EFFICIENCY AND MANAGERIAL ABILITY OF PADDY FARMING UNDER MINOR IRRIGATION CONDITIONS: A FRONTIOR PRODUCTION FUNCTION APPROACH

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ABSTRACT

In economics, it is well recognized that resources involved in the production process are limited in supply and the scare resources should be efficiently used without wasting. Efficient utilization depends on managerial ability of entrepreneurs-farmers, firm, etc. Available literature suggests that farmers in the developing countries fail to exploit the full potential of a technology and make allocative errors. Thus, increasing the efficiency in production assumes greater significance in attaining potential output at the farm level. However it is an undeniable fact that the majority of dry zone paddy farmers are characterized by poor economic status due to inefficient utilization of available resources. This paper investigates the economic and technical efficiency of paddy farming in a minor irrigation scheme in Sri Lanka and to suggest some policy recommendation for improving the efficiency of resource use.The experiment sites were four minor tanks in Tricomalee district and respective tanks were randomly selected based on the list of the village tank in same district. The empirical study was carried based on a sample of 158 farmers in selected tanks. In this study, the technical efficiency of paddy farmers was estimated by using stochastic frontier production function, incorporating technical efficiency effect model. The Cobb Douglas production function was found to be an adequate representation of the data.According to the results obtained from the stochastic frontier estimation, the average technical efficiency of selected farmers given by the Cobb Douglas model is 69.08 per cent. This indicates that there is scope of farther increasing the output by 30.2 percent without increasing the level of input. With imputed cost profit margin of paddy farming under village tanks was Rs.0.27 per kg and Break even yield was 3,505 kg per ha.The analysis using the Cobb-Douglas function indicated miss-allocation of resources in most of the location in the sample area due to managerial inability of farmers.

Keywords:*Paddy Farming, Irrigation, Technical and Managerial Efficiency, Frontier Production Function.*

INTRODUCTION

Agriculture playing significant role in rural employment in Sri Lanka and it is account for 12 percent of gross domestic product (GDP), 24 percent of total export and 33 percent of total employed labour force (Central Bank of Sri Lanka, 2009). There are more than 10,000 minor irrigation reservoirs (commanding area is ≤ 80 ha) and 238 major reservoirs (commending area is more than 80 ha) (Henegedara, 2002). The majority (72 percent) of the people lives in rural areas and earns a livelihood from agriculture and related activities in Sri Lanka. The agriculture sector which has the characteristics of a dualistic economy (Snodgrass, 1966) consists of two sub sectors, the non plantation or domestic food crop sector and the plantation sector. The non plantation sector which mainly consists of paddy, other food grains, maize, soybean, vegetable and perennial crops account for 76 percent of total cultivable lands while plantation sector consisting of tea, rubber, coconut accounting for 24 percent of the total agricultural land (Department of Census and Statistics abstract,2010).

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Rice is the staple food for about 50 percent of the world's population that resides in Asia, where 90 percent of the world's rice is grown and consumed. The world's paddy production was 619.8 million tons in 2010, covering an area of 153.51 million ha with an average yield of 3.87 tons per ha. (Institute of International Rice Research, 2010). In Sri Lanka paddy being the staple food crop accounts for 25 percent of total cultivable land and more than two million farmer families are engaged in farming as their main occupation. Highly water-intensive rice cultivation consumes more than 70 percent of the total water allocated for food production in the country (Henegedara, 2002). The principle irrigated crop, paddy is grown on nearly 730,000ha of land, and 243,000 of this total is grown under major irrigation system. Of the remaining 170,000ha under minor irrigation and nearly 146,000ha are under the Mahaweli development project which is the selected study area (Department of Census and Statistics,2010). Beside there are another 171,000ha which is non irrigable paddy land sown by small scale paddy farmers under rainfed system – especially in wet zone (Henegedara, 2002).

It is important to emphasize that more than 80 percent of cultivated paddy land are under irrigation and more than 70 percent of paddy farmers belong to the "small farmer category" which own less than one hectare of land. More than 90 percent of irrigated paddy lands are locating in the dry zone including the irrigated land under Mahaweli development project (Henegedara, 2002).

