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Production Efficiency of small holder Sugarcane Farmers in Swaziland: A Case Study of Ubombo (Lusip & Poortzicht) Andhhohho (Kddp & Vuvulane) Farmers

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***Abstract**: Instating production efficiency is imperative for increased productivity and profitability in sugarcane production. This study aimed at establishing efficiencies and their relationship with farmers' socioeconomic characteristics. The study used primary data collected from 147smallholder sugarcane farmers of which 76 were inHhohho (KDDP &Vuvulane) and 71 in Ubombo (Poortzicht& LUSIP). This study estimated farmers' efficiency using Data Envelopment Analysis (DEA) model. The findings of the study revealed that the majority of the farmers interviewed were females (59.2% in Ubombo& 55.3% in Hhohho), with 32.4%(Poortzicht& LUSIP) and 44.7% (KDDP &Vuvulane) of farmers attained secondary education, average mean age of 58 (Poortzicht& LUSIP) and 55 (KDDP &Vuvulane)years, farming experience of 10 (Ubombo&Hhohho, respectively) years, cultivate about 5.9 (Poortzicht& LUSIP) and 3.1 (KDDP &Vuvulane) hectares and obtained95.82 (Poortzicht& LUSIP) and 92.45 (KDDP &Vuvulane) tonnes per hectare per annumofsugarcane.Farmers' estimated technical efficiency, allocative efficiency and economic efficiency were 90.18%, 85.43% and 77.07%(Poortzicht& LUSIP) and 89%, 84.48% and 75.82% (KDDP &Vuvulane), respectively.The results suggest that farmers can still improve efficiencies by9.82%, 14.57% and 22.93%(Poortzicht& LUSIP) and 11%, 15.52% and 24.18% (KDDP &Vuvulane), respectively without changing the available technologies.Technicalefficiencywas affected byage, irrigation system (10% significant levels), education, experience (1% significant levels), fertilizer (5% significant level) (Poortzicht& LUSIP) andhousehold size (10% significant level), age, ripener, herbicide (5% significant levels), education, occupation and irrigation system (1% significant levels) (KDDP &Vuvulane). Allocative efficiency was influenced bywater, irrigation system (1% significant levels), ripener (10% significant level)(Poortzicht& LUSIP) and education (10% significant level), age, occupation, water, fertilizer, ripener and irrigation system(1% significant levels) (KDDP &Vuvulane). Economic efficiency was affected by education (5% significant level), experience, water, fertilizer, irrigation system (1% significant levels) (Poortzicht&LUSIP) and herbicide (5% significant level) age, education, occupation, water, ripenerand irrigation system (1% significant levels) (KDDP &Vuvulane).The study therefore recommends formulating rural development programmes and policies that target young farmers' engagement and participation in sugarcane production and consider farmers' socio-economic factors for increased productivity.*

***Index Words**: efficiency, farmers' goals, principal component, smallholder farmers, sugarcane*

I. Introduction

In addition to the existing Poortzicht and Vuvulane sugarcane producing areas, Komati Downstream Development Project (KDDP) and Lower Usuthu Smallholder Irrigation Project (LUSIP) were established in 2000 and 2003, respectivelyso as to expand the Swazi sugar industry(Simelane, 2014; SSA, 2015; Terry &Ogg, 2016).The area under sugarcane increased as more smallholder farmers were involved in sugarcane production and access to irrigation increased through significant investments by the Swaziland government and private organisations. Although, recently land in LUSIP and KDDP areas were given to smallholder farmers to increase sugarcane production and alleviate rural poverty, an increase in production costs were impacting negatively on profitability and sustainability. Climate change and variability posed a threat to the sugarcane crop, even though Swaziland has 4.5 billion cubic meters of renewable water resources available with 23% withdrawn annually, of which most (97%) of the water withdrawn is used for irrigation of sugarcane land currently (SSA, 2015).

