[02] TECHNICAL EFFICIENCY IN STOCHASTIC FRONTIER PRODUCTION MODEL: A CASE STUDY ON IRRIGATED PADDY FARMING UNDER VILLAGE TANKS IN SRI LANKA

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ABSTRACT

The predominance of paddy cultivation as a major economic activity in domestic food production sector in Sri Lanka hardly needs any emphasis. Being the staple food crop account for 25 percent of total cultivable land and more than two million farmer families are engaged in farming as their main occupation. Village tanks are the backbone of the village paddy farming and the livelihood of families in the dry zone. However, yet, most of the dry zone paddy farmers have failed to capture technical efficiency and to adopt new technologies interventions basically due to poor managerial ability of economic resources. This paper investigated the resource use characteristics, profitability and managerial and technical efficiencies of paddy farming in a sample of paddy farmers selected from four minor tanks in Trincomalee district. In this study, the technical efficiency of paddy farmers was estimated by using stochastic frontier production function, incorporating technical inefficiency 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 60.23 per cent. This indicates that there is scope of farther increasing the output by 39.77 percent without increasing the level of input. With imputed cost profit margin of paddy farming under village tanks was Rs.2.05 per kg and Break even yield was 3,288 kg per ha.

***Key Words**: Stochastic Frontier Production Function, Cobb Douglas Function, Technical Efficiency, Village Tanks, Paddy Farming*

INTRODUCTION

About one-third of the world's food supply is produced on 250 million hectares of irrigated land, or less than onefifth of the total cultivated area (United National Asia Pacific Center for Agricultur, 2003). In developing countries, where two-thirds of farmers depend on irrigation, 50% of the increase in agricultural output since 1970 has occurred on irrigated land (Barrow, 1995). In Sri Lanka tanks divided into two categories with regard to command area. A tank with more than 80 ha of command area referred to as major irrigation and a tank having less than 80 ha of command area is known as minor irrigation (United National Asia Pacific Center for Agricultur, 2003). There are around 10,000 such minor tanks in the dry zone irrigating 100,000 – 120,000 ha of paddy lands and play an important role in Sri Lankan agriculture, especially in paddy cultivation. (Karurasena, Marambe, Sangakkara, & Dhannasene, 1997).

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 account 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 abstract, 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 (Henegedara, 2002). More than 80 percent of irrigated paddy lands are locating in the dry and intermediate zones including the irrigated land under Mahaweli development project.

Insufficient water distribution is the most crucial issue in village irrigation schemes. Some time, due to lack of water, farmer's irrigable land is completely abandonment of seasonal cultivation. Most of the paddy lands under village tanks have become less productivity not only due to water shortage but also due to technical inefficiency, poor resource management, subsidiary orientation rather than commercial or market orientation and poor technology. "Village tank farmers fail to adopt new technological interventions basically due to the fact that they are not compatible with their farming traditions and practices, which have evolved and adjusted according to changing farming environment" (Dharmasena, Nijamudeen & Ranaweera Banda, 2002).

In generally, the national output of this commodity has significantly increased 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).

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 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) (Barch & Pandey, 2005). Beside the cost of production have been increased unexpectedly during last three decades and the inevitable consequences of this situation is de-motivation of paddy farmers by slimmer profit margin.

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, Prasada, Kodithuwakkku, Weerahewa, & Little, 2006). The hypothesis advanced by Schultz states that no appreciable increase in agriculture production will results by reallocating the factors at the disposal of the farmers. The hypothesis implies that substantial increase in output is possible through new technologies such as the HYVs, irrigation, newly fertilizer and management of pest. However, initially yield obtained by farmers who use improved management are far below the potential because farmer use inputs or practices that are allocatively inefficient. (Karurasena, Marambe, Sangakkara, & Dhannasene, 1997).

In view of the growing competition in world rice market and high production costs, production efficiency will become an important determinant of the future of Sri Lanka's paddy industry. 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.

