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Evaluation of Allocative Efficiency of Small-Scale Pineapple (*Ananas comosus*) Production in Bureti District, Kenya

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Abstract: The current level of pineapple production in Kenya and in Bureti district in particular is lower than the expected optimum level, hence prohibiting farmers' significant returns from this enterprise. This research aimed at measuring the level of allocative efficiency, as well as determining the causes of allocative inefficiency in small-scale pineapple, production in Bureti District. This will contribute to the understanding of the extent to which they can appropriately adjust productive resources in order to achieve the optimal level of output. Multistage sampling procedure was used to get a random sample of 150 pineapple farmers and primary data was collected by use of a pretested structured questionnaire. A stochastic frontiers production analysis method was used to estimate the allocative efficiency of the pineapple growers. The results of the study indicate that the average allocative efficiency of pineapple production was 0.355. Regarding the sources of allocative inefficiencies, the results showed that the estimated coefficients of age and access to credit were significant with negative effects, thus implying that they reduced allocative inefficiencies. The findings of the study point to the importance of increased youth participation in agriculture, as well as improved farmer access to credit. Through this pineapple, farming will be more productive leading to improved income and thus reducing poverty level among the pineapple producing households. If farm households were to operate on the frontier, they will achieve a cost savings of 64.48% and if the average farm household in the sample was to achieve the allocative efficiency level of its most efficient counterpart, then the average farm household could realize a 59.18% cost savings while the most allocatively inefficient farming household revealed a cost saving of 86.94%.

Key words: Allocative efficiency, pineapple production, small-scale, stochastic frontier functions, Kenya

INTRODUCTION

Agriculture is an important sector to the Kenyan economy, contributing approximately 25% of the GDP and it employs 70% of the national labor force through forward and backward industrial linkages, thus providing food and incomes to individuals and households (Omiti *et al*., 2009). Statistics also shows that Agricultural incomes among majority of Kenyan households account for 60% of the total household income (Kuyiah *et al*., 2006). According to Davis (2006), smallholder farmers derive their livelihood from land holdings of about 5 ha, owning at most 20 heads of livestock with a mix of commercial and subsistence production, they also have a greater share of family labour in production and the farm is the main source of income.

Kenya has a long history of growing horticultural crops such as pineapples for both domestic and export markets due to the ideal climatic condition. The horticultural sub-sector has contributed to foreign exchange earnings and sustains millions of livelihoods in the country (HCDA, 2011). The estimated changes in Kenyan smallholders share of the fresh horticultural export market vary widely with most researchers putting it to be as high as 75% in the early 1990s (Harris *et al*., 2001). Scholars of international management and economic developments have increasingly argued that the competitiveness of emerging markets often depends on the ability of their firms to upgrade and/or combine existing resources in new ways to create new, higher value products (Giuliani *et al*., 2005).

Pineapple (*Ananas comosus*) is a native of Southern Brazil and Paraguay where wild relatives occur and the crop was spread by the Indians up through South and Central America to the West Indies (Sampson, 1986). Spanish introduced it into the Philippines and may have

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taken it to England in 1660. By 1720, the crop was grown in green houses in England, from where it came to Africa in the early 18th century (Ubi *et al*., 2006). Pineapple have oval to cylindrical shaped fruit, develops from many small fruits fused together. The fruit may be dark green, yellow, orange yellow or reddish when it's ripe for harvest. In addition, its both juicy and fleshy with the stem serving as the fibrous core (Sampson, 1986). Pineapple is used mainly as food in the form of snacks and fruit-juice while in most parts of the world the fermented juice is used to make vinegar and alcoholic spirit (Ubi *et al*., 2008).

