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Research Paper

Productive efficiency of rice farming under rainfed conditions in Gampaha and Kalutara districts of Sri Lanka

H.U. Warnakulasooriya[1*] and W. Athukorale[2]

Abstract: This study was conducted to evaluate technical and allocative efficiencies of rice farming in the low country rainfed water regime of the Gampaha and Kalutara districts of Sri Lanka. Data of 2009 *Yala* season, and 2009/2010 *Maha* season were collected from 49 rainfed farms per season of the Gampaha district and 50 rainfed farms per season of the Kalutara district. Stochastic frontier production functions of Cobb-Douglas form with an intercept dummy variable representing the Kalutara district were estimated for each season. Values of γ above 0.78 in the *Yala* season and above 0.9 in the *Maha* season indicated that inefficiencies explain a major portion of the total product variation. The average technical efficiencies were 0.67 in Gampaha and 0.73 in Kalutara districts in the *Yala* season, and 0.76 in Gampaha and 0.78 in Kalutara in the *Maha* season. The average allocative efficiencies were 0.59 in Gampaha and 0.46 in Kalutara in the *Yala* season, and 0.63 in Gampaha and 0.53 in Kalutara in the *Maha* season. Increase of technical efficiency has resulted in potential cost savings of approximately 33 % in Gampaha and 27 % in Kalutara district in the *Yala* season, and 24 % in Gampaha and 22 % for Kalutara in the *Maha* season. About 40 % of the cost of resources in the Kalutara district and 0.27 of that in the Gampaha district in the *Yala* season, and 37 % of the resource cost in the Kalutara district and 29 % of that in the Gampaha district could be saved by raising allocative efficiency. The average cost savings indicated by raising both forms of efficiencies were Rs.29,375 per farm (Rs 79,325/ha) in the Kalutara district and Rs 27,645 per farm (Rs 85,870/ha) in the Gampaha district during the *Yala* season while it was Rs. 29,190 per farm (Rs 89,260/ha) in the Kalutara district and Rs. 22,325 per farm (Rs 81,230/ha) in the Gampaha district in the *Maha* season. Costs of allocative inefficiencies were more prominent in both seasons in the Kalutara district and in the *Maha* season in Gampaha district, whereas costs of technical inefficiencies were more important in the Gampaha during *Yala* season

Keywords: Allocative efficiency, productive efficiency, rice farming, technical efficiency, economic efficiency

Introduction

Rainfed area constitutes about 24 % of the national rice cultivated extent, and contributes to around 19 % of the annual national rice production in Sri Lanka. Districts in the low country wet zone contribute to 36 % of rainfed rice

[1] Department of Agriculture, Peradeniya, Sri Lanka
[2] Department of Economics and Statistics, Faculty of Arts, University of Peradeniya, Sri Lanka
[*] Corresponding Author: hmudiyanse@yahoo.com

production (DCS, 2014). Hence, rainfed rice-growing areas in the low country are important for national food security as stability of production in these areas is relatively high, particularly during drought years. Abandonment of land is a common incidence in these areas, mainly due to relatively low productivity and profitability (Warnakulasooriya *et al.,* 2008). Land abandonment raises both on-farm and off-farm costs to farmers in the form of increased costs on initial land preparation/canal clearing, and thereby leads to further declining of profitability and impose environmental costs to the society. Raising profitability of rainfed farming in the low country wet zone would dissuade abandoning of rice lands and induce farmers to continue rice farming. Farm level profitability depends on efficiency of resources allocation, and productivity that in turn depends on technological improvements, technical efficiency improvement, and level of input use. Accordingly, raising technical and allocative efficiencies of farmers would favourably affect farm profitability.

