Technical Efficiency in Grape Farming among Smallholder Farmers in Dodoma Urban District, Central Tanzania

James Lwelamira, Patrick Wambura, John Safari*

Institute of Rural Development Planning (IRDP), P.O. Box 138, Dodoma, Tanzania

*Corresponding author email: jlwelamira@irdp.ac.tz

Abstract

This study was carried out in Dodoma urban district with the aim of estimating Cobb-Douglas Stochastic Frontier Production Function for grape production among smallholder farmers; identifying the production factors with significant influence on grape production; estimating values for technical efficiencies, and determining the factors for technical inefficiency. This study involved a random sample of 126 engaged in grape production for at least two years. Data were collected through interviews and analyzed for descriptive statistics using Statistical package for Social Sciences program version 18. Stochastic frontier production function, technical efficiencies and model for technical inefficiency were estimated using FRONTIER program version 4.1. Results indicated that the amount of grapes produced was positively influenced by farm size ($p<0.01$), household labour ($p<0.01$), inorganic fertilizer ($p<0.05$) and pesticide application ($p<0.01$). The sum of elasticities for production function indicated increasing return to scale and therefore, farmers were operating in irrational zone of production function. In addition, inefficient effect in production function existed at significant rate ($\gamma = 0.728$, $p< 0.01$). Technical efficiency among farmers ranged from 57.0% to 98.0% with a mean of 77.8%, indicating wider possibility for improvement. Increased education level, age, farming experience, and household size, as well as access to extension services were associated with increased technical efficiency. Thus, grape productivity can be increased through increased farm sizes coupled with optimal use of inorganic fertilizers and pesticides.

Keywords: Grape production, household income and welfare, semi-arid areas

1.0 Introduction

High incidence of poverty specifically in the rural areas is a major development challenge in Tanzania (Kisusu *et al*., 2010; Mkenda *et al*., 2004). High poverty levels have been associated with low agricultural productivity of major food crops due to harsh and unreliable weather conditions (Liwenge, 2003; Swai *et al*., 2012; Msaki *et al*., 2013). Opting for high value crops could be one of the strategies for dealing with this challenge (Temu and Temu, 2005; IFAD, 2008). In Dodoma urban district, grape is one of the high value crops with a great potential for poverty reduction among farmers. However, statistics show that grape production in the area has not been to its full potential. For example, the estimated grape yield under smallholder farmers is about 2 tons per acre per year compared to at least 8 tons under optimal management (Mgwasa, 2012; Lwelamira *et al*., 2015). Therefore is therefore an imminent need to increase grape production, and this would require identification of input factors influencing productivity and the factors influencing efficiency in production i.e.Technical Efficiency (TE) (Adeyemo *et al*., 2010; Akinbode *et al*., 2011). Technical efficiency is the achievement of the maximum potential output from a given quantity of inputs under a given technology. It is the attainment of production goal without wastage (Jondrow *et al*., 1982; Okoye *et al*., 2008). It is usually evaluated as the ratio of observed output to the corresponding frontier output given the available technology (Jondrow *et al*., 1982). Technical inefficiency arises when less than maximum output is obtained from a given bundle of factors. Scant information exists on economics of grape farming, specifically efficiency studies in Tanzania. Therefore, this study estimated Cobb- Douglas Stochastic Frontier Production Function, and identified production factors that influence grape sub-sector. The study further estimated values for technical efficiencies among farmers, and determined the factors for technical inefficiency.

2.0 Methodology

2.1 Study area

This study was conducted in six randomly selected villages (*Mbabala A, Mbabala B, Mpunguzi, Matumbulu, Veyula and Mchemwa*) from three randomly selected wards in Dodoma urban district with two villages from each ward. The wards include *Mbabala, Mpunguzi and Makutupora*. These are among the wards in the district with highest number of grape farmers in Dodoma Region. The district lies between latitude 30.5^0 and 70^0 South and Longitude 32^0 and 35^0 East. The area is semi- arid which receives between 500 and 800 mm of rains annually. The dominant ethnic group is *Gogo* involved in both crop and livestock production.

