, the same also indicates that the farms can still increase their agricultural output by near about 18 percent without additional resources through proper use of existing inputs and technology. It can be said that 18 percent of the technical potential of the areas has not yet been realized in raising the agricultural productivity.

The study points out that with the resources/inputs available with the farmers, the farm's efficiency can still be increased by proper application of quality human resources engaged in agricultural pursuits, the services of experienced farmers and utilizing the benefits of alternative occupations of the members of agricultural households in the Char Chapari areas of Assam.

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