TECHNICAL EFFICIENCY OF ORGANIC TEA SMALLHOLDERS: EVIDENCE FROM UVA REGION OF SRI LANKA

A. Kodagoda[1] & **R.A.P.I.S. Dharmadasa**[2]

Correspondence: arunikakodagoda@gmail.com

ABSTRACT

Today, the society is moving to the sustainable agriculture where the major concern of the consumers are health benefits and environment pollution. Therefore, the production of organic tea plays a major role in tea industry. In Uva region, the highest number of organic tea smallholders are in Diyathalawa and their productivity is varied from farmer to farmer and therefore, necessity of how to maximize the productivity arises. Hence, this research aims to find the determinants of the technical efficiency of the organic tea smallholders. Data were collected from organic tea smallholders in Diyathalwa using stratified random sampling method. The data were analyzed using stochastic frontier production model. The results suggest that mean technical efficiency of organic tea smallholders is 24.7%. Most importantly, the efficiency of organic tea production increases when tea smallholders are educated and young. The results further reveal that efficiency in organic tea production reduces if the tea smallholders diversify their crop cultivation and engage in livestock management.

Keywords: Diyathalawa, organic tea smallholders, stochastic frontier, technical efficiency

1. INTRODUCTION

Tea is a beverage that is only second to water. Bekit (2006) opined that the tea is used as a medicine by Chinese at first and later it became a beverage. Tea cultivation has a history of over 3000 years. Tea was first introduced to Sri Lanka in 1824 by the British. In Sri Lanka, agrochemicals have been used in tea cultivation since 1950's with the objective of obtaining higher yield. Prematilake, (2003) noted that first serious attempt to apply chemicals in weeding in tea field was made in the late 1950's. Due to the heavy use of chemical for a long period of time in the cultivation, some issues such as soil degradation, massive alteration of natural ecosystem, reduction in water, air and soil quality arise. As a solution, farmers started organic agriculture (Zoysa & Munasinghe, 2004). Gaffar (1999) has defined organic agriculture as a sustainable farming system where the cultivation is carried out without the use of chemically synthesized products such as Urea, Ammonium Sulphate, pesticides, herbicides, hormones, activators, etc. With the introduction of organic agriculture to the world, organic tea became important. Therefore, in 1983, Sri Lanka pioneered the organic tea production in the world and it came into the market in 1987 (FAO, 2016). Sri Lanka has been identified as the first country to start the organic tea cultivation (Zoysa & Munasinghe, 2004). The country continues to produce organic and biodynamic tea in 4905.58ha which is 2.21% from the total tea cultivated land (FAO, 2017). Hughner et al., (2007) listed the top five reason for organic food consumption as, healthier, tastes better, environmental concern, concern over food safety, and concern over animal welfare. Also, Herath et al., (2001) shows that benefit cost ratio of conventional tea is 2.41 while the benefit cost ratio of organic tea is 3.13. It is noted that benefit cost ratio of organic tea is higher. This is due to the higher price offered to organic tea. The main destination of Ceylon

[1] Department of Export Agriculture, Uva Wellassa University of Sri Lanka.
[2] Department of Export Agriculture, Uva Wellassa University of Sri Lanka.

organic tea are Australia, Canada, China, France and Germany. Organic tea is cultivated by both the estate sector as well as smallholder sector. Contribution of organic tea smallholder's is important since 57% of total holdings belong smallholders in Badulla district (Ministry of Plantation industry, 2017).

Hayami and Ruttan (1985) shows that adoption of new technologies can increase the farm productivity and income. In Sri Lankan context, tea smallholders lack interest on adopting to new technologies due to the lack of credit facilities (Jayasinghe, 1995). Therefore, it is preferred to increase the productivity using existing technologies. The productivity is found to be varying depending on the differences in production technology, environmental settings and production efficiency (Jayasinghe and Tayoda, 2004).The level of production efficiency of organic tea smallholders is strongly affected by the use of inputs, technology and the management ability of the individual farmer and at present, the major issue that small farmers and policy makers faced is ascertaining whether the organic tea productivity, using the present technology, could be increased without the use of high capital investment (Jayasinghe and Tayoda, 2004). Technologies that could implement for organic tea smallholders are organic fertilizers, organic pesticides and biodynamic practices. Katugaha and Premathilaka (2016) have found that these practices are followed by the organic tea farmers in Badulla district. However, the major issue is the variation in productivity from smallholder to smallholder. This variation is mainly due to the inefficiency of farmers. The output from the existing inputs and technology is maximized when farmers operate efficiently. Therefore, the questions arise here are; (1) what determines the efficiency of production (2) what level of efficiency the smallholders have (3) whether the farmers use resources efficiently.