2.2 Study design

This study was carried out in selected villages in September, 2013. A study involved a cross- sectional survey in the area. The study enrolled 126 farmers who had harvested grapes for at least two years. The sample size (n) was estimated as described by Fisher *et al*. (1991) as follows:

$$n = \frac{(Z_{\alpha/2})^2 pq}{\lambda^2} = \frac{(1.96)^2(0.09 \times 0.91)}{(0.05)^2} = 126$$

Where: $Z_{\alpha/2}$ = 1.96 (By assuming 95% confidence interval); $p = 1 - q = 0.5$ = Proportion of households engaged in grape ; and λ = Maximum error = 5%. Nearly equal number of respondents was selected from each village. Where a grape farmer did not meet the selection criterion of harvesting grapes for a minimum of two years, a nearby farmer fulfilling this inclusion criterion was selected instead. This criterion was set to have yield data needed for estimating technical efficiency. A study involved face-to-face interviews with respondents using a pre-tested questionnaire.

2.3 Data analysis

2.3.1 Descriptive statistical analysis

Data were analyzed for descriptive statistics to determine distributions among various variables using Statistical Package for Social Sciences program version 18. Descriptive statistics used included means, standard deviations, frequencies and percentages.

2.3.2 Model specification and estimation of parameters

FRONTIER Version 4.1 software was used to estimate Stochastic Frontier Production Function (SFPF), identify the factors influencing productivity, estimate technical efficiencies and identify the factors for technical inefficiencies. The SFPF model was specified as follows (Sharma *et al*., 1999);

$Y_i = f(X_i : \beta) \exp(V_i - U_i)$…………..………………………………..…(1)

Where, Y_i = Total grape yield per year in kg for i^{th}farmer ,

X_i = Vector of input quantities for the i^{th} farmer,

β = Vectors of unknown parameters to be estimated,

V_i = Error due to random factors out of control by farmers such as weather, diseases outbreak, risk and measurement error (symmetrical error). The random error V_i is assumed to be independently and identically distributed as N(0, σ_v^2) random variables independent of U_i. U_i = Error due to technical inefficiency which is the non-negative random variable representing inefficiency in production relative to the stochastic frontier. It is distributed as non-negative truncation of the N(0, σ_u^2) distribution (i.e. half-normal distribution).

Further, the production technology of the grape farmers was assumed to be specified by the Cobb-Douglas production frontier function as was defined by Battese (1992). Thus, the following model was used.

$\ln Y_i = \beta_0 + \beta_1 \ln X_{1i} + \beta_2 \ln X_{2i} + \beta_3 \ln X_{3i} + \beta_4 \ln X_{4i} + \beta_5 \ln X_{5i} + \beta_6 \ln X_{6i} + e_i$ …..............(2)

Where,

Y_i = Total grape yield per year in kg for i^{th} farmer

X_1 = Farm size (acre)

X_2= Family labour (man-day)

X_3= Hired labour (man-day)

X_4= Chemical Fertilizer (kg)

X_5= Organic Fertilizer (kg)

X_6= Pesticides (litre)

β_0, β_1............ B_6 = regression parameter to be estimated

$e_i = V_i - U_i$ = Error term

We expected β_1............B_6 to be positive.

2.3.3 Estimation of Technical Efficiency (TE)

TE was estimated according to Jondrow *et al*. (1982) and Okoye *et al*. (2008) as indicated below

$$\mathrm{TE} = \frac{Y_i}{Y_i^*} = \frac{f(X_i;\beta)\exp\,(V_i - U_i)}{f(X_i;\beta)\exp\,(V_i)} = \exp(-U_i) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots . (3)$$

Where Y_i = is the observed output and

Y_i^* = is the frontier output.