Kenya has been one of the world's leading pineapple producers for many years and is currently ranked 9th in total production where Del Monte's farm in Thika is the leading producer but small-scale growers are also increasing their production for the local market (USAID, 2005). The horticultural crops have high market value and yield more throughout the year, hence suit the needs of smallholder farmers who face resource constraint and have no marketable surplus (Kibet *et al*., 2011). In Bureti district pineapples production is dominated by small-scale farmers for both home consumption and commercial purpose. The area has a production potential of 500,000 ton and due to this huge potential, the Kenya government has commissioned the construction of a US $600,000 modern pineapple processing factory in the district (Ministry of Agriculture, 2011). Despite these efforts coupled with intensive agricultural extension services to train farmers on better management practices, pineapple farmers in the region only produce as low as 56,000 ton of the crop with a market value of US $7.2 million and the bulk of the crop is sold locally. In addition, this level of pineapple production only translate to 18.6% of the expected optimum level which points to huge loss in potential incomes to rural households and may hinder agro-processing push by both county and national governments. To achieve economic optimum output and thus profitability of such enterprises, resources have to be optimally and efficiently utilized. It is against this backdrop that the study sought to examine the determinants of allocative efficiency in pineapple production in order to determine the extent to which smallholder farmers in Bureti district can appropriately adjust their productive resources in order to achieve optimum productivity.

MATERIALS AND METHODS

The study area: The study was conducted in Bureti District in Kericho County of Kenya. The district occupies a total area of 321.10 km^2 with a population of 167,649. It is located in the South Western region of Kenya, lying in the highlands of the great rift-valley and it is ranked the best producer of pineapples in the country due to its agro ecological zones. Temperature varies from 20-28°C and the mean annual rainfall ranges from 1400-1800 mm. Administratively, the district has 3 divisions: Roret, Cheborge and Buret where the major farming activities includes, tea, dairy, maize, beans, potatoes, vegetables, coffee and pineapple production.

The data: A random sample of 150 smallholder pineapple growers was selected through multistage sampling procedure. First, Cheborgei and Roret divisions were purposively selected due to their importance as the major pineapple growing divisions among the 3 divisions in the district. Secondly, simple random sampling method was employed to select small-scale farmers to be contacted from each of the 2 divisions. This was based on the list of pineapple farmers that was obtained from district agricultural office and the required sample size was determined in line with the proportionate to size sampling methodology proposed by Anderson *et al*. (2007). Data were collected using a well-designed, pre-tested questionnaire on socioeconomic factors, inputs and output variables, their current market prices and production problems.

Analytical method: To achieve the objective of determining the allocative efficiency of small-scale pineapple farmers, an analysis was carried out using stochastic frontier model (Aigner *et al*., 1977) and applied by Kolawole and Ojo (2007). According to Kolawole and Ojo (2007), the cost frontier of Cobb-Douglas functional form which is the basis of estimating the allocative efficiencies of the farmers is specified as follows:

$$Ci = g(Pi;\alpha)\exp(V_i + U_i);= 1,2,...,n \quad (1)$$

Where:

- Ci = Represents the total input cost of the ith farms
- g = Suitable function, such as the Cobb-Douglas function
- Pi = Represents input prices employed by the ith farm in food crop production and measured in Kshs
- α = The parameter to be estimated
- V_i and U_i = Random errors and assumed to be independent and identically distributed truncations (at zero) of the N (μ, σ^2) distribution. U_i provides information on the level of allocative efficiency of the ith farm

About 2 kinds of information are needed in estimating the efficiency of firms: First, the varying degrees of success of firms at maximizing output from given levels of inputs, this is the technical efficiency dimension; second, the judgment of firms in respect of relative prices of inputs and outputs, this is the allocative efficiency dimension. The requirement for the fulfillment of allocative efficiency is for the Marginal Physical Products (MPPs) of all productive resources to be known (Ellis, 1988).