It is widely held that production efficiency is at the heart of sugarcane production. This is because the scope of sugarcane production can be expanded and sustained by farmers through efficient use of resources. Production levels and success of a sugarcane farm depends on the input use efficiency and the quality of decisions made by the smallholder farmer (Kalinga, 2014). The concern of having low returns in the sugar industry in Swaziland raises the supposition that poor sugarcane productivity could be increased if smallholder farmers could operate at a full technical, allocative and economic efficiency levels with the existing technologies (Dlamini*et al*., 2010; SSA, 2015). In farming, choices must be made among alternative production activities depending on how individual farmers use existing technologies. In order to increase productivity, many studies have recommended the use of tangible resources with less emphasis on intangible resources (Dlamini*et al*., 2012; Dlamini&Masuku, 2012; Ali *et al*., 2013; Thabethe*et al*., 2014; Kibirige, 2013). Sugarcane productivity is thought to be boosted through increased amount of inputs, training of farmers and increased use of agro organic and chemical applications. However, the mentioned agro-inputs and farmer training may not be the only factors responsible for increased sugarcane productivity but also intangible factors like farmers' socioeconomic characteristics and technical, allocative and economic efficiency may augment productivity (Padilla-Fernandez &Nuthall, 2001;Ali *et al*., 2013;Nyariki *et al*., 2015; Kibirige *et al*., 2016; Ali & Jan, 2017).A few studies have been undertaken to measure production efficiency of smallholder sugarcane farmers in Swaziland (Dlamini*et al*., 2010; Dlamini*et al*., 2012). Therefore, the study sought to close this research gap by examining the technical, allocative and economic efficiencies of Ubombo (Poortzicht& LUSIP) and Hhohho (KDDP &Vuvulane) smallholder sugarcane farmers in Swazilandand the results to be a stepping stone for more research studies thereby improving production efficiency and the Swaziland economy. It is with great presumption that there would be improvement in household income, reduction in poverty and rural development in Swaziland.The purpose of the study was to explore smallholder sugarcane farmers' socioeconomic characteristics and their impact on production efficiencyin Ubombo (Poortzicht& LUSIP) and Hhohho (KDDP &Vuvulane) regions in Swaziland.

II. Methodology

The smallholder sugarcane farmers in the Ubombo (Poortzicht& LUSIP) and Hhohho (KDDP &Vuvulane) farming areas, in Swaziland, were used in the study. Currently sugarcane isgrowing on over 11100 and 6500 hectares of irrigated sugarcane inLubombo region in the southern part of the country and Hhohho region in the northern part of the country, respectively (Terry &Ogg, 2016). A stratified random sample size of 147 farmers was obtained, consisting of 71 and 76 farmers inUbombo (Poortzicht& LUSIP) and Hhohho (KDDP &Vuvulane) sugarcane farming areas, respectively. The data collected was for the 2014/15 farming season. Data which included demographic characteristics of the farmers, input and output variables were collected through the use of personal interviews using a structured questionnaire. The collected data were coded and analysed using Statistical Package for Social Sciences (SPSS version 20). Statistical analysis was carried out to produce means, frequencies, standard deviation, minimum and maximum values, and percentages. An Ordinary Least Square regression (OLS) model was employed in order to analyse the relationship between farmers' socioeconomic characteristics and production efficiency.

2.1 The Econometric Model

One of the most important principles in any business is the principle of efficiency, where the best possible economic effects (outputs) are attained with as little economic sacrifices as possible (inputs) (Martic*et al*.,2009). Data Envelopment Analysis approach(DEA) model involves the use of linear programming methods to construct a non-parametric piecewise surface over data so as to be able to determine efficiencies relative to this surface. The model employs standard constant returns to scale (CRS) and variable returns to scale (VRS) (Coelli, 1996).Technical efficiency looks at the level of inputs and outputs. Being technically efficient means to minimise inputs at a given level of outputs, or maximiseoutputsat a given level of inputs. The method produces relative efficiency scores by establishing which farmers are efficient in comparison with the other farmers in a certain situation. Furthermore, the efficiency of a Decision Making Unit (DMU) is measured relative to all other DMUs with the simple restriction that all DMUs lay on or below the extreme frontier. Data Envelopment Analysis (DEA) analyses each DMU separately and computes a maximum performance measure for each unit (Martic*et al*., 2009).

A farm's efficiency consists of technical and allocative components. Technical efficiency reflects the capability by the farm to maximise output for a given set of resource inputs (Dlamini*et al*., 2012; Nyariki*et al*., 2015; Ali *et al*., 2013). Allocative efficiency reflects the competency to generate output with the least cost of production to obtain maximum profits (Kibirige*et al*., 2014; Sihlongonyane, 2014; Thabethe*et al*., 2014). The measures of technical efficiency and allocative efficiency are then combined to give a measure of total economic efficiency. Therefore, economic efficiency is achieved when producer combines in the least cost combinations of inputs to produce maximum output (Kibirige*et al*., 2014; Thabethe*et al*., 2014; Sihlongonyane, 2014; Masuku*et al*., 2014).

2.2 Model Specifications

2.2.1 Technical Efficiency

Technical efficiency reflects the capability by the farm to maximise output for a given set of resource inputs (Nyariki*et al*., 2015; Ali *et al*., 2013).Specific model is given as follows:

Maximize $\theta\ \lambda^{\theta}$.. (1)

Subject to: $-Y_{ij} + Y\lambda \geq 0$

$\theta X_{ij} - X\lambda \geq 0$ i = 1, 2,…,m

$N1'\lambda = 1$

$\lambda_j \geq 0$ j = 1, 2, …, n

Where: θ is a scalar, N1 is an N x 1 vector of ones and λ is an N x 1 vector of constants. The value of θ obtained is the Technical Efficiency score for the j^{th} farmer and these scores normally lie between zero and one. If θ = 1, then the farmer is said to be efficient and lies on the frontier. X_{ij} = (transport, amount of water, labour, fertilizer, herbicides, ripeners). Y_{ij} = (value of output $i^{th}$and farmer j^{th} crop enterprise).