2. METHODOLOGY

Data and Data collection

Most of the organic tea smallholders are concentrated in Diyathalawa, Bandarawela and Welimada in Uva Region. Diyathalawa belongs to the Huputale Divisional Secretariat in Badulla Districts and it has around 600 organic tea smallholders. Diyathalawa was selected since organic cultivation has been practiced for more than 10 years in some villages and most of the organic smallholders in Uva region are scattered in Diyathalawa area. Data were collected through a structured questionnaire covering the 4 sections: household information, occupation and income details, production details and information on organic cultivation practices. The survey was carried out in 9 organic tea smallholding societies namely Heennarangolla, Rathkorowwa, Kirinda, Horadorowwa, Weralapathana, Walgahawela, Othube, Attampitiya and Wewakelle covering the entire Diyathalawa area. This study was conducted using in Diyathalawa. A sample of 100 organic tea smallholders was drawn from the population of organic tea smallholders in Diyathalawa area using a stratified sampling method where each strata represents organic tea smallholding societies.

2.1 Estimation of Technical Efficiency

Two main methods are generally used to analyze the efficiency of production. They are parametric method where the stochastic production frontier, which was independently proposed by Aigner et al., (1977) and Meeusen and Van den Broek (1977) is used, and non parametric method where Data Envelopment

Analysis (DEA) is used to compute technical efficiency scores. This study employs stochastic production frontier as it makes allowance for stochastic errors due to statistical noise or measurement errors while it accounts for firm specific inefficiency (Forsund et al., 1980; Battese, 1992; Coelli et al., 1998).
Although there are its well-known limitations, the stochastic production frontier is specified using the Cobb-Douglas functional form in this study as it provides an adequate representation of the production technology as long as interest rests on efficiency measurement and not on the analysis of the general structure of the production technology. We specify its Cobb-Douglas stochastic production frontier in the following way:

$$lnY = \beta_0 + \beta_1 lnX_1 + \beta_2 lnX_2 + \beta_3 lnX_3 + V_i - U_i$$

Where:
ln - denotes Natural logarithms; Y - is the average green tea leaf production, v - is a pure noise component with mean 0 and constant variance σ_v^2 and that $u_i \geq 0$ follows a half normal distribution with variance σ_u^2. βs - are unknown parameters to be estimated. The subscripts, *j*, *i* and refer to the j^th input (*j* = 1,2,3), i-th tea smallholder (*i*=1,2,…, 100) respectively.

Table 1: Variables of the Cobb-Douglas Production Function

Notation	Variable	Unit
Y	Green Leaf Yield	Kg
X_1	Land	Acres
X_2	Labor	Man days
X_3	Organic fertilizer	Kg

Source: Sample survey (2018)

The efficiency model specified for Battese and Coelli (1995) specification is,

$$u_{ij} = \delta_0 + \sum_{j=1}^{17} \delta_j Z_{ij} + \mathrm{W_i}$$

Where;

δ_j (*j*=0,1,….,17) are unknown parameters; W_i is unobservable random variables.