Allocative efficiencies of labour and capital are to be estimated since it is these factors that are substituted for in the various technologies. The estimation of efficiency is based on the allocative efficiency rule which states that the slope of the production function (MPP) should equal the inverse ratio of input price to output price at the point of profit maximization (Ellis, 1988).

$$MPP = \frac{W}{P_y} \quad (2)$$

Where:

W = The wage rate

P_y = The price of output (pineapple)

By cross multiplying, researchers get Eq. 3:

$$MPP_L P_Y = MVP_L = W \quad (3)$$

Equation 4 is derived by dividing all through by W:

$$\frac{MLP_L}{W} = 1 \quad (4)$$

That is the marginal value product of the variable input divided by the input price should equal 1 which is the allocative efficiency index (Z) for a single input is given by Eq. 5:

$$Z = \frac{MVP_x}{P_x} \text{ for any input} \quad (5)$$

Similarly, the allocative efficiency index (Z) for capital is shown in Eq. 6 as follows:

$$Z = \frac{MVP_k}{r} \quad (6)$$

Where, r is the unit price of capital. Following (Seidu *et al*., 2005), the marginal products Eq. 7 for labour and 8 capital, respectively are calculated as follows:

$$MP_L = \frac{uY_i}{uX_i} * E \quad (7)$$

$$MP_K = \frac{uY_i}{uX_i} * E \quad (8)$$

The allocative efficiency ratios are then expressed in Eq. 9 and 10 for labour and capital, respectively:

$$Z = MP_L * \frac{P_y}{w} \quad (9)$$

$$Z = MP_K * \frac{P_y}{r} \quad (10)$$

Where:

MP_L = The marginal products of labour

MP_K = The marginal products of capital

μY_i = The arithmetic mean (log) of the output of a particular processing method

X_i = The arithmetic mean (log) of the inputs of a particular processing method

If Z = 1, it implies the input is utilized efficiently. If Z>1, it implies an under utilization of the factor input. On the other hand if Z<1, it implies an over utilization of the factor input.

Following a study by Chioma (2011), a regression analysis was used to identify the factors influencing allocative inefficiency of small-scale pineapple farmers in Bureti District. The inefficiency indices were regressed on socio-economic factors in order to identify sources of allocative inefficiency. Ordinary Least Squares (OLS) was used and the allocative inefficiencies are explained as specified by Rahji (2005) as shown in Eq. 11:

$$u_i = d_0 + d_1 z_{1i} + d_2 z_{2i} + d_3 z_{3i} + d_4 z_{4i} + d_5 z_{5i} + d_6 z_{6i} + d_7 z_{7i} + d_8 z_{8i} + d_9 z_{9i} + d_{10} z_{10i} \quad (11)$$

Where:

μ_i = Inefficiency scores

d_0 = The intercept

z_i = Socio-economic factors

The μ/z are independently distributed with zero means, $0 \leq \mu_i \geq 1$ with limit point $\mu_i = 1$ possessing positive probability. The $\mu_i = 1$ means that the pineapple farmer is allocatively efficient and $\mu_i = 0$ means the pineapple farmer is allocatively inefficient.

RESULTS AND DISCUSSION

The study results of 2 tailed t-test of continuous socio-economic characteristics of small-scale pineapple farmers that includes; age, household size, farm size, experience in pineapple production and distance to nearest trading centre are presented in Table 1.

Table 1: Summary of continuous socioeconomic characteristics of pineapple farming households in Bureti District, Kenya

Characteristics	Mean Roret	Mean Cheborgei	Overall mean	t-ratio	Sig.
Age of head (years)	46.63 (1.5312)	44.96 (1.4225)	45.79	0.7970	0.4260
Size of Head (number)	5.23 (0.2050)	5.45 (0.2811)	5.34	-0.6520	0.5160
Farm size (ha)	2.67 (0.2659)	1.87 (0.1788)	2.27	2.4800**	0.0140
Experience (years)	8.92 (0.7826)	7.79 (0.6175)	8.35	1.1370	0.2570
Mkt. distance (km)	4.69 (0.2801)	4.81 (0.2326)	4.75	-3.1100	0.7560
Pineapple area (ha)	0.88 (0.1376)	0.34 (0.0331)	0.53	3.7750***	0.0000

*, **, ***Significant at 10, 5 and 1%, respectively; Figures in parentheses are standard errors