Efficiency of rice farming has been examined by several researchers over the years (Bogahawatte, 1982; Chandrasiri and Karunagoda, 2008; Ekanayake, 1987; Ekanayake, 1989; Ekanayake and Jayasuriya, 1987; Ekanayake and Jayasuriya, 1989; Hafi, 1985; Karunarathna & Herath, 1989; Gunarathne and Thiruchelvam, 2002; Thiruchelvam, 2005; Thibbotuwewa *et al.*, 2012; Udayanganie *et al.*, 2006; Warnakulasooriya and Athukorale, 2015). Tibbotuwewa *et al*. (2012) examined both technical and allocative efficiencies within the data envelopment analysis (DEA) framework, and Ekanayake (1987) measured the allocative efficiency in irrigated rice farming within stochastic frontier production function (SF) framework but deviating from Fareel's (1957) definition of allocative efficiency. Ekanayake (1987) defined allocative efficiency as the ratio of predicted profit at the level of inputs actually used to obtain expected maximum profit for a farmer-specific production function. Warnakulasooriya and Athukorale (2015) examined both technical and allocative inefficiencies in four major irrigated districts of Sri Lanka within the SF. Apparently, there is a dearth of studies on measurement of efficiency of rainfed farming, and generally the allocative efficiency measurement has been overlooked.

Kalutara and Gampaha districts are two major districts in the low country that cultivate rainfed rice. These two districts contribute to about 32 % of rice production from lands under rainfed rice production in the wet zone of Sri Lanka. Kalutara district has the second largest extent (19 %) and Gampaha district has the fourth largest extent (13 %) of rainfed rice under wet zone districts (DCS, 2014). Agro-ecology in the Gampaha district (WL_3), in general, is better than that in the Kalutara district (WL_{1b} and WL_{2a}) for rice cultivation. The WL_3 region experiences an annual mean rainfall of 1700 mm whereas the mean annual rainfall received by WL_{1b} is 2900 mm and WL_{2a} is 2400 mm. During the years 2009 and 2010, the average number of rainy days per year was 121 days for the Gampaha district and 191 days for the Kalutara district. More rainy days would cause lesser sunshine days for Kalutara district than the Gampaha district. High rainfall and low lying nature of lands have resulted in Kalutara district having more boggy lands with problems of acidity and iron toxicity.

The new improved varieties in the Bw, Ld and At series are grown in areas with boggy lands in the Kalutara district whereas Bg varieties that have higher yield potential are entirely grown in the Gampaha district. With the same level of use of conventional inputs, Gampaha district is expected to give higher productivity that that in the Kalutara district due to better agro-climatic conditions for rice cultivation in the former. This study was thus, conducted with the objectives (a) to measure technical, allocative, and economic efficiencies of rice farming in the *Maha* and *Yal*a seasons in rainfed water regimes of Kalutara and Gampaha districts, and (b) to measure the costs of these inefficiencies and the influence of raising efficiency levels on farm profitability.

Methodology

Farrell (1957) introduced two indices of technical efficiency *i.e.* one in input- output (output-oriented technical efficiency or $TE^{[o]}$) space and the other in the input-input space (input oriented technical efficiency or $TE^{[i]}$). Generally, the output-oriented index is used in the measurement of technical efficiency in most of the studies. The technical efficiency index ($TE^{[i]}$), allocative efficiency index (AE), and associated economic efficiency (EE) index in the input-input space introduced and elaborated by Farrell (1957) were used in this study to measure the efficiency of production.

There are two alternative approaches that have evolved in the measurement of efficiency of production, *i.e.* (a) data envelopment analysis (DEA) approach that uses programming methods to derive efficiency frontier, and (b) stochastic frontier production function (SF) approach that uses econometric methods to estimate frontier production function. The coefficients estimated through the SF approach have statistical properties whereas the general DEA estimates do not have statistical properties. Further, SF approach has not been previously used in analysis of allocative efficiency in rainfed rice farming in Sri Lanka. Therefore, the SF approach and efficiency measurement in input-input space (Kopp, 1981; Russel and Young, 1983; Dawson 1985; Karagiannis *et al*., 2003) was used in this study to measure efficiency of production.