We specify the inefficiency model in the following way;

$$\mathrm{U_i} = \delta_0 + \delta_1 Z_1 + \delta_2 Z_2 + \delta_3 Z_3 + \delta_4 Z_4 + \delta_5 Z_5 + \delta_6 Z_6 + \delta_7 Z_7 + \delta_8 Z_8 + \delta_9 Z_9 + \delta_{10} Z_{10} + \delta_{11} Z_{11} + \delta_{12} Z_{12} + \delta_{13} Z_{13} + \delta_{14} Z_{14} + \delta_{15} Z_{15} + \delta_{16} Z_{16} + \delta_{17} Z_{17} + \mathrm{W_i}$$

Table 2: Explanatory Variables Used in Technical Inefficiency Model

Explanatory variable	Variable name	Units
Z_1	Age of the farmer	Years
Z_2	Experience of the farmers	Years
Z_3	Household size	Number
Z_4	Availability of livestock	Yes=1, No=0
Z_5	Duration of organic tea	Years
Z_6	Gender of the farmer	Male=1 Female=0
Z_7	Other crops cultivated	Yes=1, No=0

Z_8	VP	Yes=1, Other=0
Z_9	Seedling	Yes=1, Other=0
Z_{10}	Education level: Some primary	Yes=1, Others=0
Z_{11}	Education level: Some secondary	Yes=1, Others=0
Z_{12}	Education level: Up to OL	Yes=1, Others=0
Z_{13}	Education level: OL passed	Yes=1, Others=0
Z_{14}	Education level: Up to AL	Yes=1, Others=0
Z_{15}	Education level: Al passed	Yes=1, Others=0
Z_{16}	Education level: Technical college	Yes=1, Others=0
Z_{17}	Education level: Graduate	Yes=1, Others=0

Source: Sample survey (2018)

The expression of Technical Efficiency relies on the value of the unobservable $\boldsymbol{U_i}$, which must be predicted. These predictions are obtained by deriving the expectation of the appropriate function of $\boldsymbol{U_i}$ conditional on the observed value of $\mathbf{v_i - u_i}$. The maximum likelihood method is used to estimate the parameters of both the stochastic frontier model and inefficiency effects model. According to Battese and Corra (1977), the variance parameter of the likelihood function is estimated in terms of $\sigma^2 = \sigma^2_u + \sigma^2_v$ and $\gamma = \sigma^2_u / \sigma^2$. So that $0 \leq \gamma \leq 1$
Much of stochastic frontier analysis is directed towards the prediction of inefficiency effects. The most common output-oriented measure of technical efficiency is the ratio of observed output (q_i) to the corresponding stochastic frontier output.

$$TE = \frac{Y_i}{\exp(x_i\beta + v_i)} = \frac{\exp(x_i\beta + v_i - u_i)}{\exp(x_i\beta + v_i)} = \exp(-u_i)$$

The technical efficiency of production for the *i*-th tea smallholder could be defined by $\boldsymbol{TE = exp(-U_i)}$
Finally, a stochastic translog production function was estimated to test the robustness of the functional form. The following is the translog specification of the function;

$$\mathrm{Lny} = \beta_0 + \beta_1 \mathrm{lnx}_1 + \beta_2 \mathrm{lnx}_2 + \beta_3 \mathrm{lnx}_3 + \beta_4 \mathrm{ln}^2\mathrm{x}_1 + \beta_5 \mathrm{ln}^2\mathrm{x}_2 + \beta_6 \mathrm{ln}^2\mathrm{x}_3 + \beta_7 \mathrm{lnx}_1 \mathrm{lnx}_3 + \beta_8 \mathrm{lnx}_2 \mathrm{lnx}_3 + \beta_9 \mathrm{x}_1 \mathrm{lnx}_2 + \mathrm{v_i} - \mathrm{u_i}$$

3. RESULTS AND DISCUSSION

Results of the estimates of Stochastic Production Frontier

To understand whether the farmers are operating at its optimum level or there is a room for improvement we estimated regression function using ordinary least square (OLS) method. Multicollinearity and heteroscedasticity were tested as pre-requisites for the variables used in the function. To test the multicollinearity, calculation of variance inflation factor (VIF) for independent variables was done. Mean VIF is 1.66 which is less than 10 showing there is no collinearity among the independent variables. For heteroscedasticity, Breusch-Pagan/Cook-Weisberg test was conducted. Here, the chi squared value is 1.31, where H_0 is not rejected, which means there is a constant variance and regression disturbances are normally distributed. According to the table 3, the returns to scale of the function is 1.144, which is an increasing returns to scale. Adedeji et al., (2011) shows when the returns to scale is increasing, optimum efficiency has not yet been achieved and farmers are under utilizing the technology which indirectly state that there is a technical inefficiency. In the model land, labour and organic fertilizer significantly affect the organic tea production. When the land is increased by 1% the production increases by 0.217% while the man days of labour is increased by 1%, the amount of production increases by 0.694%. Elasticity of production with respect to organic fertilizer 0.233% which encourage farmers to apply more organic fertilizer in order to increase the production. Jayasinghe and Toyoda (2004), also shows that compost land and labour are positively significant in smallholder's organic tea production in mid country organic tea production. Basnayake and Gunaratne (2002) show that in convention tea, land labour and fertilizer positively affect the tea smallholder's production.