However in Sri Lanka the available literature does not provide empirical evidence with regard to the technical efficiency in paddy farming, specially, under minor tanks. Further there is a scant of studies that were endeavored to identify the technical inefficiencies with different water availability in village tanks. Therefore, the problem addressed in this study is to investigate how farmers optimize technical efficiency in paddy under minor tanks in the dry zone in Sri Lanka.

The main objective of this study is to estimate the technical efficiency of paddy farming under village tanks and determinants of inefficiency in dry zone the economic and to suggest some policy recommendations for improving the efficiency of resource use. Specific objectives of the study are:

To identify the factors causing technical inefficiency of paddy farming under village tanks and;
To measure returns to scale, profitability and return to labour and capital under village tanks paddy farming in dry zone.

METHOD 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, Marambe, Sangakkara, & Dhannasene, 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 entire selected tank were considered for the study. Main characteristics of randomly selected minor tanks are given in table 01.

Table No: 01: Population and sample

D.S Division	Tank	Com mand Area (ha)	Farmer Families	Samp le Size
Morawewa	Ehalawewa	20	70	70
Padavipura	Nagaswewa	32	28	28
Gomaran kadawala	Palugaswewa	20	15	15
Kuchchaveli	Sinnakulam	8	10	10
Total		80	123	123

Methods used for gathering data and information included key informant interviews and focus group discussion in the field. Interviews were conducted with staff from the Agrarian services, irrigation Department as well as other public officers. In the field farmers were interviewed thrugh 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 will be organized with the help of *Grama Niladaries* and the leaders of Farmer organizations. A questionnaire survey was carried out in 2009/2010 Maha season. Following information were used for analysis based on difference sources.

Table No: 02: Sources of information

Type of data/informations used	Source of Data/information

Basic data of selected tanks Department Of Irrigation Cultivated Extent and Agrarian services
cropping Intensities Questionnaire Survay Farm and non farm income Questionnaier Survay Yield,cost of production The Water Resource
and net retuns Secretariat
Assest and wealth Group discussions

differences information
Existing technologis for Group discussion with paddy farming farmers and officers
Use of resources Group discussions

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 which had an error term which had two components, one to account for random effect and another to account for technical efficiency. The model can be expressed in the following form (Coelli, 1994).

$Y_i = X_i \beta + \varepsilon_i \qquad \varepsilon_i = V_i - U_i$

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 ε_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.
$[N(0, \sigma u2)]$.

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 ϒ, which replaces σ_v^2 and σ_u^2 with σ^2

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

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

The estimation of frontier function and efficiency can be completed either in one stage or in two stages. The twostage 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.

Analytical Framework

In any empirical study of production process a mathematical representation of the production function must be specified to apply the theoty to a body of data. In empirical literature the most generally used functional form to estimate production functions are Cobb Douglas ((CD), the transcendental logarithm (TL), the generalized Leontief (GL), and generalized quadratic (GQ). Among those functions two type of functions, namely CD and TL dominate the technical efficiency literature. In this study, it is assumed that the Cobb-Douglas is the appropriate form of the frontier production function. The CD production function satisfies the reqularity conditions globally. It has unitary elasticity of substitution by construction. It does not allow for technical independent or competitive factors. The function is $\sum_{k=1}^{k} \alpha k$ homogeneous of degree and the technology exhibits constant returns to scale if $\sum_{k=1}^{k} \alpha k$ =1. Further the CD form is first-order Taylor series approximation to the true production frontier and it does not accommodate the cross-economic effects. Cross-economics effect can be defined as the effect on the productivity of one input due to the change in employed quantity of another input (at constant level of output)Thus it is a relatively simple form and easy to manipulate analytically.

Two-stage methods of determining technical efficiency and its determinants have been criticized on various grounds (battese and Coelli, 1995). Therefore, the stochastic frontier production function and inefficiency effects model is estimated one stage by means of the computer program FRONTIER 4.1 written by Coelli (1996). Log Likelihood ratio Test is used to test various hypotheses.