2.3.4 Model for technical inefficiency

In identifying the factors for technical inefficiency, the following model wasused.

$U_i = \delta_o + \delta_i Z_i + \varepsilon_i$ ....(4)

Whereby;

U_i = Technical Inefficiency

δ_o = Constant

δ_i = Vector of coefficients to be estimated

Z_i = Vector for independent variables such as socio-demographic variables and access to support services

Z_1 = Age (years)

Z_2 = Sex (1 = if male, 0 = otherwise)

Z_3 = Marital status (1 = if married, 0 = otherwise)

Z_4 = Education level (years in school)

Z_5 = Household size (number of individuals in a household)

Z_6 = Farming experience (years)

Z_7 = Access to credit (1 = if accessed, 0 =otherwise)

Z_8 = If frequently visited by agricultural extension agent (1 = if Yes, 0 = otherwise)

Z_9 = Membership to farmers associations (1 = if Yes, 0 =Otherwise)

ε_i = Random error

We expected regression coefficients forZ_1………Z_9 to have negative values.

The stochastic frontier production function in equation 1 and the inefficiency model in equation 2 were simultaneously estimated using Maximum Likelihood Method as proposed by Battesse *et al*. (1996)

3.0 Results and Discussion

3.1 Characteristics of respondents

Socio-demographic characteristics of respondents are shown in Table 1. Results indicate most of the respondents (80.2%) were between 35 – 64 years. Three quarters of surveyed farmers (75.4%) were males indicating male predominance in grape farming in the area. Further, the findings show that most farmers were literate as more than 80% of farmers had at least primary education, an attribute necessary for a target group to comprehend agricultural extension packages for improved agricultural productivity (Namwata *et al*., 2012).

Table 1. Socio- demographic characteristics of respondents (n = 126)

Variable	Frequency	Percent
Age (Years)		
< 35	18	14.3
35 -64	101	80.2
64+	7	5.6
Sex		
Male	95	75.4
Female	31	24.6
Marital status		
Married	93	73.8
Single	17	13.5
Others	16	12.7
Education level		
None	19	15.1
Primary	89	70.6
Secondary+	18	14.3
Household size		
Less than 6	87	69.0
6 and above	39	31.0

3.2 Information related to grape farming

Results from Table 2 indicate that majority of respondents (90.5%) had been engaged in grape farming for at least 5 years, and therefore had rich experience in this subsector. Most of respondents owned small farm sizes for grapes with nearly three quarters (74.6) having less than two acres, and grape productivity was generally low. Data showed that nearly two-thirds (58%) harvested less than 1,000 kg per year. Given the farm sizes and the recorded level of production, it is clear that the production potential of grapes has not been fully realized.

Table 2. Information related to grape farming (n = 126)

Variable	Frequency	Percent
Number of years engaged in grape farming		
Less than 5	12	9.5
5 – 10	76	60.3
More than 10	38	30.2
Current farm size under grapes (acre)		
Less than 2	94	74.6
2 - 4	22	17.5
More than 4	10	7.9
Total Yield in last year (kg)		
Less than 1000	74	58.7
1000 – 2000	45	35.7
More than 2,000	7	5.6