The results show that the average age for the sampled household heads was about 46 years while an average household had a family of 5.3 persons. The average farming experience on pineapple production was 8.35 years and the average distance to the nearest trading centre was 4.7 km. Except for land holding and area under pineapples, there was great homogeneity in the characteristics of pineapple farmers in the 2 administrative divisions of Bureti District. The average land owned by farmers in Roret and Cheborgei was 2.67 and 1.87 ha, respectively. Results of 2-tailed t-test showed that land holding was statistically significant at 5% level. In addition, the average area under pineapple in Roret and Cheborgei was 0.88 and 0.34 ha and the results of 2-tailed t-test showed that area under pineapple was statistically significant at 1% level.

Table 2 shows results of categorical variables including, credit access, marital status, level of formal education, growing other crops, keeping livestock, gender of the head and extension services access. Apart from the level of formal education and growing of other crops, farmers in the 2 divisions were largely homogenous with respect to gender of the household head, marital status, household size, keeping livestock, credit access and extension services access. From the farmers interviewed, 78.7% were married, 96.7% had access to credit, 83.3% were male headed households, 85.3% grew other crops and only 14.7% had access to extension services.

In terms of education level, the results indicate that 94% of farmers in the study area were able to access education. Furthermore, the results show that 18, 39.3, 23.4 and 13.3% of farmers managed to attend primary school, reached secondary level, attained college education and were university graduates, respectively. Results of χ^2 analysis show that Roret division had a higher percentage of farmer with no formal education compared to Cheborgei division and the results were statistically significant at 10% level. In addition, the

Table 2: Summary of categorical socio-economic and institutional characteristics of small-scale pineapple farmers in Bureti District

Characteristics	Category	Mean Roret	Percentages Cheborgei	Overall	χ^2	Sig.
Education	None	6.7	5.3	6.0	8.5720*	0.0730
	Primary	9.3	26.7	18.0		
	Secondary	45.3	33.3	39.3		
	College	22.7	24.0	23.4		
	University	16.0	10.7	13.3		
Marital status	Married	76.0	81.3	78.7	1.5940	0.6610
	Single	4.0	5.3	4.7		
	Divorced	4.0	4.0	4.0		
	Widowed	16.0	9.3	12.7		
Gender	Male	84.0	82.7	83.3	0.0480	0.8270
	Female	16.0	17.3	16.7		
Credit access	Yes	98.7	94.7	96.7	1.8620	0.1720
	No	1.3	5.3	3.3		
Extension service	Yes	17.3	12.0	14.7	0.8520	0.3560
	No	82.7	88.0	85.3		
Grow other crops	Yes	88.0	77.3	82.7	2.9780*	0.0840
	No	12.0	22.7	17.3		
Keep livestock	Yes	84.0	86.7	85.3	0.2130	0.6440
	No	16.0	13.3	14.7		

*, **, ***Significant at 10, 5 and 1%, respectively

results indicate that 82.7% of the farmers grew other crops in addition to pineapple production and the practice of growing multiple crops was significantly higher in Roret division than in Cheborgei at 10% level.

Allocative efficiency of pineapple production: In order to achieve the objective of this study of determining the level of allocative efficiency of small-scale pineapple farmers in Bureti District, the computer program (Frontier 4.1) was used to calculate the predictions of individual firm cost efficiencies from estimated stochastic cost frontiers. Table 3 present Ordinary Least Square (OLS) and Maximum Likelihood (ML) estimates of the stochastic cost function parameters. The OLS function provides estimates of the stochastic cost frontiers while the ML model yields estimates of the stochastic production frontier. LR test statistic was 0.285 and this was significant when compared with mixed χ^2 and at 1 degree of freedom. Thus, the generalized likelihood-ratio test rejects the composite hypothesis since LR value is different from zero. That means that given the assumption of Cobb-Douglas specification, the function is an adequate representation of the stochastic frontier function.