The rational output of this commodity has witnessed significant increase over the past three decades and this can be traced primarily to the expansion of cultivated area as well as to increased productivity of inputs. The latter is an outcome of the application of newer research findings on a variety of aspects such as improvement in genetic constitution of the crop, introduction of superior quality fertilizer, newer method of plant establishment, better method of weed, pest and weed control (Abeysekera, 1996).

Problem Statment

A majority of such innovation originating from research institutions primarily seek enhanced crop yields by application of better production methods which are technically efficient. However, it is to be noted that all these production techniques do not necessarily guarantee the most economic means of resource use at the farm level representing the highest economic efficiency where maximum paddy output is produced using a minimum of production inputs. Good Agricultural Practices (GAPs) are efficient and effective farming practices that include integrated agricultural practices, conservation agriculture, nutrient management, integrated pest management, water management and others (Institute of International Rice Research, 2010). Despite such efforts, the performances of paddy farmers in Sri Lanka were not satisfactory. The yield levels in Sri Lanka (tons/ha) were low at tons per ha compared to other major rice producing countries viz., Japan (6.52t/ha), China (6.24t/ha) and Indonesia (4.88t/ha) (Bos, *et al*, 1990). Beside the cost of production have been increased unexpectedly during last three decades and the inevitable consequences of this situation is demotivation of paddy farmers by slimmer profit margin (Udayanganie, *et al*, 2006).

The major issue in this regard for the agricultural economist and policy planners is to assess available means for the farmers to increase productivity under the given technology avoiding the costly and capital-intensive investments (Udayanganie, *et al,* 2006).

In view of the growing competition in world rice market and high production costs, production efficiency will become an important determinant of thefuture paddy industry in Sri Lanka. Developing and adopting new production technologies could improve production efficiency. In addition the industry could maintain its economic viability by improving the efficiency of existing operation with a given technology. In other words, the industry's total output can be increased without increased the total cost by making better use of available inputs and technology.

Available literature suggests that farmers in developing countries fail to exploit the full potential of technology and make allocative errors (Taylor and Shonkwiler, 1986; Ali and Flinn, 1989; Kalirajan and Shand, 1989; Bravo-Ureta and Evenson, 1994; Shanmugan and Palanisami, 1994; Sharma and Datta, 1997; Thomas and Sudaresan, 2000, IWMI, 2002; and IRRI, 2010).Most researches and studies have been discussing the technical inefficiency of irrigated paddy farming around the world. However, In Sri Lanka very little empirical effort have been made to measure the technical efficiency and has assessed the focal factors on this technical efficiency in irrigated paddy farming.

Objectives of the Study

This paper attempts to analyze the economic and technical efficiency of paddy farming in minor irrigation schemes in Sri Lanka and to suggest some policy recommendation for improving the efficiency of resource use. It is hoped that the study results would assets in further understanding of the existing difference allocative behavior among paddy farmers and hence set useful guidelines for readjusting the existing resources allocation pattern at the farm level as a means in increasing the production.

MATERIALS AND METHODS

The Study Area

The *Trincomalee* district was selected for the study. There are about 450 minor irrigation tanks in *Trincomalee* district and majority of these tanks date back to several centuries (Karurasena, *et.al* 1997). A large number of minor tanks have been abandoned for many years due to the conflict situation and the displacement of the resident. The Meteorological Department of Sri Lanka has identified *Trincomalee* district as an area with a high risk of drought and farmers are more vulnerable to drought with irrigation farming under minor tanks. According to last two decades records provided by Irrigation Department farmers may cultivate their irrigable land only in *Maha* season (September to March).

Population, Sample and data gathering tools

The experimental sites (four village tanks) were randomly selected based on the list of village tanks provided by the Intergraded Food Security Programme (IFSP) in *Trincomalee* district. All farmer families in the selected tanks were considered for the study. Main characteristics of randomly selected minor tanks are given in Table 01.

Various methods have been used for gathering data and information including key informant interviews and focus group discussion. Interviews were conducted with staff from the agrarian services, irrigation department as well as other public officers. In the field, farmers were interviewed through questionnaier individully as well as in group. The questionnire was prepared based on information collected from farmer participatory workshops and from avilable literature. Focus group discussion have been organized with the help of *Grama Niladaries* and the leaders of farmer organizations. The survey was carried out in 2009/2010 Maha season. Information were gatherd from difference sources (Table 02).