3.3 Production function analysis

Results in Table 3 show the value of 0.752 for Sigma squared (σ^2) which is different from zero ($p< 0.001$) indicating a good fit and correctness of specified distributional assumption of the composite error term (Okoye *et al*., 2008; Idumah and Okunmadewa, 2013). The value for Gamma (γ) is 0.728, also different from zero ($p< 0.001$), which means that there was a substantial inefficiency effect (presence of one sided error term) in production of a crop under study (Battese and Coelli, 1995; Donkoh *et al*., 2013). This effect accounted for 73% of variations of actual production from frontier (optimal) production given the available technologies and resources in grape farming in the area. It is also noted that effects of all factors considered in the production model were in the expected direction (according to *priori* expectations). As shown in Table 3, several factors significantly increased grape production. These include farm size ($p<0.05$), family labor ($p<0.05$), inorganic fertilizer application ($p< 0.05$), and pesticide application ($p< 0.05$). Since most farmers are smallholders owning less than 2 acres of grapes, increasing farm size would increase production substantially, taking into consideration vast land suitable for grape farming in the area (Kalimang'asi *et al*., 2014; Lwelamira *et al*., 2015). Results from Table 3 further reveal that sum of elasticities (sum of β coefficients for explanatory variables) in production function was 1.364 indicating increasing return to scale in production. This means that grape farmers were operating in stage I of the production function and that farmers were inefficient as described earlier (Adeleke *et al*., 2008). On the other hand, this observation indicates that there is high potential for improving grape production in the study area. The value for return to scale obtained in this study is within the range reported in studies conducted for other crops such as rice, cassava, maize and yam in small holder farmers in Africa (Idiong *et al*., 2007; Adeleke *et al*., 2008; Edeh and Awoke, 2009).

Table 3: Maximum likelihood estimates for the parameters of stochastic frontier production function

Variables	Parameter	Coefficient	Standard – Error	t-ratio
Production Model				
Constant	β_0	6.464	0.976	6.623
Farm size, X_1	β_1	0.710	0.349	2.034*
Family labor, X_2	β_2	0.108	0.038	2.842**
Hired labor, X_3	β_3	0.043	0.049	0.878
Inorganic Fertilizer, X_4	β_4	0.260	0.116	2.241*
Manure, X_5	β_5	0.091	0.104	0.875
Pesticide, X_6	β_6	0.152	0.052	2.923**
Sum of elacticities (Return to scale)		1.364		
Diagnostic Statistics				
Log likelihood function		-156.721		
sigma-squared	σ^2	0.752	0.062	12.129**
gamma	γ	0.728	0.281	2.591**

* = Significant at p<0.05, ** = Significant p< 0.01

3.4 Technical efficiency scores among grape farmers

Results from Table 4 show that technical efficiency ranged from 57.0% for the least efficient farmer to 98.0% for most efficient farmer, with a mean of 77.8%, which is comparable to results of studies on other crops under smallholder farmers' conditions in Africa (Binam *et al*., 2004; Donkoh *et al*., 2013; Adeyemo *et al*., 2010; Abdulai *et al*., 2013). Findings show that 59.5% of farmers had values for technical efficiency below 80 % implying that few farmers were efficient in grape production. Based on the mean value for technical efficiency obtained in this study, average grape farmer in the area had a possibility of increasing production by 20.2% (i.e. 98.0 – 77.8) by adopting technology that the most efficient farmer used, and would save costs by 20.6% (i.e. 1.0 – 77.8/98). Similarly, the least efficient grape farmer had a possibility of increasing production by 41% (i.e. 98.0 – 57.0) if this farmer adopted the technology used by the most efficient counterpart, and would have 41.8% cost saving (i.e. 1.0 – 57.0/98.0) (Binam *et al*., 2004; Adeyemo *et al*., 2010).

Table 4. Distribution of respondents by technical efficiency scores

Interval for Technical efficiency	Percent of respondents
50 – 60%	7.9
61 – 70%	15.9
71 - 80%	35.7
81 – 90%	25.4
91 – 100%	15.1
Total	**100.0**
Descriptive statistics	
Mean Technical Efficiency	77.8%
Standard Deviation	9.0%
Minimum Technical Efficiency	57.0%
Maximum Technical Efficiency	98.0%

