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ECONOMIC ANALYSIS OF TECHNICAL EFFICIENCY IN RICE FARMS USING DIFFERENT IRRIGATION SYSTEMS IN TAMILNADU

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ABSTRACT:

Rice is the stable food in India, improvement in efficiency levels is one of the major means of sustaining the staple food production and thereby ensuring food security. This study was taken up to determine the technical efficiency of rice cultivation under different irrigation systems in Tamil Nadu. It could be concluded that the mean technical efficiency was 0.76, 0.75 and 0.71 for canal, well and tank irrigation system respectively. This showed that in the study region, the efficiency of the farmers was almost same for all the three systems of irrigation. Thus, productivity can be increased by adoption of non-monetary inputs like timely sowing, maintaining optimum plant population, timely irrigation, efficient use of fertilizers and irrigation water, need based plant protection measures and timely harvesting of crop.

KEY WORD: *Rice cultivation, Technical Efficiency, Different irrigation systems.*

INTRODUCTION:

Rice being the most important stable food in India, improvement in efficiency levels is one of the major means of sustaining the staple food production and thereby ensuring food security. Changes in productivity occur due to changes in technology and changes in technical efficiency (Jayaram *et al.*, 1992). The study was taken up to determine the efficiency of rice cultivation under different irrigation systems in Tamil Nadu. Moreover, the study also explores the farm level technical efficiency of rice cultivation under different irrigation systems. The study attempts to compare farmers' responses with respect to technical efficiency in rice production depending upon the systems of irrigation in Tamil Nadu.

METHODOLOGY:

Measurement of Technical Efficiency using Stochastic Frontier Production Function Analysis

The stochastic frontier production function for estimating farm level technical efficiency (Goyal *et al.*, 2006) is specified as:

$$Y_i = f(X_i, \beta) + \varepsilon_i \qquad (1)$$

Where i is the n^th observations, Y_i is output, X_i denotes the actual input vector of production function and β is the vector of parameters of production function and ε is the error term that is composed of two elements, that is

$$\varepsilon_i = V_i - U_i \qquad (2)$$

Where V_i is the symmetric disturbances assumed to be identically, independently and normally distributed as N (0, σ_{Vi}^2) given the stochastic structure of the frontier. The second component U_i is a one sided error term that is independent of V_i and is normally distributed as (0, σ_{Ui}^2) , allowing the actual production to short fall below the frontier but without attributing all short falls in output from the frontier as inefficiency.

The farm-specific technical efficiency is defined in terms of observed output (Y_i) to the corresponding frontier output (Y_i^*) using the available technology derived which is defined as follows:

$$TE_i = \frac{Y_i}{Y_i^*} = \frac{E(Y_i/u_i, X_i)}{E(Y_i/u_i=0, X_i)}$$

$$= E\,[\exp(-U_i)/\varepsilon_i] \qquad (3)$$

TE takes values within the interval (0, 1), where 1 indicates a fully efficient firm.

The stochastic frontier production function model (Hazarika, C and S.R. Subramanian, 1999) specified for rice crop is given below.

$$\ln(Y) = \beta_0 + \beta_1 (\ln X_1) + \beta_2 \ln(X_2) + \beta_3 \ln(X_3) + \beta_4 \ln(X_4) + \beta_5 \ln(X_5) + \beta_6 \ln(X_6) + \beta_7 \ln(X_7) + \beta_8 \ln(X_8) + \beta_9 \ln(X_9) + (V_i - U_i)$$

Where

Y = Yield of Paddy (Kg/ha)
X_1 = Seed (Kg/ha.)
X_2 = Human labour (man days/ha.)
X_3 = Machine power (hp hrs. /ha.)
X_4 = Farm yard manure (tonnes/ha)
X_5 = Plant protection chemicals (Rs/ha.)
X_6 = Nitrogen (Kg/ha.)
X_7 = Phosphorous (Kg/ha.)
X_8 = Potash (Kg/ha.)
X_9 = Irrigation (ha.cm.)
β_0 = $\ln \beta_0$ = Regression Constant
$\beta_1, \beta_2, \beta_3, \beta_4, \ldots\ldots \beta_9$ = Elasticity coefficients