The estimated sigma squared (δ^2) was 0.2717, thus it was significantly different from zero at the 5% level of significance. This indicates a good fit and the correctness of the specified distributional assumption of the composite error term. In addition, the value of Gamma (γ) is 0.44 implying that 44% of variation in output is due to inefficiency that is the allocative inefficiency effects are significant in the stochastic frontier cost function.

Table 3: Estimates for parameters of the stochastic frontier cost model for small scale pineapple farmers in Bureti District

Function	Parameters	Ols estimates	mL estimates
Constant	β_0	4.0058 (1.1251)	4.1078 (1.0948)
Capital	β_1	0.4387 (0.0302)	0.4368 (0.0301)
Labour	β_2	0.4482 (0.1509)	0.4610 (0.1490)
Sigma-squared	δ^2	0.2686	0.2717 (0.0106)
Gamma	γ	0.4400	0.4531 (0.4008)
Log likelihood function		-89.6054	-89.4683
LR test statistic		0.2850	

Figures in parentheses are standard errors

All the input coefficients in both models are positive as expected implying that they contribute to increased output. The estimated coefficients show relative change in pineapple output (Y) due to a percentage change explanatory variable. For example, a 10% increase in the coefficient of labour (β_2) and holding other things constant, output would increase by 4.4%. Similarly, a 10% increase in the coefficient of capital (β_1) would increase output by 4.3%.

The coefficient of labour input was the highest implying that it is the most important explanatory variable in pineapple production. This is largely because farmers tend to utilize the relatively cheaper labour input instead of more expensive capital derived inputs and practices.

The efficiency scores from the SFPF model are presented in Table 4. Allocative efficiency ranges from 11.36-87.02 with a mean of 35.52% (Table 5). This implies that there is room to improve allocative efficiency of the farm households by 64.48%, if they operate on the frontier. This finding agrees with that of Daniel *et al.* (2010) that cotton farmers in Nigeria were not efficient in resource utilization. If the average farm household in the sample was to achieve the allocative efficiency level of its most efficient counterpart, then the average farm household could realize a 59.18% cost savings (i.e., 1-(35.52/87.02)). A similar calculation for the most allocative inefficient farm household reveals cost saving of 86.94% (i.e., 1-(11.36/87.02)). None of the sample farmers had a 100% allocative efficiency index. This implies that allocative efficiency among the respondents could be increased by 64.48% through better utilization of resources in optimal proportions given their respective prices and given the current state of technology.

Table 4 shows that majority of farmers (34%) were in modal class of (>20≤30%) allocative efficiency. Farmers who operated at less than 50% allocative efficiency level were 86% of the sampled population, implying that only 14% of the farmers were operating above 50% allocative efficiency level.

Table 4: Frequency distribution of allocative efficiency of small scale pineapple farmers in Bureti District

Efficiency level	Frequency	Percentage	Cumulative (%)
>0≤10	0	0.0	0.0
>10≤20	18	12.0	12.0
>20≤30	51	34.0	46.0
>30≤40	38	25.3	71.3
>40≤50	22	14.7	86.0
>50≤60	10	6.7	92.7
>60≤70	4	2.7	95.4
>70≤80	5	3.3	98.7
>80≤90	2	1.3	100.0
>90≤100	0	0.0	100.0
Total	150	100.0	100.0

Min. = 0.1136; Max. = 0.8702; Mean = 0.3552; SD = 0.1512

Table 5: Estimates of the allocative inefficiency sources model for small scale pineapple farmers in Bureti District

Variables	Coefficient	SE	t-value	Sig.
Constant		0.149	6.8340	0.0000
Gender head	0.0080	0.042	0.0740	0.9410
Farming experience	0.1070	0.002	1.1470	0.2530
Age of hh head (years)	-0.3050	0.001	-2.8770	0.0050***
Education level (years)	0.0290	0.012	0.3390	0.7350
Household size (No.)	-0.1440	0.006	-1.6130	0.1090
Land size (ha)	-0.0460	0.007	-0.4720	0.6370
Market distance (km)	-0.0310	0.006	-0.3710	0.7110
Extension access	0.0190	0.036	0.2290	0.8190
Credit access	-0.1330	0.067	-1.6750	0.0960*
Grow other crops	-0.0220	0.032	-0.2800	0.7800
Keep livestock	0.0100	0.035	0.1250	0.9010
R^2	0.2110			
F-statistic	3.061			0.001***