Table 3: Estimates of the Cobb-Douglas OLS Model and ML Estimates for the Organic Tea Smallholders

Variable	Parameter	Coefficient		Standard error		T statistics	Z Statistic6.55
		OLS	MLE	OLS	MLE	OLS	MLE
Constant	β_0	1.783***		0.260	0.201	6.85	9.09
Land	β_1	0.217***		0.042	0.034	5.11	6.23
Labour	β_2	0.694***		0.113	0.095	6.10	7.83
Organic fertilizer	β_3	0.233***		0.035	0.027	6.55	8.74
R^2		0.82456					
F-statistics		122.26					
σ^2			0.389				
γ			0.790				
LR Test			6.55				

*, **, *** significant at 10%, 5% and 1% significance levels respectively.

The maximum likelihood estimates of the parameters of the stochastic frontier production function are presented in Table 3. Before running the model the continuous variables were transformed into log linear form. The dependent variable of the model was yield which is organic tea production in Kilograms. The independent variables were land in acres, labour in man days and organic fertilizers in kilograms. The skewness of the OLS residual was computed as preliminary test for stochastic frontier. The test value is -0.393 which implies that OLS residuals are skewed to the left and confirm the validity of the model's stochastic frontier specification. Likelihood ratio test was used to test the existence of the inefficiency component in the stochastic frontier model of the organic tea smallholders. H_0: of σ^2=0 is rejected at 1% significant level according to the table 3. This means there is an inefficiency and it is worth to measure. And frontier was stochastic rather than deterministic. As shown in table 3, gamma parameter has been estimated as 0.790 which is greater than zero and close to one, which means majority of the error is due to the technical inefficiency. On the other hand, technical inefficiency significantly contributes to the degree and fluctuation of organic tea yield of the smallholders. The maximum likelihood estimates indicated that cultivated land, labour and organic fertilizers are significant at 1% significant level. The observed positive effect of land, labour and organic fertilizers were in line with studies of Jayasinghe and Toyoda, (2004), Basanyake and guneratne (2002) and Premaratne and Priyanath (2018). According to this study when cultivated land is increased by one percent, output will increase by 0.212%. When the labour is increased by one percent the output will increase by 0.744%. When the organic fertilizer is increased by one percent the output will increase by 0.245 percent. Among the three inputs used for the production function the elasticity of labour was the highest. Therefore, use of more labour for organic tea production affect the yield largely. Jayasinghe and Toyoda, (2004) also confirms that highest elasticity is by the labour for organic tea smallholders. But according to the Basnayake and Guneratne, (2002) land has the highest elasticity in conventional tea cultivation of smallholders.

Technical inefficiency estimates

The maximum likelihood estimates of the parameters of the inefficiency model are presented in table 4. The coefficients of the variables of age of the farmers, experience of the farmers, and gender of the farmers, other crops cultivation and technical college education are significant at 10% significant level. Availability of livestock, duration of organic tea cultivation and education level of farmers up to O/L are significant at 5% significant level and the indicator for the education level of farmers who passed A/L is significant at 1% significant level.