Table 01: Characteristics of selected tanks

D.S Division	Tank	Command Area (ha)	Farmer Families	Sample Size
Morawewa	Rottawewa	78	40	40
Padavipura	Meegaswewa	32	28	28
Gomarankadawala	Kubukwewa	38	40	40
Kuchchaveli	Theivanayakulam	24	50	50
Total		172	158	158

Source: Department of Agrarian Services

Table 02: Sources of information

Type of data/information used	Source of Data/information
Basic data of selected tanks	Department of Irrigation
Cultivated Extent and cropping Intensities	Agrarian services
Farm and non farm income	Questionnaire Survay
Yield,cost of production and net retuns	Questionnaier Survay
Assest and wealth differences information	The Water Resource Secretariat
Existing technologis for paddy farming	Group discussions
Use of resources	Group discussion with farmers and officers

Model Specification

Aigner *et al*. (1977) and Meeusen and Van den Breck (1977) developed the stochastic frontier (SF) approach to estimate technical efficiency of firms/producers using parametric econometric techniques. The original specification involved a production function specified for cross-sectional data with an error term which had two components, one to account for random effect and another to account for technical inefficiency. The model can be expressed in the following form (Coelli, 1994_):

$Y_i = X_i \beta + \varepsilon_i \varepsilon_{i =} V_i - U_i$

Where Y_i is the production (or the logarithm of the production) of the i-th firm;

X_i is a kx1 vector of (transformation of the) input quantities of the i-th firm;

β is an vector of unknown parameters;

The error term $\varepsilon_{i,}$ includes two components in which an account for random effect (V_i) and other captures technical inefficiency (U_i).The error component V_i are assumed to be independently distributed as N (0,σ^2v). U_i which are non-negative random variables ($U_i \leq 0$) which are assumed to account for technical inefficiency in production and are often assumed to be iid.

This original specification has been used in a vast number of empirical applications over the past two decades (Coelli, 1995). The specification has also been altered

The parameter γ, which replaces σ_v^2 and σ_u^2 with σ^2

So that $\sigma^2 = \sigma_v^2 + \sigma_u^2$ Thus, $\gamma = \sigma_u^2 / (\sigma_v^2 + \sigma_u^2)$

The parameter γ, must lie between 0 and 1 and if the γ equals zero, the difference between farmers yield and efficient yield is entirely due to statistical noise. On the ther hand $\gamma = 1$ indicate the differences is entirely due to inefficient use of technology (Coelli,1995).

The estimation of frontier function and efficiency can be completed either in the stage or in two stages. The two-stage analysis of explaining levels of technical efficiency (or inefficiency) was criticized by Battese and Coelli (1995) as being contradictory, in the assumption made in the separate stages of analysis. In this paper, we fallow the Battese and Coelli (1995) approach of modeling both the stochastic and the technical inefficiency effect in the frontier, in terms of observable variable, and estimating all parameters by the methods of Maximum likelihood, in a single-step analysis.

Empirical model and variables

The primary data which were collected from 158 paddy farmers covering four minor tanks in *Trincomelee* district was used in the study. We used Cobb-Douglas production frontier for relevant measurements using cross-sectional data with half-normal distribution. The model is defined by:

$$Ln(Y_i) = \beta_0 + \beta_1 ln(X_{1i}) + \beta_2 ln(X_{2i}) + \beta_3 ln(X_{3i}) + \beta_4 ln(X_{4i}) + \beta_5 ln(X_{5i}) + \beta_6 ln(X_{6i}) + \beta_7 ln(X_{7i}) + (Vi - U_i)$$

Where *ln* denotes logarithms to base e and

Y = Output (Kg/ha)

X_1= Extent of land (ha.)

X_2= Family labour (man days)

X_3= Hired labour(days/ha)

X_4= Quantity of Fertilizer (NPK) (kg/ha).

X_5 = Plant protection chemicals (liters/ha)

X_6= Cost of machinery (Rs/ha)

X_7 = Off farm income (Rs./month/household)

$\beta_0, \beta_1 \ldots\ldots \beta_7$ *are parameters to be estimated and*

V_i = Random variables which are assumed to be iid, $N(0,\sigma^2 v)$ and *independent of theUi.*

U_i= which are non-negative random variables which are assumed to account for technical inefficiency in production and are often assumed to be iid..The computer programme FRONTIER 4.6 (Coelli, 1994) was used to estimate simultaneously the parameters of the stochastic production frontier and the technical inefficiency effect.