2.2.2 Allocative Efficiency

Allocative efficiency is the extent, to which farmers make efficient decision by using inputs up to the level at which their marginal contribution to production value is equal to the factor cost (Kalinga, 2014).Specific model is given as follows:

Minimize: $\theta \lambda^{\theta}k$.. (2)

Subject to: $-Y_i + Y\lambda \geq 0$

$\theta X_i^k - X^k \lambda \geq 0$

$X_i^{n-k} - X^{n-k\lambda} \geq 0$ i = 1, 2,…,m

$N1'\lambda = 1$

$\lambda_j \geq 0$ j = 1,2,…,n

Where: $^{\theta}k$ is the input k sub vector technical efficiency scores for$_i^{th}$. The constraints with terms X_i^k and X^k includes only the K^{th} input in the third constraint, which contains X_i^{n-k} and X^{n-k}.

2.2.3 Economic Efficiency

Economic efficiency is achieved when producer combines in the least cost combinations of inputs to produce maximum output (Kibirige*et al*., 2014; Thabethe*et al*., 2014; Masuku*et al*., 2014). The model specification for economic efficiency is shown in the equation below:

EE = TE x AE.. (3)

EE = Economic Efficiency

TE = Technical Efficiency

AE = Allocative Efficiency

2.3Impact of Inputs and Farmer Characteristics on Production Efficiency

Ordinary least square (OLS) linear regression model was used to establish the impact of farmers' socioeconomic characteristics and goal orientations on technical, allocative and economic efficiencies as shown below:

$\theta_i = \beta_0 + \beta_1 HHSZE + \beta_2 AGE + \beta_3 EDUC + \beta_4 EXPE + \beta_5 OCCPTN + \beta_6 WATER + \beta_7 FERT + \beta_8 HERB + \beta_9 RIPNR + \beta_{10} IRRI + U^*$.. (4)

Where:

β_0= Constant or intercept

U* = error term

β_1-β_{10} = Unknown scalar parameters to be estimated

HHSZE = size of farming household in number

AGE = age of farmer in years

EDUC = years in school of farmer

EXPE = farming experience in years

OCCPTN = occupation of the farmer (farmer = 1, otherwise = 0)

WATER =amount of water in cubic meters

FERT = quantity of fertilizerinkilogrammes

HERB = amount of herbicidesinlitres

RIPNR =amount of ripeners in litres

IRRI = irrigation system (overhead = 1, furrow = 0)

θ_i = 1 to 3

1. Technical Efficiency
2. Allocative Efficiency
3. Economic Efficiency

III. Findings And Discussion

3.1 Socioeconomic Characteristics

Table 1 reveals household heads were mainly "husband" (38%), "wife" (53.5%) and "child" (8.5%) in (Poortzicht& LUSIP) and "husband" (46%), "wife" (50%) and "child" (4%) in(KDDP &Vuvulane). This implies that husbands were more inHhohho (KDDP &Vuvulane) while wives were more in Ubombo (Poortzicht& LUSIP) farming areas. Fifty nine (59.2%) percent of the respondents were females while forty one

(40.8%) percent were malesinUbombo (Poortzicht& LUSIP) whereas fifty five (55.3%) percent were females yet forty five (44.7%) percent were males inHhohho (KDDP &Vuvulane). Indicating that there were more malesinHhohho (KDDP &Vuvulane) than Ubombo (Poortzicht& LUSIP) farming areas. This implies that there were more females than males in sugarcane production. Men were engaged in off-farm work. There were 85.5% married, 10.5% widows and 4% single household headsinHhohho (KDDP &Vuvulane) whereas 88.7% married, 8.5% widows and 2.8% single household heads wereinUbombo (Poortzicht& LUSIP). All of the respondents had formal education with the majority having attended secondary school (32.4%),high school (29.6%),primary school (26.8%)andtertiary levels(11.2%)inUbombo (Poortzicht& LUSIP) and a greater number attended secondary school (44.7%), primary school (34.3%) and high school (18.4%) and a few tertiary levels (2.6%) in Hhohho (KDDP &Vuvulane).