The TE index of a firm is the ratio of the cost of a hypothetical firm operating on the production frontier with the firm's input ratios and output level to the actual cost of the firm. The AE index of the firm is the ratio of the cost of a cost minimizing hypothetical firm operating on the frontier (a technically and allocatively efficient firm) with the firm's output level to the cost at technically efficient input level of the firm. The EE index is the ratio of the cost of a cost minimizing firm operating on the frontier with the firm's output level to the cost of the firm. Accordingly, EE is the product of TE and AE.

The method of measuring AE and TE in input-input space is depicted in Figure 1 for a two-factor case of production. The *AB-e*fficient unit Isoquant represents the various combinations of the two factors, X_1 and X_2 used by technically, perfectly efficient firms of an industry to produce an output, *P*. Any firm producing an output *P* cannot be positioned in between *AB* and the origin *O*. The *Q* and *S* respectively are two technically efficient and inefficient firms that produce an output *P*. These two firms lie on a "Fixed Inputs Use Proportion Ray" (OT) where inputs X_1 and X_2 are used in the same ratio. The *Q*' is a technically and allocatively efficient firm that lies on *AB*-efficient unit isoquant on the point, which touches the price line *DD*'

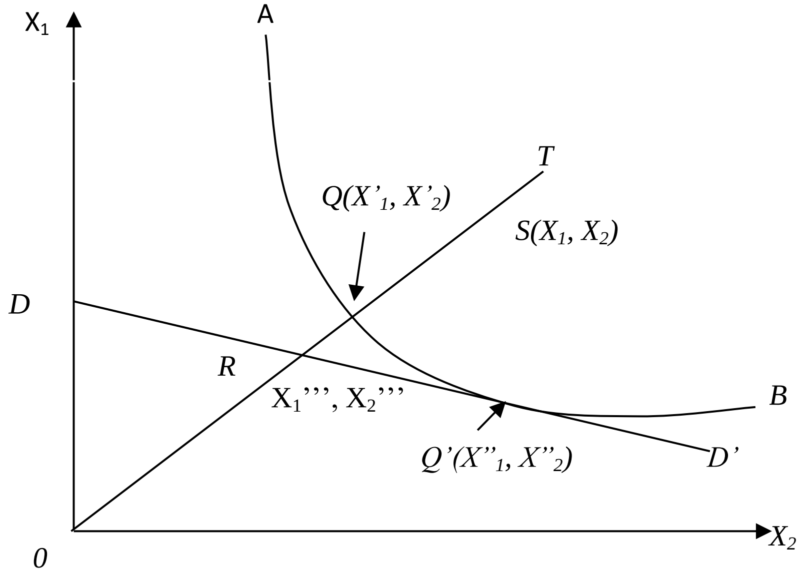

Figure 1. Measurement of efficiency in input-input space

The input based technical efficiency (hereafter TE[1]) of the firm *S* is given as, $TE_s^{[i]} = C'/C_s$, where, C_s, and C', respectively, are the cost of firm *S* and the cost of firm *Q* which is a technically efficient firm that produces, output *P* using inputs in the same proportion as firm *S*. As same input proportions are used by the efficient firm (*Q*) and inefficient firm (*j*), input based technical efficiency ($TE_j^{[i]}$) is given also by the vector norm formula *OQ*/*OS*. Allocative Efficiency of the firm S has been defined as $AEs^{[i]} = C''/C'$ where, C" is the cost of firm Q (a technically and allocatively efficient firm with the same output level as of firm S) and C' is as given above. Since measurements are made along the fixed input use proportion ray, OT, $AE_j^{[i]}$ is represented also by the vector norm formula *OR*/*OQ*. The EE index indicates the possibility of cost reduction feasible by eliminating both technical and allocative inefficiencies. The *EE* of a firm is given by $E_s^{[i]} = C''/C_s$

where, *C"* and C_j are as given above. By definition, *EE* is equal to the product of $TE^{[i]}$ and $AE^{[i]}$ and, and given also by the vector norm formula *OR/OS*.