RESULTS AND DISCUSSION:

Technical Efficiency in Rice Farms - Stochastic Production Frontier using MLE Method

The technical efficiency of canal, well and tank irrigated rice cultivating farmers was estimated by using the stochastic frontier production function of Cobb-Douglas form using the MLE method. The stochastic frontier function analysis attempted in this study had the rice output kg/ha as the dependent variable and independent variables included were, human labour (man days/ha.), machine power (hp hrs./ha), seed rate (Kgs/ha), FYM (tonnes/ha), PPC (Rs./ha), nitrogen (Kgs/ha), phosphorus (Kgs/ha), potassium (Kgs/ha), and irrigation (ha.cm). The Maximum Likelihood Estimates (MLE) of the parameters of Cobb-Douglas stochastic frontier function were obtained using maximum likelihood procedures through FRONTIER 4.1 package and the results are presented in Table below.

Canal Irrigated Rice Cultivation

MLE results showed that in canal irrigated system of rice cultivation, the quantity of human labour and irrigation had significance at 1 per cent level. The estimate of γ would refer to ratio of the variance of farm specific performance of Technical efficiency (σu^2) to the total variance of output (σv^2). A high value for γ (0.99) would indicate the presence of significant inefficiency in the production of the crop. The estimate of γ would indicate that 99 per cent of the difference between the observed and frontier output was mainly due to the inefficient use of resources, which were under the control of the farmers. The remaining portion i.e., 1 per cent was due to factors beyond the farmers' control. The average technical efficiency was estimated at 76 per cent indicating that output can be raised by 24 per cent through following efficient crop management practices without actually increasing the level of application of inputs.

Tank Irrigated Rice Cultivation

MLE results showed that in tank irrigated system of rice cultivation, the application of N, P and irrigation were positively significant at 1 per cent level. Human labour and seed rate were significant at 5 per cent level. The estimate of γ was 0.91 which would indicate that 91 per cent of the difference between the observed and frontier output was mainly due to the inefficient use of resources which were under the control of the farmers. The remaining portion 0.9, i.e., 9 per cent was due to factors beyond the farmers' control. The mean technical efficiency (MTE) was only 0.71 which would imply that, on an average, the sample farmers would realize only 71 per cent of their technical abilities and the remaining 29 per cent accounted for the inefficiency of the farmers. Thus, the technical efficiency showed that there would be a reasonably good scope for increasing the productivity of rice with the existing level of input use in the study region by adopting better crop management practices.

Well Irrigated Rice Cultivation

The MLE results showed that in well irrigated system of rice cultivation, the human labour was significant at 1 per cent level, whereas the inputs like FYM, PPC and irrigation were significant at 5 per cent level. The estimate of γ was 0.75 which would indicate that 75 per cent of the difference between the observed and frontier output was primarily due to factors which were under the control of farmers. The remaining portion of 25 per cent was due to factors beyond the farmers' control. The estimated mean technical efficiency was 0.75 implying that, on an average, the sample farmers would realize only 75 per cent of their technical abilities and the remaining 25 per cent showed the inefficiency of the farmers.

It could be concluded that the mean technical efficiency was 0.76, 0.75 and 0.71 for canal, well and tank irrigation system respectively. This showed that in the study region, the efficiency of the farmers was almost same for all the three systems of irrigation. Thus, productivity can be increased by adoption of non-monetary inputs like timely sowing, maintaining optimum plant population, timely irrigation, efficient use of fertilizers and irrigation water, need based plant protection measures and timely harvesting of crop.

Distribution of Farmers according to Technical Efficiency Ratings

Distribution of sample farmers according to different technical efficiency ratings of canal, well and tank irrigation systems were presented in Table.

Canal Irrigated Rice Cultivation

The results showed that 11.20 per cent of farmers using canal system of irrigation to cultivate rice were found to operate at technical efficiency rating of more than 0.90. About 14 per cent of farmers were found to be operating at technical efficiency rating of below 0.60 per cent.