This test is defined as follows
$LR (\lambda) = -2\{In[L(H_0)/L(H_1)]\}$
$= -2\{In[L(H_0)]-In\{L(H_1)]\}$

Where $L(H_0)$ and $L(H_1)$ are the values of the likelihood function under the null and alternative hypothesis, H_0 and H_1respectively. In good number situations this static has asymptotic chi-square distribution with degrees of freedom equal to the difference between the number of parameters in H_1 and H_0 if H_0 is true.

Empirical Model

We used Cobb-Douglas production frontier using crosssectional data and a half-normal distribution. Moreover flexible functional form imposes the problem of multicollinearity.

The model is defined by:

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

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 (man days)
X_4= Cost of Fertilizer (Rs.)
X_5 = Cost of chemical (Rs.)
X_6= Cost of machinery (Rs.)
X_7 = off -farm income (Rs./month/household)

Determinants of Technical Efficiency Many studies have identified a positive relationship between technical efficiency and socio-economic variables (Kalirajan, 1991`; Bravo-Ureta and Evenson, 1994; Parikh and shah, 1994; Shanmugham, 2003; Bhende and Kalirajan, 2007). 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.

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

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

Z_1 = Age of farmers (years)

Z_2 = knowledge and experience of water management, a dummy variable equal to one with enough knowledge water and zero otherwise.

Z_3 = Education (years)

Z_4 = Location of farm on the watercourse, if the farm is located at the head of the watercourse, then it has the value of one, otherwise zero.

Z_5 = Sowing time, if the paddy field is sown in time, then it has the value of one, otherwise zero.

Z_6 = Right of entry formal credit, if farmer has a right to taken formal credit it has the value of one otherwise zero.

Z_7 = Contact with extension agencies

Validity and Reliability

The questionnaire and other dada gathering tools ware prepared based on information collected from farmer participatory workshop and from available literature. Several times re-build the questionnaire and other data gathering tools with experiences we were made 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. Thus, we were made test-retest method to assets external reliability of the instrument used to collect data. This approach to determining reliability involves measuring the same thing repeatedly under the same conditions and calculating the variability of the resulting measure. Following table shows the test-retest reliability of the instrument based upon a sample of 20 farmers.

Table 03: Test- Retest of Major Variables in selected Village Tanks

Major Variable	Test (T1) Mean	Re-Test (T2) Mean	Test-retest coefficient
Paddy yield (Kg/ha)	3626.0	3789.0	0.956
Extent Cultivated (ha)	0.56	0.58	0.965
Fertilizer Cost (Rs/ha)	8,170	8,321	0.982
Family Labour (Man days/ha)	53.8	50.6	0.940
Hired Labour (Man days /ha)	30.5	31.8	0.959
Chemical Cost (Rs/ha)	7765.8	6879.9	0.885
Machinery Cost (Rs/ha)	13,654	12,567	0.920
Other cost (Rs/ha)	6,245	6,358	0.982
Total Cost of Production(Rs/ha*	51,093.8	50025.9	0.979
Gross Income (Rs/ha)	79,772.0	78,234.0	0.981
Profit (Rs/ha)1*	28,678.20	28,208.1	0.984

Source: Authors computation, 1* excluding imputed cost.

The Spearman – Brown Coefficient (SBC) used to measure the internal consistency reliability of multipleitem measurements, representing the average correlation between the items. The results of SBC test is given in table No 4. 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 4: SBC Test for Major Variables in Selected Village Tanks

Variables	Correlation	SB Coefficient

Paddy yield (Kg/ha)	0.456	0.879
Extent Cultivated (ha)	0.342	0.865
Fertilizer Cost (Rs/ha)		
Family Labour (days/ha)	0.123	0.712
Hired Labour (days /ha)		
Chemical Cost (Rs/ha)	0.256	0.897
Machinery Cost (Rs/ha)		
Other cost (Rs/ha)	0.201	0.701
Gross Income (Rs/ha)		
	0.013	0.612
Profit (without imputed cost) considered	0.221	0.792
as dependent	0.101	0.756
variable	0.482	0.886

Source: Authors computation.