Specification of the analytical model

The SF function model proposed by Aigner *et al.* (1977) and Meeusen and van den Borek (1977), and further developed by Coelli (1996) was used in the study. The SF is specified in the log-log linear (Cobb-Douglas) form as shown in Equation 1;

$$\ln Y_j = \alpha + \theta_k D_k + \sum_{j=1}^{j} \beta_i lnX_{ij} + \varepsilon_j \quad (1)$$

where y_j is the output of j^{th} farmer, D_k={0,1}, D_k is a dummy variable that takes value of 1 for Kalutara district and 0 for Gampaha district, $Land_j$ is the land extent used by j^{th} farmer, $Labour_j$ is the amount of labour used for production operations excepting labour used for water management and transport operations, $material_j$ is the operating expenditure incurred on all inputs, and $machine_j$ is the cost of machinery services incurred on land preparation, harvesting, and threshing, ε_j is a composite error tem where, $\varepsilon_j = \nu_j - \upsilon_j$: ν_j is an error term assumed to be distributed identically and independently as $N(0,\sigma_v^2)$ that reckons random variation of output, and u_j is one sided ($u_j \geq 0$) error term that reckons variation of output due to inefficiency. In this paper u_j was assumed to follow a half normal distribution (u. $N(0, \sigma_u^2)$. The efficiency parameter $\gamma = (\sigma_\upsilon^2 / \sigma_\upsilon^2 + \sigma_v^2)$ lies between 0 and 1, and if γ = 0, the difference between farmer's production and production estimated by the frontier function is entirely due to statistical noise. Conversely, γ=1 indicates that the difference of actual and estimated production is entirely due to less than efficient use of technology.

Estimation of technical and allocative efficiency indices

Frontier 4.1 (Coelli, 1996) was used to estimate the model. Then the output oriented technical efficiency index $[TE_j^{[o]}]$ is given by the software. The input oriented technical efficiency for a double log frontier production function is given as $TE_j^{[i]} = [TE_j^{[o]}]^{(1/\Sigma\beta_i)}$ where, $\Sigma\beta_i$ is the sum of estimated production elasticities or the scale coefficient. The cost minimizing allocatively efficient input point along efficient unit iso surface could be represented by equation 2.

$$Y_j = A\prod_{i=1}^{i} X''^{\alpha_i}_{i_j} \quad (2)$$

The cost minimizing point subject to output constraint requires that the inverse price ratios of inputs should be equal to ratios of marginal products ($MP_1 / MP_2 = r_1 / r_2$). The relationship of inputs at cost minimization subject to output constraint of a Cobb-Douglas production function is given as (Henderson and Quandt, 1980).

$$X''_{ij} = \frac{\propto_i . r_k}{r_i . \propto_k} X''_{kj} \tag{3}$$

where, r_i and r_k are prices of k^{th} and i^{th} inputs

Substituting value of X''_{ij} of (3) in ( ) gives the equations 4, 5 and 6.

$$Y_j = A \prod_{i=1}^{i} \left(\frac{\propto_i}{\propto_k} . \frac{r_k}{r_i} X''_{kj}\right)^{\propto_i} \tag{4}$$

$$Y_j = \left(A.\left(\frac{r_k}{\propto_k}\right)^{\Sigma\propto_i} \prod_{i=1}^{i} \left[\frac{\propto_i}{r_i}\right]^{\propto_i}\right).X_{kj}^{(\Sigma\propto_i)} \tag{5}$$

$$X''_{kj} = \left[\frac{Y_j}{\left(A.\left(\frac{r_k}{\propto_k}\right)^{\Sigma\propto_i} \prod_{i=1}^{i}\left[\frac{\propto_i}{r_i}\right]^{\propto_i}\right)}\right]^{\frac{1}{\Sigma\alpha_i}} \tag{6}$$