Determinants of Technical Efficiency

Many studies have identified a positive relationship between technical efficiency and socio-economic variables (Kalirajan, 1991`; Bravo-Ureta and Evenson, 2007; Parikh and shah, 1994; Shanmugham, 2003; Bhende and Kalirajan, 1994). In this study, the factors such as age of farmers, paddy farming experiences, water management knowledge, education level, distance of field from canal irrigation structure (km), sowing time, right of entry formal credit and contact with extension agencies were considered as factors of technical efficiency in paddy farming.

The inefficiency model specified for Battese and Coelli (1995) specification was,

$$U_i = \alpha_0 + \alpha_1 Z_{1i} + \alpha_2 Z_{2i} + \alpha_3 Z_{3i} + \alpha_4 Z_{4i} + \alpha_5 Z_{5i} + \alpha_6 Z_{6i} + \alpha_7 Z_{7i} + \alpha_8 Z_8$$

Z_1 = Age of farmers (years)

Z_2 = Paddy farming experiences(years)

Z_3 = Water management knowledge, a dummy variable equal to one with sufficient knowledge and zero otherwise.

Z_4 = Education level of farmers (school years)

Z_5 = Distance of field from canal irrigation structure (km)

Z_6 = Sowing time, if the paddy field is sown in time, then it has the value of one, otherwise zero.

Z_7 = Right of entry formal credit, if farmer has a right to taken formal credit it has the value of one otherwise zero.

Z_8 = Contact with extension agencies

Validity and Reliability

Validity

The questionnaire and other dada gathering tools ware prepared based on information collected from farmer participatory workshops and from available literature. Questionnaire and other data gathering tools were re-build several times with experiences gathered in the field level in order to cover research problem and objectives. Further individual test questions were drawn from a large pool of items that cover a broad range of topics. Thus, we were ensuring the content validity of the data/information gathering instruments. Lack of reliability is a serious drawback of an outcome measure as it indicates errors in measurement. An application of test-retest method aided to assets external reliability of the instrument used to collect data. This approach was supported to determining reliability involves measuring the same thing repeatedly under the same conditions and calculating the variability of the resulting measure. Table 03 shows the test-retest reliability of the instrument based upon a sample of 20 farmers.

Reliability

The Spearman – Brown Coefficient (SBC) used to measure the internal consistency reliability of multiple-item measurements, representing the average correlation between the items. The results of SBC test is given in Table 04. It was interesting to examine that, since all SBC values unless coefficient of chemical were greater than 0.7, relevant measures were reliable for research purpose and this is frequently a criterion for publishing the outcome measures.

Table 03: Test- Retest of major variables in selected sample (20)

Variables	Test (T1)	Re-Test (T2)	Test-retest coefficient
	Mean	Mean	
Paddy yield (Kg/ha)	3548.0	3466.0	0.976
Extent Cultivated (ha)	0.64	0.58	0.906
Fertilizer Cost (Rs/ha)	8,345	8,321	0.997
Family Labour (Man days/ha)	52.9	50.6	0.956
Hired Labour (Man days /ha)	31.1	31.8	0.977
Chemical Cost (Rs/ha)	7428.1	6879.9	0.926
Machinery Cost (Rs/ha)	12,911	12,567	0.920
Other cost (Rs/ha)	6,431	6,358	0.973
Total Cost of Production(Rs/ha)*	50,665.1	50,025.9	0.987
Gross Income (Rs/ha)	78,056.0	78,234.0	0.997
Profit (Rs/ha)*	27,390.9	28,208.1	0.971

Source: Authors computation, * excluding imputed cost

Table 04: Spearman-Brown coefficient test for major variables in selected sample (20)

Variables	Correlation	SB Coefficient
Paddy yield (Kg/ha)	0.531	0.798
Extent Cultivated (ha)	0.322	0.823
Fertilizer Cost (Rs/ha)	0.241	0.876
Family Labour (Man days/ha)	0.343	0.701
Hired Labour (Man days /ha)	0.278	0.721
Chemical Cost (Rs/ha)	0.019	0.709
Machinery Cost (Rs/ha)	0.221	0.792
Other cost (Rs/ha)	0.101	0.756
Gross Income (Rs/ha)	0.482	0.886
Profit (without impute cost) considered as dependent variable		

Source: Authors computation.