Table 1: Frequencies and percentages of farmer's tenurial status

Variable	Description	Ubombo (Poortzicht& LUSIP)(n1 = 71)		Hhohho (KDDP &Vuvulane)(n2 = 76)	
		Frequency	Percentage	Frequency	Percentage
Position of head	Husband	27	38	35	46.0
	Wife	38	53.5	38	50.0
	Child	6	8.5	3	4.0
Gender	Male	29	40.8	34	44.7
	Female	42	59.2	42	55.3
Marital Status	Married	63	88.7	65	85.5
	Single	2	2.8	3	4.0
	Widow	6	8.5	8	10.5
Education	Primary	19	26.8	26	34.3
	Secondary	23	32.4	34	44.7
	High	21	29.6	14	18.4
	Tertiary	8	11.2	2	2.6

The study further revealed that the average age of respondents was 58 years, household size of about 10 people and 9 years in formal schoolinUbombo (Poortzicht& LUSIP). Conversely, results reveal average age of 55 years, household size of almost 9 people and 8 years in schoolin the Hhohho (KDDP &Vuvulane) area. Therefore, there were older farmers inUbombo (Poortzicht& LUSIP) than Hhohho (KDDP &Vuvulane). The age of a household head represents general decision making ability (Martz, 2006).The results further established that farmers in Ubombo (Poortzicht& LUSIP) had 10 years of farming experience cultivating on 5.9 hectares as indicated in Table 2. Similarly, farmers had 10 years farming experienceproducing sugarcane on 3.1 hectares in Hhohho (KDDP &Vuvulane). This indicates that Ubombo (Poortzicht& LUSIP)has more sugarcane land thanHhohho (KDDP &Vuvulane). The average farming experience indicated that most of the sugarcane growers had relatively sufficient experience in sugarcane production. Farming experience is held to increase production efficiency of a smallholder producer (Sihlongonyane, 2014).

Table 2: Average distribution of farm and farmer characteristics

Variable	Ubombo (Poortzicht& LUSIP)(n1 = 71)		Hhohho (KDDP &Vuvulane)(n2 = 76)	
	Mean	Standard Deviation	Mean	Standard Deviation
Household size	10.3803	5.53267	8.9211	4.31049
Age in years	57.5915	8.95637	55.4211	9.72730
Years in school	9.3662	3.83309	8.3158	3.76018
Experience	9.8028	4.95009	10.1974	6.23329
Land size	5.88	8.93048	3.1289	1.52261

The study further revealed that smallholder farmers obtained an average sucrose yield of 95.82tonnes per hectare per annum inUbombo (Poortzicht& LUSIP) whereas 92.45 tonnes per hectare per annum was obtained inHhohho (KDDP &Vuvulane). This postulates thatUbombo (Poortzicht& LUSIP) obtained higher yield than Hhohho (KDDP &Vuvulane) had. The yields obtained are less than what SSA (2015) obtained, which was 101 tonnes per hectare per annum. The SSA (2015)'s findings were inclusive of large scale sugarcane estates which were more efficient. Regarding labour, the study revealed Ubombo (Poortzicht& LUSIP) had more labour of 33.3 man days per hectare per annumthan32.6 man days per hectare per annum in Hhohho (KDDP &Vuvulane) as indicated in Table 3. In a study by Dlamini and Masuku (2012) labour was reported to be 31.25 days per hectare per annum among sugarcane farmers which is less than what was found in the study. On average a smallholder farmer in Hhohho (KDDP &Vuvulane) used 15476.36m^{3}of water which is more than 15540.75 m^{3}used inUbombo (Poortzicht& LUSIP) to irrigate one hectare of sugarcane per annum.

Table 3: Average values of inputs for sugarcane production

Variable	Ubombo (Poortzicht& LUSIP)(n1 = 71)		Hhohho (KDDP &Vuvulane)(n2 = 76)	
	Mean	Standard Deviation	Mean	Standard Deviation
Sugarcane (t/ha)	95.8169	21.07491	92.4474	20.27767
Man days/ha	33.2958	4.94944	32.6316	6.66902
Water (m3/ha)	15540.7465	1995.06018	15476.3553	1916.83260
Fertilizer (kg/ha)	636.5775	95.89096	667.8421	134.75222
Herbicide (l/ha)	10.5070	2.02748	12.7632	3.17435
Ripeners (l/ha)	1.3338	0.46719	1.0039	0.61480

Fertilizer (basal & urea) share in the production of sugarcane constitutes a mean of 667.84 kilogrammes (kg) per hectare per annum intheHhohho (KDDP &Vuvulane) farming area which was more thanUbombo (Poortzicht& LUSIP) of which each farmer applied 636.58kilogrammes (kg) per hectare per annum. The study further revealed that on average a farmer used 12.76 litres of herbicides per hectare per annum in the Hhohho (KDDP &Vuvulane) farming area. This is more than 10.51litres of herbicides per hectare per annum used in the Ubombo (Poortzicht& LUSIP). Dlamini and Masuku (2012) reported that smallholder farmers used 14.3 litres of chemicals (herbicides) per hectare per annum which is more than what was found in the study. On average, smallholder farmer used 1.33 litres of ripeners per hectare per annum inUbombo (Poortzicht& LUSIP) more than what each Hhohho (KDDP &Vuvulane) farmer used (1.01 litres of ripeners) per hectare per annum.