Any X_{ij} could be found by substiting a value at X_{kj} in the Equation 3, and the cost of cost-minimising input combination could be found by multiplying the input values by prices faced by farmer. Then, the AE is estimated as given in equation 7.

$$AE^j = \frac{C''_j}{C'_j} = \frac{C''_j}{C_j.TE_j^i} \tag{7}$$

Estimates of potential cost savings

Cost savings feasible for each farm firm by raising technical efficiencies to unity are estimated as $\Delta S_{TEj} = C_j\ (1 - TE_j)$ where, C_j is the total cost of production of farmer j and ΔS_{TEj} is the potential cost savings for farmer j with raising his technical efficiency to unity. Cost savings feasible for each farm firm by raising allocative efficiencies to unity are estimated as equation 8.

$$\Delta SAE_j = C_j.TE_j(1 - AE_j) = C_j.(TE_j - AE_j.TE_j) = C_j.(TE_j - EE_j) \tag{8}$$

where, ΔS_{AEj} is the potential cost savings for farmer j by eliminating his allocative inefficiency. Accordingly, the term (TE_j – EE_j) gives the proportionate cost savings feasible by eliminating allocative inefficiency. Then sample sums of cost savings are divided by aggregate extent to find per acre cost savings.

Data used

All input use and output data collected by the Socio-Economics and Planning Center, Department of Agriculture, Sri Lanka for cost of cultivation studies of paddy farming during the above two seasons were processed and used. The samples of each season include randomly selected 49 farmers from Gampaha district and 50 farmers from Kalutara district (total sample size for each season was 99 farms).

Lands were mostly owned by the farmers and land rents were rarely recorded in the data set used. Therefore, rent value of land was not explicit. The Paddy Lands Act No. 1 of 1958 and subsequent Agrarian Development Act No. 46 of 2000 prescribe a land rent of 25 % of the output. Accordingly, the value of land is decided as 25 % of the value of average yield for the district during the season.

In deciding on the variable labour, eight hours of work by a man was considered as a man day, and a female work day is considered as equal to 0.7 of man days except in operations of manual weeding and transplanting for which one female work day was considered as equal to one man day. Hired labour was considered as equivalent to family/exchange labour. Some farmers had given harvesting operations on contract and had not reported the amount of labor used for the operation. In such cases, the amount of labour used was estimated by dividing the contract value from the average wage rate for the operation. In valuing labour, family labour was valued by the market wage rate faced by the farmer for a particular operation.

The variable 'Material' was formed by aggregating the operating expenditure incurred on material inputs, which generally include cost of seed, cost of fertilizer received at subsidized prices, cost of pesticides, *etc.* Machine is a variable representing services of machinery, measured as cost of services. Machine includes cost of draft power services on land preparation, and the machinery cost for harvesting and threshing. Machinery costs were charged on the basis of 'per land area' by the machinery service providers, and therefore, machinery service values on per hour basis were not available. The cost components of material inputs and services of own machinery costs were valued at the costs incurred by the farmer. Own seed was valued by the average price paid for the seed of each variety by farmers who have purchased seed. The rental value of own machinery was estimated by the going rental rate of such machinery. The opportunity cost was computed using the cost incurred on material inputs and machinery and was charged with the interest rate of the banks for loans given through pawning of jewelry.

Results and Discussion

The mean input use levels of the two districts were similar. The land sizes were approximately 0.4 ha in each district during both cultivating seasons, and the costs of material inputs and machinery services were marginally above Rs 10,000 in the Kalutara district and marginally below Rs 14,000 in the Gampaha district during each season. The mean labour use in each district during the *Yala* season was higher than that during the *Maha* season, which was mainly due to the higher labour requirement for water management during the *Yala* season (Table 1).