3.5 The Source of inefficiency in grape farming

This study also assessed the factors affecting technical inefficiency in grape production, and results are presented in Table 5. The signs and coefficients in the inefficiency model are interpreted in the opposite direction so that a negative sign means that the variable increases efficiency while the positive sign decreases it. Findings show that with the exception of membership to farmers' organization, all variables considered in this analysis affect technical inefficiency as per *priori* expectations. As shown in Table 5, significant effect of technical inefficiency was observed for age ($p < 0.01$), education level ($p< 0.01$), household size ($p< 0.01$), farming experience ($p< 0.05$) and access to agricultural extension services ($p< 0.01$) In addition, increased age and farming experience were associated with increased technical inefficiency. A possible explanation for this observation is that senior farmers are likely to have more experience and resources to adopt modern farming technologies as has been reported elsewhere (Idiong *et al*., 2007; Amos, 2007; Ebong *et al*., 2009; Asogwa *et al*., 2012). Likewise, increased level of formal education was associated with increased technical efficiency; suggesting that farmers with low level of formal education were less efficient in grape production compared to those with formal education which is consistent with previous findings (Nyagaka *et al*., 2010; Donkh *et al*., 2013). In a similar study by Asogwa *et al*. (2012), it was found that farmers with formal education respond readily to new agricultural technologies and produce closer to frontier output. Overall, these findings underline the importance of formal education in improving agricultural productivity.

Another important observation from this study relates to farmers' access to extension services. Our results indicate that frequent access to extension services was associated with increased technical efficiency. A number of studies have also indicated that access to extension services among farmers is important aspect for increased agricultural productivity. Farmers need to be informed on proper management practices to improve production efficiency (Idiong *et al*., 2007; Raphael *et al*., 2008; Nyagaka *et al*., 2010; Asogwa *et al*., 2012). These findings have important policy implications in terms of the need to strengthen agricultural support services to smallholder farmers. In the study area, farmers had no access to credit and, therefore, analysis of its effect to technical efficiency in grape farming was not possible. However, grape farming is generally an activity that requires substantial financial resources to carter for inputs such as pesticides, improved seedling, and water supply and storage facilities. Thus, access to credit services is needed to accelerate grape sub-sector and this call for a clear set of policy for servicing rural financial markets as a strategy of expanding investment in agriculture.

Table 5. Maximum likelihood estimate for the parameters of inefficiency model

Variables	Parameter	Coefficient	Standard Error	t-ratio
Constant	δ_0	-0.039	0.417	-0.094
Age, Z_1	δ_1	-0.046	0.012	-3.833**
Sex, Z_2	δ_2	-0.074	0.398	-0.186
Marital status, Z_3	δ_3	-0.062	0.334	-0.186
Education level, Z_4	δ_4	-0.096	0.035	-2.743**
Household size, Z_5	δ_5	-0.121	0.041	-2.951**
Farming Experience, Z_6	δ_6	-0.069	0.029	-2.379*
Access to Credit, Z_7	δ_7	-0.007	0.557	-0.013
Agriculture extension visits, Z_8	δ_8	-0.193	0.047	-4.106**
Membership to farmers organization, Z_9	δ_9	0.055	0.575	0.096

* = Significant at $p<0.05$, ** = Significant $p<0.01$

4.0 Conclusion and Recommendations

Grape production was positively influenced by farm size, household labour, inorganic fertilizer and pesticide application. The sum of elasticities for production function indicated increasing returns to scale and hence farmers were operating in irrational zone of the production function which is characterized by inefficiency in production.. Inefficient effect in production function existed at significant rate in production function. The study has also illustrated that the average farmer can increase production by 20% by adopting technology used by the most efficient farmers in the area while the least efficient farmer can increase production by 41% by adopting technology used by the most efficient counterpart. There is therefore a wide range for increasing grape production in the area. A number of factors were noted to be significantly associated with increased technical efficiency. These include increased education level, age of farmer, farming experience, household size and access to extension services. Strategies to increase grape production should include providing agricultural education especially to young and less experienced farmers and to those with low level of formal education. Grape production can also be increased through optimal application of inorganic fertilizers and pesticides coupled with increased farm sizes.

References

Abdulai, S., Nkegbe, P.K and Donkoh, S.A. (2013).Technical efficiency of maize production in Northern Ghana. *Journal of Agricultural Research*, 8(43): 5251 – 5259.