RESULTS AND DISCUSSION Descriptive Statistics

Table-5 shows the descriptive statistics of some important variable with paddy farming among selected farmers in four tanks. Paddy was the only crop grown during *Maha* by all sample farmers and far size was small and variable from tank to tank. Average profit including imputed cost per hectare obtained by paddy farmer was Rs.7,428.2 with variability index of 31.25 percent. While without imputed cost the profit per hectare was Rs. 28,678 with 19.6 percent variability index. It is apparent that the paddy farmers under minor tanks were getting slimmer.

Table No: 05: Descriptive analysis of the paddy cultivation of selected tanks

Variables	Mean	Std. Deviation
Paddy yield (Kg/ha)	3,626.0	1205.34
Extent Cultivated (ha)	0.56	0.19
Fertilizer Cost (Rs/ha)	8,170	1998.98
Family Labour (days/ha)	53.8	16.71
Hired Labour (days /ha)	30.5	12.78
Chemical Cost (Rs/ha)	7,765.8	1391.88
Machinery Cost (Rs/ha)	13,654	2,125.55
Other cost (Rs/ha)	6,245	3,245
Total Cost of Production(Rs/ha)[1*]	51,093.8	22,459.98
Total Cost of Production (Rs/ha)[2*]	72,343.8	28,765
Gross Income (Rs/ha)	79,772.0	23,298.5
Profit (Rs/ha)[1*]	28,678.20	5,634
Profit (Rs/ha)[2*]	7,428.2	2,321.41

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

Profit margin by engaging irrigated paddy farming. Average yield per hectare was 3,626.0 with variability index of 33.24 percent and it was 67.12 percent below compare to average paddy yield in the dry zone. A drastic yield differences was observed between the selected tanks, mainly due to irrigation inequality. The highest yield (5234 kg/ha) was reported by *Ehalawewa* tank and lowest (921kg/ha) was reported by *Sinnakulam* tank. A family labour accounts for large portion of labour cost in selected tanks and it was ranged from 32-67 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.

Table 06: Average returns to resource unit in selected tanks (including imputed cost)

Variables	Mean	Std. Deviation
Return to family labour [1*]	394.9	87.8
Return to family labour [2*]	138.1	43.6
Returns to Capital [1*]	1.56	0.87
Returns to Capital [2*]	1.10	0.56
Per unit cost [1*]	14.11	7.98
Per unit cost [2*]	19.95	9.23
Break even yield [1*]	2,322	1.11
Break even yield [2*]	3,288	1.87
Profit margin per kg [1*]	7.89	2.78
Profit margin per kg [2*]	2.05	0.87

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

The table no: 06 shows average returns to resource unit in selected tanks in dry zone. Return to family labour is Rs. 394 per day without imputed cost while with imputed cost it was Rs. 138 per day. Both values very at 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 41.6 per cent higher than the break even yield without imputed cost. However, current average yield is just 10.3 per cent greater than the break even yield. Average profit margin is Rs.2.05 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 7. The results show that around 82 percent of the variation in paddy output among the farmers is explained by variation of the explanatory Variable fitted for the total sample. 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 1.211 and it was suggested that increasing return to scale was prevails.

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.

Table 7: Empirical Estimates of Ordinary Least square (OLS)

Variables	Parameter	Coefficient	S.E	t-ratio

β_0	Intercept	12.76**	0.78	16.36
β_1	Extent of land	0.389**	0.024	16.21
β_2	Family labour	0.121**	0.002	60.5
β_3	Hired labour	0.076**	0.009	8.44
β_4	Fertilizer	0.246**	0.003	82.00
β_5	Chemical	-0.154*	0.091	1.69
β_6	Machinery	0.102**	0.008	12.75
β_7	Off farm income	0.123*	0.059	2.01
R^2		0.823		

** Significant at 1% level * Significant at 10% level

Maximum Likelihood Estimates

Maximum likelihood estimates of the stochastic frontier are presented in table 8. The estimate of Υ is 0.62 which indicates that the vast majority of error variation is due to the 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.