RESULTS AND DISCUSSION

Descriptive Statistics

Table 05 shows the descriptive statistics of some important variablesin paddy farming among selected farmers in four minor tanks. Paddy was the only crop grown during *Maha* by all sample farmers and farm size was small and variable from tank to tank. Average profit including imputed cost per hectare obtained by paddy farmer was Rs.940.90 with variability index of 81.4 percent.

Table 05: Descriptive analysis of the paddy cultivation of selected tanks

Variables	Mean	Std. Deviation
Paddy yield (Kg/ha)	3548.0	1522.09
Extent Cultivated (ha)	0.64	0.24
Fertilizer Cost (Rs/ha)	8,345	1567.8
Family Labour (Man days/ha)	52.9	14.57
Hired Labour (Man days /ha)	31.1	16.8
Chemical Cost (Rs/ha)	7428.1	1543.8
Machinery Cost (Rs/ha)	12,911	1897.5
Other cost (Rs/ha)	6,431	3,154.8
Total Cost of Production(Rs/ha)[1*]	50,665.1	16,321.8
Total Cost of Production (Rs/ha)[2*]	77,115.1	21,378.6
Gross Income (Rs/ha)	78,056.0	21,675.8
Profit (Rs/ha)[1*]	27,390.9	7835.7
Profit (Rs/ha)[2*]	940.90	765.8

[1*] excluding imputed cost, [2*] including imputed cost

While without imputed cost the profit per hectare was Rs. 27,390 with 28.6 percent variability index. It is apparent that the paddy farmers under minor tanks were getting slimmer profit margin by engaging irrigated paddy farming. Average yield per hectare was 3,548.0 kg withvariability index of 42.89 percent and it was 69.12 percent below compare to average paddy yield in the dry zone. A drastic yield difference was observed between the selected tanks, mainly due to irrigation inequality. The highest yield (5856 kg/ha) was reported by *Kubukwewa* tank and lowest (887kg/ha) was reported by *Rotawewa* tank. A family labour accounts for large portion of labour cost in selected tanks and it was ranged from 21-62 man days in selected tanks. It was revealed that, yet, family members were jointly engaging paddy farming although they were receiving slimmer profit margin with respective field.

The Table 06 shows average returns to resource unit in selected tanks in dry zone. Return to family labour is Rs. 517.78 per day without imputed cost while with imputed cost it was Rs. 17.78 per day. With imputed cost value was very low level compare to average unskilled wage rate in the dry zone. In fact, paddy farmers are de-motivated by such inadequate retunes for labour. It was an undeniable fact that the majority of dry zone paddy farmers were characterized by poor economic status. Break even yield with imputed cost was 65.6 per cent higher than the break even yield without imputed cost. However, current average yield is just 1.0 per cent greater than the break even yield. Average profit margin without imputed cost was Rs.7.74 per kg. It was very poor profit margin with regard to other field crops in dry zone.

The empirical shown of the Cobb-Douglas production function for all selected paddy farmers are presented in Table 07. Estimated R^2 is 0.801 implies that around 80 percent of the variation in paddy output among the farmers is explained by selected explanatory Variables fitted for the model. The entire coefficient have expected positive sings unless chemical implying that an increase in an input ultimately increase the output level. Summation of elasticities of production indicates return to scale is 0.997 and it was suggested that dcreasing return to scale was prevails.

Table 06: Average returns to resource unit in selected tanks

Variables	Mean	Std. Deviation
Return to family labour (Rs/day)1*	517.78	68.9
Return to family labour (Rs/day)2*	17.78	29.6
Returns to Capital (Rs/unit)1*	1.61	0.89
Returns to Capital (Rs/unit)2*	1.10	0.76
Per unit cost (Rs/kg)1*	14.26	9.21
Per unit cost (Rs/kg)2*	21.73	12.23
Break even yield (kg.ha)1*	2,302.9	1.76
Break even yield (Kg/ha)2*	3,505.2	1.65
Profit margin (Rs/kg)1*	7.74	2.11
Profit margin (Rs/kg)2*	0.27	0.97