Adeleke, O.A., Fayibi, Y.L., Ajiboye, A and Matanmi, H.M (2008). Application of stochastic production frontier in the estimation of technical efficiency of cassava farmers in Oluynole and Akinyele local Government Areas of Oyo State. *Research Journal of Agronomy*, 2(3): 71 – 77.

Adeyemo, R.,Oke, J.T.O and Akinola, A.A. (2010).Economic efficiency of small scale farmers in Ogun State, Nigeria.*Tropicultura*, 28(2): 84 – 88.

Akinbode, S. O., Dipeolu A. O and Ayinde I.A. (2011). An examination of technical, allocative and economic efficiencies in Ofada rice farming in Ogun State, Nigeria. *African Journal of Agricultural Research*, 6(28): 6027-6035.

Amos, T.T. (2007). An analysis of productivity and technical efficiency of smallholder cocoa farmers in Nigeria. *Journal of Social Science*, 15(2): 127 – 133.

Asogwa, B.C., Umeh, J.C and Penda, S.T. (2012). Technical efficiency analysis of smallholder in rural and peri-urban areas of Nigeria. *Journal of Human Ecology*, 37(1): 57-66.

Battese , G (1992). Frontier production functions and technical efficiency: A survey of empirical applications in agricultural economics. *Agricultural Economics*, 7:185-208.

Battese, G.E and Coelli, T.J (1995).“A Model for Technical Inefficiency Effect in Stochastic Frontier Production for Panel Data.”*Empirical Economics*, 20: 325-345.

Battese, G.E., Malik, S.J and Gill, M.A. (1996). Investigation of technical inefficiencies of production of wheat farmers in fur districts of Pakistan. *Journal of Agricultural Economics*, 47 (1):37 -49.

Binam, J.N., Tonye, J., Wandji, N., Nyambi, G and Akoa, M. (2004). Factors affecting the technical efficiency among smallholder farmers in the slash and burn agriculture zone of Cameroon. *Food Policy*, 29:531-545.

Donkoh, S.A., Ayambila, S and Abduali, S. (2013).Technical efficiency of rice production at the Tono Irrigation Scheme in Nothern Ghana.*Amercian Journal of Experimental Agriculture*, 3(1): 25-42.

Ebong, V.O., Ukoro, U.S and Effiong, E.O. (2009). Determinants of technical efficiency of urban farming in Uyo metropolis of AkwaIbom State, Nigeria. *Journal of Agricultural and Social Sciences*.

Edeh, H.O and Awoke, M.U. (2009). Technical efficiency analysis of improved cassava farmers in Abakaliki Local Government Area of EbonyiState.A stochastic frontier approach.*Agricultural Journal*, 4(4), 171 – 174.

Fisher, A.A., Laing, J.E and Townsend, J.W. (1991). Handbook for family planning operations research and design.Operations research. Population council, USA

Franzel, S. (1999). Socio-economic factors affecting the adoption potential of improved tree fallows in Africa. *Agro forestry Systems*, 47: 305- 321.

Idiong, I.C., Onyenweaku, E.C., Ohen, B.S and Agom, D. (2007). A Stochastic frontier analysis of technical efficiency in swamp and upland rice production systems in Cross River State, Nigeria. *Agricultural Journal*, 2(2):299 – 305.

Idumah, F.O and Okunmadewa, F.Y. (2013). Oil pollution and technical efficiency of food crop farmers in the Niger Delta region of Nigeria. *Journal of Development and Agricultural Economics*, 5(12):519 – 526.

IFAD (2008) International Fund for Agricultural Development. The role of high value crops in rural poverty reduction in the Near East and North Africa.

Jondrow, J., Lovell, C.A.K., Materov, I.S. and Schmidt, P. (1982). On the estimation of technical inefficiency in the stochastic frontier production function model. *Journal of Econometrics*, 19: 233–238.