3.2 Production Efficiency

In this study Technical Efficiency (TE), Allocative Efficiency (AE) and Economic Efficiency (EE) were generated using DEAP version 2.1. Data were analysed using DEA Frontier Analysis (input oriented and Cost-DEA) with constant return to scale (CRS) model. The results in Table 4 reveal a mean technical efficiency inUbombo (Poortzicht& LUSIP), of 90.18% with minimum and maximum of 57% and 100%, respectively. For Hhohho (KDDP &Vuvulane) the meantechnical efficiency is 89% with minimum and maximum of 52% and 100%, respectively.This suggests that there exists a great potential for smallholder farmers to increase yield per hectare of sugarcane in both farming zones. If on average the smallholder sugarcane farmers are to operate efficiently, they would achieve an input saving of 9.82% or maximise yield by the same in Ubombo (Poortzicht& LUSIP).Comparably,if the smallholder sugarcane farmers inHhohho (KDDP &Vuvulane) are to operate efficiently, they would achieve an input saving of 11% or maximise yield by the same.

Table 4: Estimatedvaluesof efficiencies of farmers

	Ubombo (Poortzicht& LUSIP)(n_1 = 71)				Hhohho (KDDP &Vuvulane)(n_2 = 76)			
Efficiency	**Minimum**	**Maximum**	**Mean**	**Standard Deviation**	**Minimum**	**Maximum**	**Mean**	**Standard Deviation**
Technical	57%	100%	90.18%	0.12935	52%	100%	89%	0.12606
Allocative	64%	99%	85.43%	0.09083	51%	100%	84.48%	0.12833
Economic	46%	99%	77.07%	0.13955	39%	100%	75.82%	0.18195

The mean allocative efficiency of farmers inUbombo (Poortzicht& LUSIP) was revealed to be 85.43% with minimum and maximum of 64% and 99%, respectively. Likewise, the mean allocative efficiency of farmers inHhohho (KDDP &Vuvulane)was established to be 84.48% with minimum and maximum of 51% and

100%, respectively. This indicates that there exists a potential for smallholder farmers to increase yield per hectare of sugarcane in both farming zones. If on average the smallholder sugarcane farmers inUbombo (Poortzicht& LUSIP)are to operate efficiently, they would achieve a cost saving of 14.57%, while maintaining same output. Equally, if on average the smallholder sugarcane farmers inHhohho (KDDP &Vuvulane) are to operate efficiently, they would achieve a cost saving of 15.52%, while maintaining same outputThe study further revealed a mean economic efficiency of farmers inUbombo (Poortzicht& LUSIP) was disclosed to be 77.07% with minimum and maximum of 46% and 99%, respectively. Distinguishably, results reveal a mean economic efficiency of 75.82% of farmers inHhohho (KDDP &Vuvulane)with minimum and maximum of 46% and 99%, respectively. This proposes that there exists a great potential for smallholder farmers to increase yield per hectare of sugarcane. Smallholder sugarcane farmers can reduce inputs costs by 22.93%in Ubombo (Poortzicht& LUSIP)and 24.18% in Hhohho (KDDP &Vuvulane), while maintaining same out or they can increase output by 22.93%in Ubombo (Poortzicht& LUSIP)and 24.18% in Hhohho (KDDP &Vuvulane), while still maintaining same inputs and technology.Basing on the results, it can be established that farmers in Ubombo (Poortzicht& LUSIP)use resources more efficiently than farmers in Hhohho (KDDP &Vuvulane).

The results in Table 5 reveal that most farmers (67.62 %) achieved a technical efficiency between 90 and 100% and none got less than 50% in Ubombo (Poortzicht& LUSIP), whilst sixty three (63.16%) percent in Hhohho (KDDP &Vuvulane) achieved technical efficiency between 90% and 100% without any farmer obtaining less than 50%.

Regarding allocative efficiency none of the farmers obtained less than 50% but thirty nine (39.44%) percent of the respondents, attained allocative efficiency which was between 90% and 100% in Ubombo (Poortzicht& LUSIP). A higher (42.11%) percentage of smallholder sugarcane farmers in Hhohho (KDDP &Vuvulane) obtained allocative efficiency which was between 90% and 100% none got below 50%. Seven (7.04%)percent of the farmers got economic efficiency which is less than 50% with fifteen (15.49%) percent achieving economic efficiency between 90% and 100%inUbombo (Poortzicht& LUSIP).Comparably, one (1.3%) percent of the farmers got economic efficiency which is less than 40% in Hhohho (KDDP &Vuvulane) with thirtytwo (31.59%) percent achieving economic efficiency between 90% and 100%.

Considering the difference between maximum and minimum of the efficiencies accomplished, there is a lot of improvement that farmers need to do in order to operate at the frontier. Thus, Ubombo (Poortzicht& LUSIP) had a higher percentage of technically efficient farmers than Hhohho (KDDP &Vuvulane) had.