Table1. Mean input use levels during 2009 *Yala* season and 2009/2010 *Maha* season

District	*2009 Yala season*				*2009/2010 Maha season*			
	Land (ha)	*Labour (md)*	*Material cost (Rs)*	*Machine cost (Rs)*	*Land (ha)*	*Labour (md)*	*Material cost (Rs)*	*Machine cost (Rs)*
Kalutara	0.37	30.30	3480	6825	0.38	21.22	3965	6900
Gampaha	0.40	26.97	4735	8930	0.35	22.47	4365	9535

md=mandays

Estimated production functions

The dummy variable coefficients for the Kalutara district were negative and significant in frontier production functions for both seasons (Table 2). The exponential value of the dummy variable coefficients in frontier functions were 0.85 in 2009 *Yala* season and 0.81 in 2009/2010 *Maha* season. Accordingly, with the same level of input use in both districts, and with maximum technical efficiency, an average farm in the Kalutara district could obtain only 85 % of the output in the 2009 *Yala* season. For the Gampaha district, under the same conditions, only 81 % could be obtained as the average farm output in the 2009/2010 *Maha* season.

The difference of suitability of agro-ecology for rice cultivation may have resulted in the differences of the performance of the two districts. The estimated coefficients for land in frontier production functions for both *Yala* and *Maha* seasons were larger than the similar coefficients in the average production functions (Table 2). Expansion of the elasticity of production of land with raising farm technical efficiencies to frontier level agrees with priority expectations. The gross margin, which is the return to land and management, increased with increase in the technical efficiency to the frontier level. The estimated production elasticity of land indicated that increasing the land extent by 1 % would result in an increase of production by 0.68 % in *Yala* and 0.44 % in *Maha*. Although the labour coefficients had positive (expected) signs in both the *Yala* and *Maha* seasons in both average and frontier production functions, they were small in magnitude, except in the average production function for *Yala* 2009, and not significant ($p>0.1$) (Table 2). Similar results have been observed by Bhavan and Maheshwaranathan (2008). A negative relationship between output and labour has been reported by Hossain *et al.,* (2008). This situation indicated the flexibility of substitution of labour used for land preparation by machinery and chemicals (initial application of herbicides), weed control by herbicides, and threshing by threshing machines. Displacement of labour used for transplanting by that of seed sowing has a less important role in rainfed paddy farming at present.

The coefficients of material cost and machinery cost were significant in both average and frontier production functions. The estimated elasticities in frontier production functions were 0.145 in the *Yala* season and 0.219 in the *Maha* season of material inputs, and 0.164 in the *Yala* season and 0.2576 in the

Maha season for machinery services. The terms σ^2 and γ were significant ($p<0.01$) in both *Yala* 2009 *Maha* 2009/2010 seasons. The term γ indicates the ratio of variation related to efficiency to total variation. Values of γ greater than 0.78 (Table 2) in both seasons indicated that the variation due to efficiency differentials explain a major portion of yield variation, while the random effects explain only a minor portion of the total product variation.

Table 2. Estimated average and stochastic frontier production functions

Coefficient	*2009 Yala season*		*2009/2010 Maha season*	
	Average Production Function	*Stochastic Frontier Production Function*	*Average Production Function*	*Stochastic Frontier Production Function*
Intercept	4.398*** (6.09)	5.165*** 6.63	2.12*** (2.12)	3.06*** (2.93)
Kalutara	- 0.124* (- 1.86)	- 0.157*** (2.25)	-0.28*** (-3.33)	- 0.21*** (- 2.46)
Ln Land	0.589*** (4.68)	0.681*** 5.108	0.339*** (3.17)	0.441*** (3.88)
Ln Labour	0.176* (1.74)	0.122 (1.194)	0.16 (1.51)	0.089 (.928)
Ln Material	0.067 (1.27)	0.145*** (3.12)	0.261*** (2.699)	0.219*** (2.56)
Ln Machin	0.174*** (3.99)**	0.164*** (3.55)	0.254*** (2.57)	0.257*** (2.90)
σ^2		0.165*** (3.55)		0.29*** 4.023
γ		0.78*** (4.87)		0.908*** (10.92)
Log likelyhood function		-16.03		-32.5