The age of the farmer has positive association, indicating that age is a significant determinant in inefficiency. This means the younger farmers are more efficient than older farmers. This can be due to the fact that old farmers are reluctant to move into new technologies when cultivating and they don't go for innovative ways of cultivation that would increase the yield and also they might ignore the advices of the authorized institutes. The results further indicate that more experienced farmers in tea cultivation are more efficient. This is because they try to use their inputs in an optimum way with their experience. Jayasinghe and Toyoda, (2004) confirm experience really matters in increasing the efficiency. However, this result is contradicted to the result of the Basnayake and Guneratne, (2002). They showed that with experience the technical inefficiency increases in conventional tea smallholders, because most of the experience farmers tend to use seedling teas. Household size shows negative association with the output indicating technical inefficiency decreases with the increase in household size. These findings lead to the conclusion that more family members can be used for the field practices as result of increase in family size. Coelli and Battese, (1996) stated that hired labour are less productive than family labour. Therefore, usage of more family labour than hired labour could increase the production. Availability of livestock shows positive association with the technical inefficiency. When rearing animals more labour and time have to be dedicated to those activities and therefore, it results less devotion towards organic cultivation and technical inefficiency can be increased. Occupation has negative association with the technical inefficiency which means that technical efficiency increases if the farmers are engaged in tea cultivation only as their occupation. When farmers devote their full time to the organic tea cultivation, the efficiency increases. According to the table 4 gender of the farmer shows negative association meaning that males are more efficient than females. If farmers diversify into many crops, the technical inefficiency increase as farmers have to maintain and treat those crops as well. Thus their time spending on tea cultivation reduces creating more inefficiency. According to the study cultivation of VP teas shows negative association with the technical inefficiency while cultivation of seedling teas shows a positive association with the organic tea output. This indicates that VP teas are more efficient than seedling teas. This result is confirmed by the Jayasinghe and Toyoda (2004) for organic tea cultivation and for conventional cultivation too by Basnayake and Guneratne, (2002). Duration of organic tea cultivation shows negative association with the technical inefficiency. This can be due to the fact that, with the time, amount of organic fertilizer applied will be high and more production can be expected. When considering the education levels, it is the human capital of the farmers. According out findings, education of any type leads to increase the efficiency of organic tea cultivation.

The mean technical efficiency of the organic tea smallholders in Diyathalawa is 0.247 and efficiency ranges from 0.033 to 0.653. This shows that the output can be increased by 75.3% without increasing the input levels. In the study of Jayasinghe and Toyoda, (2004) the mean technical efficiency of the organic tea smallholders in mid country was 0.45, which is higher than that of Diyathalawa. Further, Basnayake and Guneratne, (2002) shows that means technical efficiency of conventional tea smallholders was 0.61 which is higher than the organic tea cultivation in the mid country. Table 5 shows the distribution of technical efficiency of organic tea smallholders in Diyathalawa. The majority lie in the range of 11% to 20%. 32.9% of the farmers lie above the average technical efficiency and the majority are below the estimated average technical efficiency. Only two farmers' efficiency lie between 61% and 70% and no farmers have technical efficiency more than 70%.

Table 4: Inefficiency Effects Model

Variable	Parameter	Coefficient		Standard error		Z statistic
		MLE	Translog	MLE	Translog	
Constant	Z_0	-4.608*		2.662		-1.73
Age of the farmer	Z_1	0.052*	0.305	0.031	0.031	1.7
Experience of the farmer	Z_2	-0.038*	-0.048**	0.023	0.022	-1.64
Household size	Z_3	-0.195	-0.208	0.188	0.173	-1.04
Livestock	Z_4	0.951**	0.853*	0.482	0.707	1.97
Occupation	Z_5	-0.664	-0.620	0.542	0.543	-1.22
Gender of the farmer	Z_6	-0.920*	-0.726	0.499	0.475	-1.84
Other crops cultivated	Z_7	0.940*	-0.468	0.526	0.707	1.79
VP	Z_8	-0.554	0.565	0.697	1.347	-0.79
Seedling	Z_9	0.102	-0.177**	1.300	0.067	0.79
Duration of organic tea	Z_{10}	-1.516**	1.253**	0.072	0.511	-2.09
Edu dummy 1	Z_{11}	-10.98	-7.407**	10.996	2.472	-0.98
Edu dummy 2	Z_{12}	-4.705	-3.647*	0.735	1.934	-2.48
Edu dummy 3	Z_{13}	-4.575**	-3.618**	1.818	1.825	-2.52
Edu dummy 4	Z_{14}	-2.516	-1.721	0.900	1.802	-1.40
Edu dummy 5	Z_{15}	-3.610**	-2.526	0.735	1.757	-2.07