1* excluding imputed cost, 2* including imputed cost

Table 07: Empirical estimates of ordinary least square (OLS)

Variables	Parameter	Coefficient	Standard error	t-ratio
β_0	Intercept	14.37**	0.872	16.48
β_1	Extent of land	0.321**	0.031	10.35
β_2	Family labour	0.212**	0.051	4.15
β_3	Hired labour	0.081**	0.011	8.44
β_4	Fertilizer	0.222**	0.002	7.36
β_5	Chemical	-0.131*	0.056	2.33
β_6	Machinery	0.101**	0.013	7.77
β_7	Off farm income	0.191**	0.059	3.24
R^2		0.801		

** and * denote Significant at 1% percent and 5% respectively

Table 08: Maximum likelihood estimates for parameters of the stochastic frontier production function.

Variables	Parameter	Coefficient	Standard error	t-ratio
β_0	Intercept	14.93**	0.980	15.23
β_1	Extent of land	0.281**	0.034	8.26
β_2	Family labour	0.224**	0.053	4.22
β_3	Hired labour	0.088**	0.012	7.33
β_4	Fertilizer	0.231**	0.033	7.00
β_5	Chemical	-0.156*	0.076	2.05
β_6	Machinery	0.109**	0.014	7.78
β_7	Off farm income	0.129**	0.021	6.14
$\sigma^2 = \sigma^2_u + \sigma^2_v$		0.432**	0.052	8.28
$\gamma = \sigma^2 / (\sigma^2_u + \sigma^2_v)$		0.721**	0.028	25.75
Log				
Likelihood		-28.87		
LR test		41.23		

** and * denote Significant at 1% percentand 5% respectively

There are close similarity between the intercepts and input coefficient of both Cobb-Douglas and stochastic production functions. The greater the intercept of stochastic frontier function suggested that it represent shift compare to Cobb-Douglas production function.

Maximum Likelihood Estimates

Maximum likelihood estimates of the stochastic frontier are presented in Table 08. The estimate of γ is 0.72 which indicates that the vast majority of error variation is due to the technical inefficiency error U_i and not due to random error V_i. This indicates that the random component of the inefficiency effect does make a significant contribution in the analysis. A high value of Gamma (γ) indicates the presence of significant inefficiencies in the production of rice crop. It shows about 72 percent differences between the observed and the maximum production frontier outputs were due to the factors which were under farmer's control. The stochastic frontier analysis has further shows that 72 percent of observed inefficiency was due to farmer's inefficiency in decision-making and only 28 percent of it was due to random factors outside their control in the case of small-scale paddy farming in the dry zone. As show in Table 08, the one sided LR test of $\gamma=0$ provides a statistics 41.23 which exceeds the chi-square five percent critical value. Therefore the stochastic frontier model does appear to be a significant improvement over an average Cobb-Douglas production function. The significance of the parameter γ is able to show that there is sufficient evidence to suggest that technical inefficiency is present in the data.

The estimated ML coefficient of extent of land showed positive values with 5 percent significant level. Therefore, to increase output by one unit the extent cultivated should be increased by 0.32 units. The estimated ML coefficients in Table 08 for family labour, hired labour, fertilizer and chemicals showed positive values with 1% and 5% significant levels. Statistically significant and positive value of the estimated coefficient indicated that farmers could increase yield per hectare by applying more unit of these inputs. The negative value for the coefficient of chemicals as an input implies, as result of one percent increment of cost of chemicals would results in reduction of paddy yield by 0.15 units. This may be due to overuse of chemicals by the paddy farmers to minimize risk caused with pest, weed, insect and fungi and it is common practice by the paddy farmers throughout the dry zone under irrigation schemes.

Table 09: Distribution of sample rice farmers under different level of technical efficiency

Efficiency (%)	Number of farmers	% of total
Less than 40	6	3.8
41-50	14	8.8
51-60	24	15.2
61-70	43	27.3
71-80	31	19.6
81-90	28	17.7
91-100	12	7.6
Total farms	158	100
Mean efficiency	69.8	

Technical Efficiency

Table 09 shows the frequency distribution of sample farms by the level of technicalefficiencies in selected four tanks in the dry zone. The technical efficiency ranges from as low as 12 percent to as high as 98 per cent among selected sample. The average level of technical efficiency has been estimated as 69.8 per cent for farm as a whole, implyingthat on an average the sample farmers tend to realize around 69.8 percent of their technical abilities. Hence, on average approximately 30 percent of the technical potential are not realized. Therefore, it is possible to improve the yield by 30.2 percent by following efficient resource management practices without increasing the level of inputs application. It was also observed that a majority of the farmers (72.2%) operated at technical efficiency levels above 60 percent. It was important to emphasize that about 7.6 percent of the sample farmers were operating close to the frontier with the technical efficiency of more than 90 percent.