Table 5: Distribution of efficiencies

Efficiency Range	Ubombo (Poortzicht& LUSIP)(n1 = 71)						Hhohho (KDDP &Vuvulane)(n2 = 76)					
	Technical		Allocative		Economic		Technical		Allocative		Economic	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
90-100	48	67.62	28	39.44	11	15.49	48	63.16	32	42.11	24	31.59
80-89	8	11.26	27	38.03	29	40.85	13	17.1	22	28.95	17	22.37
70-79	8	11.26	10	14.08	12	16.90	8	10.53	13	17.1	4	5.26
60-69	3	4.23	6	8.45	11	15.49	3	3.95	6	7.89	16	21.06
50-59	4	5.63	0	0	3	4.23	4	5.26	3	3.95	7	9.21
40-49	0	0	0	0	5	7.04	0	0	0	0	7	9.21
30-39	0	0	0	0	0	0	0	0	0	0	1	1.3
Total	71	100	71	100	71	100	76	100	76	100	76	100
Average		0.90		0.85		0.77		0.89		0.84		0.76
Maximum		100		0.99		0.99		100		100		100
Minimum		0.57		0.64		0.46		0.52		0.51		0.39

3.2.1 Determinants of Production Efficiency

In this study an ordinary least square (OLS) linear regression of technical, allocative and economic efficiency scores against explanatory variables were estimated. The inefficient effects were specified as those related to farmers' socioeconomic characteristics and production inputs. The OLS regression model representing technical, allocative and economic efficiencies for farmers in Ubombo (Poortzicht& LUSIP)have Durbin-Watson value scores of 1.700, 1.963 and 1.549, respectively.

Likewise,the OLS regression model representing technical, allocative and economic efficiencies for farmers inHhohho (KDDP &Vuvulane) have Durbin-Watson value scores of 1.959, 1.956 and 1.946, respectively. These Durbin-Watson value scoressignify limited autocorrelation problems. The F-values exhibited that the explanatory variables combined, significantly influence changes in the dependent variables at 1% significant levels.

Table 6: Factors affecting production efficiency

Variable	Ubombo (Poortzicht & LUSIP)(n1 = 71)						Hhohho (KDDP & Vuvulane)(n2 = 76)					
	Technical		Allocative		Economic		Technical		Allocative		Economic	
	Beta (β)	P-value	Beta (β)	P-value	Beta (β)	P-value	Beta (β)	P-value	Beta (β)	P-value	Beta (β)	P-value
Size	0.053	0.212	-0.029	0.120	0.020	0.681	0.073*	0.100	0.004	0.908	0.063	0.185
Age	0.215*	0.060	-0.020	0.690	0.193	0.137	0.270**	0.012	0.212***	0.006	0.290***	0.010
Education	0.097***	0.009	0.006	0.686	0.098**	0.020	0.139***	0.005	0.063*	0.074	0.133***	0.010
Occupation	0.013	0.610	-0.005	0.645	0.007	0.823	0.283***	0.001	0.269***	0.000	0.340***	0.000
Experience	0.106***	0.006	0.019	0.252	0.125***	0.005	0.017	0.711	0.030	0.348	0.059	0.206
Water	-0.052	0.647	-0.809***	0.000	-0.842***	0.000	-0.014	0.913	-0.448***	0.000	-0.723***	0.000
Fertilizer	0.294**	0.011	0.056	0.265	0.348***	0.009	-0.123	0.220	0.395***	0.000	0.165	0.117
Ripener	0.067	0.512	0.086*	0.059	0.154	0.190	0.172**	0.017	0.301***	0.000	0.337***	0.000
Herbicide	-0.041	0.398	0.010	0.655	-0.043	0.447	-0.369**	0.030	-0.186	0.126	-0.361**	0.042
Irrigation	0.270*	0.100	1.675***	0.000	0.949***	0.000	0.601***	0.001	0.405***	0.002	0.761***	0.000
D-Watson	1.700		1.963		1.549		1.959		1.956		1.946	
Adj R2	0.989		0.994		0.985		0.982		0.991		0.981	
F-Value	618.177		492.676		471.373		427.044		825.747		389.132	
P-Value	1%		1%		1%		1%		1%		1%	

** = 10% significant level, ** = 5% Significant level, *** = 1% Significant level*

Analysis of results in Table 6 reveals that technical efficiency ofHhohho (KDDP &Vuvulane) farmers' is positively and significantly related to household sizeof the farmer at 10% significant level.This implies that an increase in household size of a farmer by one person will improve technical efficiency. In Swaziland rural setting, increased household size means increased labour force for sugarcane production. The result is consistent with Kibirige *et al.* (2016)'s findings. In the contrary, the result is not in line with Muhammad (2015), Sihlongonyane (2014) and Ali and Jan (2017)'s findings. It is understood that an increase in the household sizeenhancestechnical efficiency by availing more labour force for a more equitable labourapportionment among sugarcane farming activities. Therefore, increased farm family labourforce may result into a higher concentration of a farmer on more demanding farm tasks and thus improving technical efficiency(Kibirige *et al.*, 2016).