* significant at p=0.1, ** significant at p=0.05, *** significant at p=0.01; Values within parenthesis indicate the 't' ratio

The average efficiency indices

The average technical efficiencies were 0.67 for Gampaha and 0.73 for Kalutara with an average of 0.70 for the two districts during 2009 *Yala* season. In 2009/2010 *Maha* season, the average technical efficiencies were 0.78 for the Kalutara district and 0.76 for the Gampaha district (Table 3). The potential cost savings indicated by alleviating technical inefficiencies were approximately 0.33 in for the Gampaha district and 27 % for the Kalutara district in 2009 *Yala*.

Similarly, the potential cost savings for the 2009/2010 *Maha* season were 22 % for the Kalutara district and 24 % for the Gampaha district.

The averages of economic efficiency for the Kalutara and Gampaha districts was 0.33 and 0.39, respectively, during *Yala*. It was 0.41 and 0.47 during *Maha*, respectively. During 2009 *Yala*, the average potential cost savings was about 67 % for Kalutara district and 61 % for Gampaha district, while that of 2009/2010 *Maha* was 59 % and 53 %, respectively (Table 3).

The proportionate cost savings interpretation of the allocative efficiency alleviation could be taken as the difference between TE[i] and EE. Accordingly, approximately 40 % of the resources cost in the Kalutara district and 0.27 of the Gampaha district during the *Yala* season, and 37 % of Kalutara district and 29 % of Gampaha during the *Maha* season could be saved by raising allocative efficiency.

Table 3. Average technical efficiency (TE [i]), allocative efficiency (AE), and econoomic efficiency in 2009 *Yala* and 2009/2010 *Maha* seasons

District	2009 *Yala* Season			2009/2010 *Maha* Season		
	TE [i]	AE	EE	TE [i]	AE	EE
Kalutara sub sample	0.73	0.46	0.33	0.78	0.53	0.41
Gampaha subsample	0.67	0.6	0.40	0.76	0.63	0.47
Sample average	0.70	0.53	0.36	0.77	0.57	0.44

TE = technical efficiency, AE = allocative efficiency, EE = economic efficiency

Potential average cost savings and raising farm profitability

The average cost savings per farm indicated by raising economic efficiency were Rs.29,375 in the Kalutara district and Rs.27,645 in Gampaha district during 2009 *Yala* season. In the 2009/2010 *Maha*, it was Rs. 29,190 in the Kalutara district and Rs. 22,325 in the Gampaha district. These figures indicate the potential for substantial resources savings (income increases). Costs of allocative inefficiencies are more prominent than technical inefficiencies in both seasons in the Kalutara district, and in 2009/10 *Maha* season in the Gampaha district, whereas costs of technical inefficiencies were more prominent in the Gampaha district during *Yala* season. When the computations are done on per hectare basis, potentials for enhancing profits were substantial (Table 4). However, the small farm sizes may act as a barrier to raise efficiency.

Rice farming in rainfed areas could be made financially attractive to farmers in both Kalutara and lampaha districts in both seasons by raising technical and allocative efficiencies of farmers that would lead to increase in profit per land area substantially. The percentage increases of profits were more pronounced in Kalutara district though the current recorded profits per ha are low (Table 6).

Table 4. Potential average cost savings per average farm with raising Technical (TE), Allocative (AE) and Economic (EE) efficiencies

District	*Potential cost savings in 2009 Yala by*			*Potential cost savings in 2009/2010 Maha by*		
	Raising TE	Raising AE	Raising EE	Raising TE	Raising AE	Raising EE
Kalutara Per farm (Rs)	12375 (42)	17000 (58)	29375	11050 (38)	18140 (62)	29190
Per ha (Rs)	32175	47150	79325	32560	56700	89260
Gampaha Per farm (Rs)	16000 (58)	11645 (42)	27645	9980 (45)	12325 (55)	22325
Per ha (Rs)	44550	41320	85870	33130	48100	81230
Average per farm	14500 (50)	14350 (50)	28850	10520 (46)	15170 (54)	25690