Kalimang`asi, N., Majula, R and Kalimang`asi, N.N. (2014).The Economic Analysis of the Smallholders Grape Production and Marketing in Dodoma Municipal: A case study of Hombolo Ward. *International Journal of Scientific and Research Publications*, 4(10).

Kisusu, R. W.,Mdoe, N. S. Y., Turuka, F. M and Mlambiti, M. E. (2000). Contribution of smallholder dairy production to food security, household income and poverty alleviation: the case of Mvumi dairy development project, Dodoma. In: Proceedings of the 18th Scientific Conference of the Tanzania Veterinary Association held at AICC, Arusha, Tanzania, 5-7 December 2000. Vol. 20 pp 89- 99

Liwenga, E. (2003). Food Insecurity and Coping Strategies in Semiarid Areas.The Case of Mvumi in Central Tanzania.PhD thesis, Stockholm University, Stockholm, Sweden.

Lupilya, G.S. (2007). Assessment of social support projects for vulnerable groups towards poverty reduction: A case study of TASAF in Bukoba district. M.A Dissertation, Sokoine University of Agriculture, Morogoro, Tanzania, 112 pp.

Lwelamira, J., Safari, J and Wambura, P. (2015). Grapevine Farming and its Contribution to Household income and Welfare among Smallholder Farmers in Dodoma Urban District, Tanzania.*American Journal of Agriculture and Forestry ,* 3(3): 73-79.

Mgwasa, D. (2012). Tanzania Distillers Limited (TDL) contribution on Dodoma vineyards development in Tanzania. Regional Workshop, held on June 16- 17, 2012, Dar-es-salaam, Tanzania.

Mkenda, A.F., Luvanda, E.G., Rutasitara, L and Naho, A. (2004). Poverty in Tanzania. Comparisons across administrative regions

Msaki, M.M., Mwenda, M.I and Regnard, I.J. (2013). Cereal bank as a necessary rural livelihood institute in Arid land, Makoje Village, Dodoma village, Dodoma – Tanzania. *Asian Economic and Financial Review*, 3(2): 259-269.

Namwata B.M.L, Lwelamira, J and Mzirai, O.B. (2010). Adoption of improved agricultural technologies for Irish potatoes (*Solanumtuberosum*) among farmers in Mbeya Rural district, Tanzania: A case of Ilungu ward. *Journal of Animal and Plant Sciences*, 8(1): 927-935.

Nyagaka, D.O., Obare, G.A., Omiti, J.M and Nguyo, W. (2010). Technical efficiency in resource use: Evidence from smallholder Irish potato farmers in Nyandarua North District, Kenya. *African Journal of Agricultural Research*, 5(11): 1179-1186.

Okoye, B.C., Onyenweaku, C.E and Agwu, A.E. (2008).Technical efficiency of small holder cocoyam farmers in Anambra state Nigeria. Implications for agricultural extension policy.*Journal of Agricultural Extension*, 12(1)

Raphael, I.O. (2008). Technical efficiency of cassava farmers in South Eastern Nigeria.*Agricultural Journal*, 3(2): 152 – 156.

Sharma, K.R., Leung, P and Zaleski, H.M. (1999).Technical, allocative and economic efficiencies in swine production in Hawii.A comparison of parametric and non-parametric approaches.*Agricultural economics*, 20, 23 – 35.

Swai, O. W., Mbwambo, J. S. and Magayane, F. T. (2012). Gender and perception on climate change in Bahi and Kondoa Districts, Dodoma Region, Tanzania. *Journal of African Studies and Development*, 4(9), 218-231.

Temu, A. E and Temu, A, A. (2005). High Value Agricultural Products for Smallholder Markets in Sub-Saharan Africa: Trends, Opportunities and Research Priorities. In: How can the poor benefit from the growing markets for high value agricultural products?. A workshop held at International Center for Tropical Agriculture, Cali, Colombia on 3rd to 5th October 2005.