Edu dummy 6	Z_{16}	-5.161***	-4.656**	0.920	1.883	-2.77
Edu dummy 7	Z_{17}	-7.078*	-35.98	4.059	4.234	-0.01

*,**,*** are significant at 10%,5%, 1% significant levels respectively

Table 5: Distribution Of Technical Efficiencies (Based On Cobb-Douglas Specification)

Efficiency level	**Frequency**	**Percentage**
0%-10%	21	25.6%
11%-20%	25	30.5%
21%-30%	9	11.0%
31%-40%	10	12.2%
41%-50%	8	9.8%
51%-60%	7	8.5%
61%-70%	2	2.4%

Estimation of stochastic translog production function

A stochastic translog production frontier was estimated to test the interaction effect among the variable in the Cobb-Douglas production function. The ML estimates are given in Table 6. In the translog model only land and labour are significant at 5% and 1% significant level respectively. Land, labour, organic fertilizer, land squared and organic fertilizer squared shows a positive relationship with the output. Labour squared, interaction of land and labour, interaction of land and organic fertilizer and interaction of labour and organic fertilizer shows negative relationship with the output. Here the γ=0.863 which is close to the one, showing that the error is due to the technical inefficiency. Table 6 shows the technical inefficiency model using translog function. Livestock and some secondary education are significant at 10%, experience of the farmer, duration of organic tea cultivation, cultivation of other crops, some primary and education of farmers upto O/L are significant at 5% significant level. Signs of the determinants of the technical inefficiency model are similar to the Cobb-Douglas technical efficiency model. Only the type of education is different.

Table 6: Maximum Likelihood Estimates For Parameters Of The Stochastic Translog Frontier

Variable	Parameter	Coefficient	Standard error	Z statistics
Ln Land	β_1	0.872 **	0.302	2.88
Ln Labour	β_2	2.434***	0.706	3.44
Ln Organic fertilizer	β_3	0.066	0.354	0.19
Ln^2 labour	β_4	-.523	0.745	-0.70
Ln^2 land	β_5	0.117	0.103	1.13

Ln^2Organic fertilizer	β_6	0.045	0.082	0.56
Ln land*labor	β_7	-0.149	0.139	-1.07
Ln land*org.fertilizer	β_8	-0.048	0.059	-0.82
Ln labor*org.fertilizer	β_9	-0.037	0.247	-0.15
σ^2		0.409		
γ		0.863		

*,**,*** are significant at 10%,5%, 1% significant levels respectively

Robustness of technical efficiency

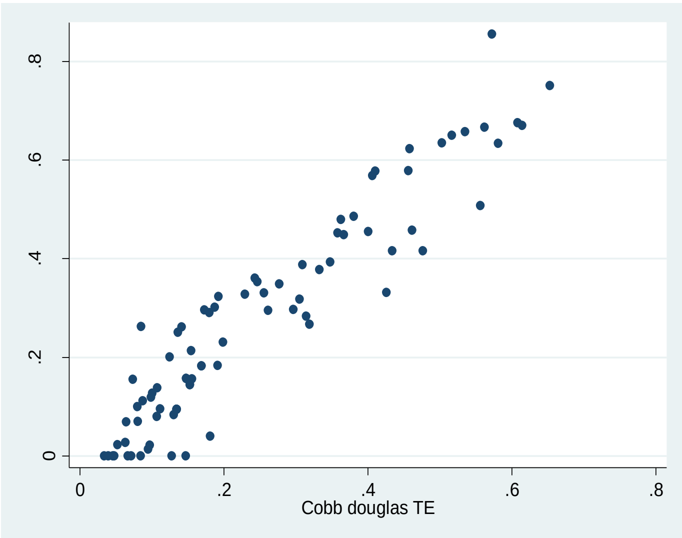

Figure 1: Robustness of the technical efficiency estimates

Figure 1 shows the robustness of technical efficiency estimates obtained by Cobb-Douglas and translog models. It clearly shows that there is no much difference of the technical efficiency value from Cobb-Douglas function and the translog function since the line is approximately 45-degree line. The mean technical efficiency from Cobb-Douglas function is 0.247, and from translog is 0.278 which approximately equal. This is implying that considerable interaction effect cannot have in the chosen stochastic frontier model. Therefore, technical efficiency estimates are not sensitive to the functional form specified.