TE = technical efficiency; AE = allocative efficiency, EE = economic efficiency; Values within parenthesis are percentages

Table 5. The potential increase of profitability per hectare by raising technical and allocative efficiencies

District	Current profit Rs/ha*	Potential profit (Rs/ha) in 2009 *Yala*		Current profit Rs/ha*	Potential profit (Rs/ha) in 2009/2010 *Maha*	
		Raising TE**	Raising TE+AE		Raising AE	Raising TE+AE
Kalutara	9540	41715 (337)	88865 (831)	2965	35525 (1098)	92215 (3010)
Gampaha	19210	63760 (232)	106880 (456)	38710	71840 (86)	119940 (210)

* Source: SEPC (2010, 2011); ** TE = technical efficiency, AE = allocative efficiency; Values within parenthesis are percentage increase of profit per ha

The distribution of efficiency indices

During *Yala* 2009, 82 % of farmers in the Kalutara district and 66 % of the Gampaha district had technical efficiency indices above 0.6. However, higher percentages of farmers in the Kalutara district compared to the Gampaha district had higher technical efficiency ranges during the same season. The economic efficiency indices spread from 0-0.19 to 0.9 in the two districts. The percentage of farmers below the 0.5 economic efficiency in Kalutara and Gampaha districts was 86 % and 61 % in 2009/2010 *Maha*, and 100% and 72% in 2009 *Yala*, respectively (Table 6). Accordingly substantial cost savings could be expected by raising technical, allocative and economic efficiencies of sizeable percentages of farmers.

Table 6. The distribution of technical, allocative and economic efficiency indices in the two districts

Efficiency Range	2009 *Yala* season (%)						2009 /2010 *Maha* season (%)					
	Kalutara			Gampaha			Kalutara			Gampaha		
	TE*	AE	EE	TE	AE	EE	TE	AE	EE	TE	AE	EE
0.0 - 0.19					02	10			02			
0.2 - 0.29			34	06	02	25			06			08
0.3 - 0.39		08	50		12	21	02	08	36		08	22
0.4 - 0.49	10	78	16	12	08	16	00	26	42	04	08	31
0.5 - 0.59	08	14		16	20	16	00	48	12	08	33	23
0.6 - 0.69	20			25	27	08	18	16	02	18	18	14
0.7 - 0.79	26			12	12	02	34	02	22	23	09	02
0.8 - 0.89	32			17		02	40			35	10	
0.9 – 1.0	04			12			06			12	04	
Total	100	100	100	100	100	100	100	100	100	100	100	100

* TE = technical efficiency, AE = allocative efficiency, EE = economic efficiency

Conclusion

The possible effects of districts on productivity differentials were controlled by introducing a district-specific intercept dummy variable in the model. Variations due to technical efficiency differentials explained the major portion of the total product variation in Gampaha and Kalutara districts. Therefore, productivity of technically inefficient farmers, and the average productivity could be improved by raising technical efficiency of production. The potential to save the resources cost incurred is 30 % in 2009 *Yala* season and 23 % in 2009/2010 *Maha* season without reducing farm production by raising technical efficiency. The potential cost savings indicated by raising allocative efficiencies are substantial, leading to ample potential savings by raising economic efficiency. The *expost* analysis was based on the assumption of certain knowledge. Rice production under rainfed is associated with uncertainty, and therefore, results of an *exante* analysis by the farmer and *expost* analysis by an analyst would be different. The implicit nature of land prices, and farmer's behavioral goals deviating from profit maximization reduce precision of conclusions based on allocative efficiency estimates based conclusions.

A consistent extension programme facilitating inefficient farmers to work in association with efficient farmers and extension workers may reduce efficiency differentials and increase average farm profitability. Such a programme would reduce abandoning of land or increase land extents and reduce off-farm costs. However, further research on farming systems is needed to enhance long term profitability.

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