*,**,***Significance at 10, 5 and 1%, respectively

Determinants of allocative inefficiencies: The allocative inefficiency indices were regressed on socioeconomic factors in order to identify sources of allocative inefficiency. Results from Table 5 shows that the estimated coefficients of the variable; age, household size, land size, market distance, growing of other crops and access to credit are negative. The estimated coefficient for access to extension services, education level, farming experience, keeping livestock and gender of the head are positive.

The findings in Table 5 shows that the explanatory ability of the variables included in the analysis is 21.1% (R^2 value is 0.211) and also that not all regressions or parameters are significant. This result agrees with the findings of Xu and Jeffrey (1998) who obtained R^2 value of 0.31 in their analysis. Furthermore, on overall the model fits the data being analyzed since the F-statistic was significant at 1%. Apart from age and credit access, experience in farming, farm size, distance to nearest urban centre, level of formal education, growing other crops, gender of the head, household size, keeping livestock and extension services were not significantly affecting allocative inefficiency.

Pineapple farmers had an average of 46 years. The estimated age coefficient was statistically significant at 1% level of significance and had a negative sign (Table 4) with respect to allocative inefficiencies. This shows that farmers whose age was above the mean age were more allocative inefficient, implying young farmers were allocatively efficient. This could be attributed to the fact that pineapple production in Bureti district is labour intensive and hence aging has a negative effect on allocative efficiency. Furthermore, access to credit facilities by pineapple farmers was statistically significant at 10% and had a negative influence on farmers allocative inefficiency. This implies that as farmers get access to credit their allocative inefficiency reduce. Thus, by enabling farmers to overcome liquidity constraints imposed by their limited income, access to credit enables the timely application of farm inputs in addition, to enabling them to effectively implement farm management decisions, leading to a reduction in allocative inefficiency.

CONCLUSION

This study revealed that small scale pineapple farmers are not allocative efficient. Results of the study indicated that the average allocative efficiency of pineapple production were 0.355. The distribution of efficiency estimates among the respondents suggests that the scope for efficiency gains is fairly large. If farm households were to operate on the frontier, they will achieve a cost savings of 64.48% and if the average farm household in the sample was to achieve the allocative efficiency level of its most efficient counterpart, then the average farm household could realize a 59.18% cost savings while the most allocatively inefficient farming household revealed a cost saving of 86.94%. The wide variation in allocative efficiency estimates is an indication that most of the farmers have not yet achieved optimal resource mix in their production process.

RECOMMENDATIONS

This suggests that the farmers in the study area are not minimizing production costs and hence utilizing the inputs in the wrong proportions given the input prices. The results further indicate that the estimated coefficients of age and access to credit were significantly and negatively affecting allocative inefficiency. This means that for allocative inefficiency to be reduced young farmers should be encouraged to start producing pineapples, since its labour intensive. Credit facilities should also be made available for the farmers to help them reduce problems of liquidity.

The study, therefore supports the policies that are geared towards making the micro-credit from government and non-governmental agencies accessible to these farmers since, they will go a long way in addressing their resource use hence solve inefficiency problems by addressing the cost of purchasing critical inputs and paying for hired labour. In addition, farmers should be encouraged to mobilize their savings through the establishment of SACCOs and strengthening the community based lending systems in terms of management. Finally, it is within the confines of this study finding that the government should provide a favourable environment to encourage more youths to engage in pineapple production in a bid to reduce food security as well as alleviate poverty status and unemployment in the district and the country at large. This is because attracting more youth in agricultural production is important since they are likely to be willing or able to properly allocate resources and adopt technical innovations.

This study determined Allocative Efficiency for pineapple production but did not determine gross margins between different farm enterprises. Further, research to determine gross margins between different enterprises is recommended.

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