4. CONCLUSION AND RECOMMENDATIONS

Stochastic frontier production model has been used with inefficiency effects to analyze the relationships between total green leaf production and organic fertilizer using data that have been collected from organic tea smallholders in Diyathalawa of Uva Region. Cultivated extent, labour usage and amount of organic fertilizer added significantly affect the organic tea production. The estimated average technical efficiency of organic tea smallholders using Cobb-Douglas Function is 24.7%. This implies that there is a scope of further increasing the output by 75.3%. Education level of the tea smallholder is an important determinant of efficiency of the organic tea production while experience of the tea smallholder contributes the efficiency in production. Experience farmers have good managerial skills which they have gained over the period. Furthermore, older farmers are less efficient. This could be due to the fact that the older farmers are reluctant to use new technologies and also they might not listen to the advice from the organic associations. Therefore, good extension services should be provided to the older organic smallholders in an effective way. The older farmers are new to the organic tea cultivation so their inefficiency is high. Male farmers contributes to increase the efficiency in organic tea cultivation. Most of the female farmers are engaged in other household activities. Therefore time spent on organic tea cultivation by females is less. Thus they contribute less to increase the efficiency. It is then recommended to encourage male to engage in organic tea farming. As smallholders have to engage in livestock management when they have animals, they are not well-engaged in organic tea cultivation and it has led to decrease their efficiency. When smallholders move into diversifying their crop cultivation their technical efficiency in tea cultivation reduces as their labour has to be reallocated among all other activities. If the other crops are cultivated it is recommended to encourage farmers to use hired labour for organic tea cultivation especially when weeding and pruning have to be done. The soil on which tea is cultivated needs come period to convert from conversional farming to organic farming. More organic fertilizer should be added to the soil with the time and it takes some time decay and release nutrients to the soil. Therefore, longer the period of cultivation, higher will be the technical efficiency. It was also found that technical inefficiency model is not sensitive to the functional form because technical efficiency value of Cobb-Douglas model and Translog model does not vary significantly for organic tea smallholders in Diyathalawa. For further research, this study can be done in panel data considering few years in order to understand how productivity and technical efficiency has varied over the time.

REFERENCES

Adedeji, I.A., Ajetomobi, J.O and Olapade-Ogunwole, F. (2011). Technical Efficiency of Cocoa Production in Oyo state, Nigeria. *Continental J. Agricultural Economics 5 (1): 30 – 40*.

Aigner, D. J., C. A. K. Lovell and P. Shemidt (1977). Formulation and Estimation of Stochastic Frontier Production Function Models. *Journal of Econometrics*, 6:21-27

Basnayake, B. M. J. K., and Gunaratne, L. H. P. (2002), Estimation of Technical Efficiency and Its Determinants in the Tea Small Holding Sector in the Mid Country Wet Zone of Sri Lanka, *Sri Lanka Journal of Agricultural Economics*, 4: 137-150.

Battese, G.E. and Coelli, T.J. (1995). A Model for Technical Inefficiency in a Stochastic Frontier Production Function for Panel Data. *Empirical Economics,* 20:325-332

Battese, G.E. and Coelli, T.J. (1996). Identification of factors which influence the technical inefficiency of Indian farmers. Australian Journal of Agricultural Economics, 40 (2): 103-128

Battese, G.E. and Corra, G.S. (1977). Estimation of a Frontier Model: With Application to the Pastoral Zone of Eastern Australia. *Australian Journal of Agricultural Economics,* 21:167-179

Coelli, T.(1995), Estimators and Hypothesis Tests for a Stochastic Frontier Function: A Monte Carlo Analysis, Journal of Productivity Analysis, 6: 247-268.

Coelli, T., Prasada, R. and Battese, G.E (1998), *An Introduction to Efficiency and Productivity Analysis*, Boston, Kluwer Academic Press

Farrell, M.J. (1957), The Measurement of Productive Efficiency", *Journal of Royal Statistical Society*, Series A 120, part 3: 253-281

Forsund, F.R., Lovell, C.A.K. and Schmidt, P. (1980), A Survey of Frontier Production Functions and of Their Relationship to Efficiency Measurement, *Journal of Econometrics*, 13: 5-25

Gaffar, N.M.A., (1999). Organic tea cultivation. Tea Bulletin 16: 23-27.