This outcome also reflecting the efficiency deviates greatly between farmers due to unequal resources distribution and different resource management practices among selected sample farmers. Technical efficiency of paddy farming highly associated with water availability in the tanks. However, the water availability among selected tanks was highly varied. Thus, technical efficiency too highly varied among selected farmers. This results again reinforces the empirical evidence from paddy cultivation environments in small scale irrigation tanks where considerable variation of technical efficiency among farmers in similar region. These information are important for policy makers to identify the nature of production technology used in small-scall irrigated paddy farming in Sri Lanka.

Table 10: Determinants of Technical Efficiency

Variable	Parameter	coefficient	Standard error	T ratio
Constant	α_0	3.46^{**}	1.254	2.756
Age of farmers	α_1	0.013^{*}	0.012	1.08
Experience	α_2	2.82^{**}	0.321	8.44
Knowledge of water management	α_3	0.101^{**}	0.012	8.78
Education	α_4	0.186^{**}	0.038	4.89
Distance of field	α_5	0.221^{**}	0.059	3.74
Sowing time	α_6	0.96^{**}	0.232	4.13
Right of entry formal credit	α_7	1.01^{*}	0.721	1.40
Contact with extension	α_8	1.41^{**}	0.329	4.28

** Significant at 1% * Significant at 5%

Determinates of Inefficiencies

According to the level of technical efficiency under given technology, some farmers were able to achieve maximum technical efficiency, while other was found relatively inefficient. Therefore, it is important to identify the factors which cause the differences in farm-specific technical efficiency. A number of studies have suggested that efficiency of farmers is determined by various socio-economic and demographic factors. The results of regression analysis carried out in this regard are presented in Table 10.

In the efficiency models, estimated coefficient of all selected variable were positive and significant at 1% and 5%. The positive and significant coefficient for the level of education suggests that the more educated farmers are more efficient than less educated farmers. The efficiency of paddy farming has been increased as knowledge of water management increased. Despite water availability right to formal credit and sowing time emerge as significant factors behind technical efficiency of paddy farmers. Contact with extension officers was also leads to enhance the technical efficiency of sample farmers. However, among selected technical efficiency variables, farmers'experiences in paddy farming were the most effective variable for technical efficiency of paddy farming.

CONCLUSIONS

The main objective of this study is to comparative analysis of economic and technical efficiency in rice production in a minor irrigation scheme in Sri Lanka and to suggest some policy recommendation for improving the efficiency of resource use. According to the results obtainedfrom stochastic frontier estimation, the average technical efficiency of farmers given by the Cobb-Douglas model is 69.8 percent. This indicates that there is scope of further increasing the paddy production by 30.2 per cent without increase the level of inputs or by reducing technical inefficiency among paddy farmers. The shortfall in realized rice productivity of the frontier has largely been due to technical inefficiency and is largely within the control of individual farmers. The study has shown the paddy industry under small tanks, despite being able to increase its production significantly over the years. However, they have been produced at a low level of efficiency. This has resulted in an inefficient utilization of resources and so does the potential to increase farm output from the existing level of inputs. Though the effective use of existing inputs the firm value-added can be increased by almost 30.2 percent at the aggregate level without any additional cost to the farmer.

From the factors considered which effect technical efficiency, water availability, education, right to formal credit and sowing time were significant at 5% significant level in inefficiency model. The study also identified the technical inefficiency on individual farmers varies, from 12 percent to 98 per cent. This is due to the structure of the industry being characteristics as unorganized within the industry. According to inefficiency model, technical inefficiency highly depends on rice farming experiencesand contact with extension officers. Therefore government policies should strengthen the extension mechanism to enhance farmers' practices through extension services and training programme. In the same time government should support for public investment on tanks rehabilitation, research, and technology and credit facilities for village level paddy farming.

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