Further, analysis of results reveal that technical efficiency is positively and significantly related to age of Hhohho (KDDP &Vuvulane) farmers (5% significant level)and Ubombo (Poortzicht& LUSIP) farmers (10% significant level). This implies that an increase in the age of a farmer will improve technical efficiency. The results are supported by those of Dlamini*et al.* (2010), Dlamini*et al.* (2012), Ali *et al.* (2013), Kibirige (2013), Thabethe*et al.* (2014), Ali and Jan (2017) and Malinga*et al.* (2015). The age of smallholder farmer plays a vital role in the rejection and selection of new practices and modern technology. Age represents general decision making ability and knowledge of production process. Farmer's age is accepted to have great contribution towards personal learning, personality development, attitude and skills with correct judgment (Supaporn, 2015; Muhammad, 2015; Kibirige *et al*., 2014; Dlamini*et al.*, 2012). Thabethe*et al*. (2014) argued that older farmers appear to be more efficient than younger farmers because of their good managerial skills, which they had learnt over time. Furthermore,Hhohho (KDDP &Vuvulane) farmers' allocative and economic efficiencies are positively and significantly influenced by age at 1% significant levels. This denotes that an increase in age of a farmer will increase allocative and economic efficiencies.This is in line with empirical hypothesis. The older the farmer is the uttermost s/he possesses knowledge about her/his production process. Conformation is made that efficient allocation of resources to get the maximum level of output is directly related to the age of the farmer (Ali *et al.*, 2013).

Both Hhohho (KDDP &Vuvulane)and Ubombo (Poortzicht& LUSIP) farmers' technical efficiency is impacted by level of education of a household head at 1% significant levels, respectively. Indicating an increase in a year in school of a sugarcane farmer will increase technical efficiency. It is conceivable that the level of education of a farmer will enhance production and lead to more efficient productivity as predicted in the empirical hypothesis. Education plays a great role in adoption of most new technologies that normally calls for better management including consistent record keeping and proper use of the various inputs in sugarcane (Kibirige, 2008). The results of the current study conforms to Muhammad (2015), Supaporn (2015), Kibirige *et al*. (2014), Thabethe*et al*. (2014), Ali *et al*. (2013) and Kibirige (2013)'s findings. However, Padilla-Fernandez and Nuthall (2001) found educational level of a farmer to be a weak predictor of technical efficiency while Kibirige *et al*. (2016) found educational level of a farmer to be negatively related to technical efficiency.

Further, education level in terms of years spent in formal schools by the farmers had a positive and significant effect onHhohho (KDDP &Vuvulane) farmers' allocative efficiencyat 10% significant level. Thisimplies that a year increase in educational level of a farmer will increase allocative efficiency. Education has direct impact on enhancing the efficiency of the farmers in resource allocation. The more educated the farmer is the higher yield of the sugarcane is expected accordingly.Education is a variable that is expected to improve managerial input and lead to better decisions in sugarcane farming**(**Mokgalabone, 2015).Furthermore, the results establish that education level in terms of years spent in formal schools by the farmers have a positive and significant effect onUbombo (Poortzicht& LUSIP) and Hhohho (KDDP &Vuvulane)farmers'economic efficiency at 5% and 1% significant levels, respectively. This implies that a year increase in educational level of a farmer will increase economic efficiency. The results are consistent with the findings of Masuku*et al*. (2014) andMokgalabone (2015).Education enhances farmers' ability to make optional decisions with regard to input use and product mix (Thabethe*et al*., 2014). In support, Kalinga (2014) documented that an increase in level of education contributes to an increase in economic efficiency. The results are in conformity with Thabethe*et al*. (2014)'s findings where education level is positively related to economic efficiency.

Farming as a major occupation is positively and significantly related to farmers' technical, allocative, economic efficienciesin the Hhohho (KDDP &Vuvulane) sugarcane farming county at 1% significant levels, respectively.This is in agreement with the empirical hypothesis. This implies that an increase in a year of those engaged in farming, as a major occupation, will increase production efficiency. The results conform to Padilla-Fernandez and Nuthall (2001)'s findings.Smallholdersugarcane farmers engaged in farming as a major occupation are probably giving more attention to farming and devoted in ensuring optimal timing and use of inputs more efficiently. This in return enhances production efficiency.Those engaged in farming, as a major occupation, were for increased output. This results in increased income, high standard of living and accumulated wealth (Kibirige *et al*., 2016).In the contrary, experience variable has positive and significant impact on Ubombo (Poortzicht& LUSIP) farmers' technical and allocative efficienciesat 1% significant levels, respectively. Postulating that an increase in the duration of farmers' involvement in sugarcane production increases productivity of his/her crops. These findings are supported by those of Ali and Jan (2017) and Mokgalabone(2015).