Hajra, N.G. (2001) 'Organic tea farming', in Hajra, N.G. (Ed.): *Tea Cultivation: Comprehensive Treatise*, International Book Distributing Company, Lucknow, India, p.478.

Hughner, R.S., McDonagh, P., Prothero, A., Shultz II, C.J., Stanton, J., (2007). Who are organic food consumers? A compilation and review of why people purchase organic food. Journal of Consumer. Behavior. 6: 94–110.

Jayasinghe, H.D., (1995). The Problems and Constraints Affecting the Tea Smallholder in Sri Lanka. Tea Bulletin 4, 17-31

Jondrow, J., C. A. K. Lovell, I.S. Materov, and P.Schmidt.. (1982). On the estimation of technical inefficiency in the Stochastic Frontier Production function model. Journal of Econometrics.:2/3 (August), 233-38.

Katugaha and Premathilake, (2016). Evaluation of Tea Smallholders Currently Involved in Organic Tea Farming in Badulla District, Undergraduate thesis, Uva Wellassa University.

Katungwe, F., Elepu, G. and Dzanja, J., (2017). Technical Efficiency of Smallholder Tea Production in South-Eastern Malawi: A Stochastic Frontier Approach. *Journal of Agricultural Sciences – Sri Lanka*, 12(3), pp.185–196.

Kumbhakar, S.C., Lovell, C.A.K.(2000), Stochastic Frontier Analysis, Cambridge University Press, Cambridge, New York.

Kumbhakar, S. C., Wang, H.-J. & Horncastle, A. (2014), A Practitioner's Guide to Stochastic Frontier Analysis,Cambridge University Press, Cambridge, England.

Lampkin, N.H., and Padel, S. (1994). *The Economics of Organic Farming—An International Perspective*. University of Wales, Aberystwyth, UK: CAB International: 467.

Katugaha, B.H.M.N.F.B., & Premathilake, K.G. (2016). Evaluation of tea smallholders currently involved in organic tea farming in Badulla District. Unpublished manuscript

Meeusen, and van den Broeck (1977). Efficiency Estimation from Cobb-Doughlas Production Function with Composite Error. *International Economic Review*, 18(2): 435-444.

Premaratne, S.P, Priyanath, H.M.S (2018). Technical Efficiency for Tea Smallholder Farmers under UTZ Certification System in Sri Lanka: A Stochastic Frontier Approach. SEISENSE Journal of Management Vol.1. Issue 2. May 2018

Premathilake, K.G. (2003). Weed management in tea. Tropical Agricultural Research and Extension, 6, 8-20.

Qiao Y, Halberg N, Vaheesan S and Scott S (2016) Assessing the social and economic benefits of organic and fair trade tea production for small-scale farmers in Asia: a comparative case study of China and Sri Lanka Renewable Agric. Food Syst. 31 246–57

Richmond, (1974). Estimating the Efficiency of Production. *International Economic Review*,15:515-521.

Schmidt, P., Lin, T.F.(1984), Simple Tests of Alternative Specifications in Stochastic Frontier Models, Journal of Econometrics, Vol. 24, 349-361.

Subal C. Kumbhakar, Hung-Jen Wang (2010). Estimation of Technical Inefficiency in Production Frontier Models Using Cross-Sectional Data. Indian Economic Review, New Series, Vol. 45, No. 2, Performance Measurement

Wang, H.J., Schmidt, P. (2002), One-Step and Two-Step Estimation of the Effects of Exogenous Variables on Technical Efficiency Levels, Journal of Productivity Analysis, Vol. 18, 129-144.

Zoysa A.N.K, Munasinghe, P.S. (2004). Future Prospects for growing Organic Tea in Sri Lanka. In W.W.Modder, *Twentieth Century Tea Research in Sri Lanka* (pp. 315-319). Thalawakele: The Tea Research Institute of Sri Lanka