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

Variables	Parameter	Coefficient	tratio
β_0	Intercept	14.83**	18.77
β_1	Extent of land	0.391**	14.48
β_2	Family labour	0.124**	41.33
β_3	Hired labour	0.078**	7.8
β_4	Fertilizer	0.249**	41.5
β_5	Chemical	-0.156*	-1.59
β_6	Machinery	0.105**	11.6
β_7	Off farm income	0.129**	2.08
$\sigma^2 = \sigma^2_u + \sigma^2_v$		0.6023 (3.21)	
$Υ = \sigma^2_u/(\sigma^2_u + \sigma^2_v)$		0.623 (3.86)	
Log Likelihood		-28.87	
LR test		49.22	

** Significant at 1% probability level *Significant at 5% probability level, Figure in parentheses indicates t value

The one sided LR test of Υ=0 provides a statistics 49.22 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 Υ 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, increase of extent cultivated by one percent output will increase by 0.39. The estimated ML coefficients for family labour, hired labour, fertilizer and chemicals showed positive values with 5% and 10% significant levels. 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. 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 dry zone under irrigation schemes.

Table 09: Distribution of Technical Efficiencies

Technical efficiency %	Number of farmers
10-20	3
21-30	5
31-40	6
41-50	15
51-60	21
61-70	31
71-80	22
81-90	13
91-100	7
Mean efficiency	60.23%

Technical Efficiency

Table no 9 shows distribution of technical efficiencies among paddy farmers in selected four tanks in the dry zone. The technical efficiency ranges from as low as 12 per cent to as high as 98 per cent among selected sample. This outcome also reflecting the efficiency deviates greatly between farmers due to unequal resources distribution within selected tanks. 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. The mean technical efficiency of sample farmers was found to be 60.23 per cent, which indicates that the output could be increased by 39.8 per cent if all farmers achieved the technical efficiency level of the best farmer.

Table 10: Determinants of Inefficiencies

Variable	Parameter	coefficient	S.E	T ratio
Constant	α_0	2.87**	1.135	3.41
Age of farmers	α_1	-.009*	0.005	-1.87
Knowledge of	α_2	-2.22**	0.263	-8.44

water.m Education				
Location	α_3	-0.085**	0.028	-2.98
Sowing time	α_4	-0.186**	0.047	-3.95
Right to formal credit	α_5	-0.121**	0.054	-2.2
Contact with extension offi.	α_6	-1.96**	0.612	-3.2
			0.676	3.14
	α_7	-2.12		

** Significant at 1% * Significant at 5%

Determinates of Inefficiencies

The estimated coefficients in the inefficiency model are depicted in table 10. The age coefficient of the model was negative with 5% significant level which indicates that older farmers are more efficient than younger ones. In the inefficiency models, estimated coefficient of all selected variable were negative and significant at 5% and 10%. The negative and significant coefficient for education suggests that the educated farmers are more efficient than others. In both models inefficiency of paddy farming has been decreased as water availability increases. There are enough empirical evidences to prove this reality in irrigation schemes in Sri Lanka. In both models, water availability was the more powerful variable that could be effect to inefficiency of paddy farming. Despite water availability right to formal credit and sowing time emerge as significant factors behind technical efficiency of paddy farmers.

CONCLUSION AND POLICY IMPLICATIONS

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 obtain from stochastic frontier estimation, the average technical efficiency of farmers given by the Cobb-Douglas model is 60.23 per cent. This indicates that there is scope of farther increasing the paddy production by 39.77 per cent without increase the level of inputs or by reducing technical inefficiency among paddy 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 39.8 per cent 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 knowledge of water management and location of paddy field (head-end farmer or tail-end farmer). Having higher technical efficiency in paddy farming, two things should be considered in the improvement of paddy productivity. On one hand, policy should be driven to consolidate the industry to achieve the economies of scale used which will lead to more efficiency. In the same time government should support for public investment on irrigation infrastructures, research and extension, technology and credit facilities for village level paddy farming. In order to overcome the technical inefficiency, with regard to water management, effective participatory water management policies are suggested.

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