Surprisingly amount of water has a negative and significant impact on both Hhohho (KDDP &Vuvulane)and Ubombo (Poortzicht& LUSIP) farmers' allocative and economic efficienciesat 1% significant levels, respectively. This implies that a decrease in amount of water applied will increase allocative and economic efficiencies. This is probably because most smallholders were applyinghighamounts of water leading to low output.High volumes of water maybe due to too much run off and system leakages which result in high operating costs. The results are not in agreement with empirical hypothesis. Further, fertilizer variable is positively and significantly associated with Ubombo (Poortzicht& LUSIP) farmers' technical efficiencyat 5% significant level. This indicates that an increase in number of smallholders applying more fertilizer result in an increase of 0.294 units of sugarcane output. The result findings are consistent with Nyariki*et al.* (2015) and Malinga*et al.* (2015)'s results. On the contrary, the study results are inconsistent with Kibirige *et al.* (2016)'s findings. Furthermore, fertilizer has a positive and significant impact on Ubombo (Poortzicht& LUSIP) and Hhohho (KDDP &Vuvulane)farmers' allocative efficienciesat 1% significant levels, respectively. This postulates that an increase in amount of fertilizer applied by sugarcane will increase allocative efficiency.

Herbicidesare negatively related to technical and economic efficiencies ofHhohho (KDDP &Vuvulane)farmers at 5% significant levels, respectively. A decrease in amount of herbicides will increase technical and economic efficiencies. Probably the negative effect is due to a combination of herbicides. The results are in line with Kibirige *et al*. (2016) but inconsistent with Malinga*et al.* (2015)'s results. Ripeners have a positive influence on the technical, allocative and economic efficiencies ofHhohho (KDDP &Vuvulane)farmersat 1% significant levels, respectively. ForUbombo (Poortzicht& LUSIP) farmers,ripeners are positively and significantly impacting allocative efficiencyat 10% significant level. This implies that an increase in amounts of ripeners used will increase technical, allocative and economic efficiencies of smallholder sugarcane farmers. The result is consistent with Malinga*et al.* (2015)'s findings. Overhead as an irrigation system is positively and significantly influencing Ubombo (Poortzicht& LUSIP) farmers' technical (10% significant level), allocative and economic (1% significant levels, respectively) efficiencies and Hhohho (KDDP &Vuvulane) farmers' technical, allocative and economic (1% significant levels, respectively) efficiencies. This implies that an increase in the use of overhead as an irrigation system by smallholder sugarcane farmers will increase production efficiency, hence sugarcane output. This is in agreement with empirical hypothesis.

IV. Conclusions

The findings of the study revealed the average technical efficiency, allocative efficiency and economic efficiency of 90.18%, 85.43% and 77.07%, respectivelyforUbombo (Poortzicht& LUSIP) farmers.Thus, there is a potential of increasing technical efficiency, allocative efficiency and economic efficiency by 9.82%, 14.57% and 22.93 %, respectively for farmers in Ubombo (Poortzicht& LUSIP). The average technical efficiency, allocative efficiency and economic efficiency were 89%, 84.48% and 75.82%, respectively forHhohho (KDDP &Vuvulane) farmers. Thus, there is a potential of increasing technical efficiency, allocative efficiency and economic efficiency by 11%, 15.52% and 24.18%, respectively for the farmers in the Hhohho (KDDP &Vuvulane) sugarcane farming areas. The determinants of technical efficientwerehousehold size, age, education, occupation, ripeners, herbicide, and irrigation system for Hhohho (KDDP &Vuvulane) farmers and age, education, experience, fertilizer, irrigation system for Ubombo (Poortzicht& LUSIP) farmers. The factors influencing allocative efficient wereage, education, occupation, water, fertilizer, ripeners, irrigation system for Hhohho (KDDP &Vuvulane) farmers and Water, ripeners, irrigation system for Ubombo (Poortzicht& LUSIP) farmers' allocative efficiency. Determinants of economic efficiency were age, education, occupation, water, ripeners, herbicide, and irrigation system for Hhohho (KDDP &Vuvulane) farmers andeducation, experience, water, fertilizer, irrigation system for Ubombo (Poortzicht& LUSIP) farmers.

V. Recommendations

Recommendation is made for rural development programs and policies that target young farmers' engagement and education should be catalysed through provision of more land for sugarcane production and equitable distribution of land regardless of age. Due to increase in demand for quality sugar on hostile global markets, it is recommended that farmers use available resources efficiently to maximise output of high quality and increase use of latest high yielding sugarcane varieties so as to boost efficiency. For further study, it is recommended that there is need for research to compare goal orientations of smallholder sugarcane farmers in KDD and LUSIP areas.

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