Tank Irrigated Rice Cultivation

The results showed that five per cent of farmers using tank system of irrigation to cultivate rice were found to operate at technical efficiency rating of more than 0.90. About 19 per cent of farmers were found to be operating at technical efficiency rating of below 0.60 per cent.

Well Irrigated Rice Cultivation

The results showed that five per cent of the farmers using well irrigation system to cultivate rice were found to operate at technical efficiency rating of more than 0.90. About 10.00 per cent of farmers were found to be operating at technical efficiency rating of below 0.60 per cent

It could be concluded that there was a variation in the level of technical efficiencies among the sample farmers who cultivated rice using different systems of irrigation. The sample farmers using canal system of irrigation for rice cultivation were technically efficient when compared to the farmers using tank and well system of irrigation for rice cultivation. This was due to the larger adoption of System of Rice Intensification technology among the sample farmers in Thanjavur district.

These results are important in that they provide detailed information to policy makers on the nature of production technologies used in farms. Thus, there was a scope to bridge the gap between the actual or realized and the potential output with the given technology by using available resources more efficiently.

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MLE Estimates of Stochastic Frontier Function for Rice Cultivation under Different Irrigation Systems

Sl. No.	Variables	Thanjavur (Canal)			Sivagangai (Tank)			Salem (Well)		
		Coefficient	Std. error	t value	Coefficient	Std. error	t value	Coefficient	Std. error	t value
A	**Frontier production function**									
1.	Constant	5.928*	0.704	8.426	4.830*	0.474	10.200	4.875*	0.637	7.654
2.	Human labour (man days/ ha.)	0.724*	0.129	5.619	0.284**	0.139	2.049	0.325*	0.049	6.680
3.	Machine power (hp. hrs/ha.)	-0.486***	0.249	-1.946	0.034 NS	0.043	0.804	0.080NS	0.084	0.949
4.	Seed rate (kgs/ha.)	0.346***	0.181	1.910	0.076**	0.027	2.850	0.029 NS	0.041	0.701
5.	Farm Yard Manure (tonnes/ha.)	-0.232***	0.136	-1.710	-0.025 NS	0.026	-0.972	0.119**	0.040	2.951
6.	PPC (Rs/ha.)	0.034 NS	0.034	0.990	0.034 NS	0.120	0.282	0.163**	0.072	2.276
7.	Nitrogen (kgs/ha.)	-0.485*	0.113	-4.273	0.262*	0.059	4.441	0.076***	0.043	1.767
8.	Phosphorous (kgs/ha.)	0.028 NS	0.038	0.736	0.178*	0.043	4.128	0.094 NS	0.073	1.284
9.	Potash (kgs./ha)	0.149***	0.081	1.829	-0.019 NS	0.062	-0.316	-0.056 NS	0.057	-0.975
10.	Irrigation (ha.cm)	0.506*	0.117	4.293	0.318*	0.045	7.080	0.152**	0.071	2.142
B.	**Diagnosis Statistics**									
11.	Sigma-square (σ^2)	0.192*	0.016		0.072*	0.017		0.197*	0.065	
12.	Gamma (γ)	0.999*	0.0002		0.912*	0.064		0.752*	0.199	
13.	Log- likelihood	7.38			30.19			21.44		
14.	Mean technical efficiency	0.76			0.71			0.75		
15.	Mean technical inefficiency	0.24			0.29			0.25		
16.	Number of Observations	80			80			80		

* - 1 % level of significance
** - 5 % level of significance
*** - 10 % level of significance
NS - Non significance

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Distribution of Farmers according to Technical Efficiency Ratings

(Number of farmers)

Sl. No	Technical efficiency rating	Canal	Tank	Well
1	<60%	11 (13.75)	15 (18.75)	8 (10.00)
2	61% - 70%	12 (15.00)	20 (25.00)	13 (16.25)
3	71% - 80%	26 (32.50)	26 (32.50)	25 (31.25)
4	81% - 90%	22 (27.50)	15 (18.75)	30 (37.50)
5	>90%	9 (11.20)	4 (5.00)	4 (5.00)
	Total	**80 (100.00)**	**80 (100.00)**	**80 (100.00)**

(Figures in parentheses indicates percentage to total)