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ESTIMATION OF TECHNICAL EFFICIENCY AMONG SMALLHOLDER MAIZE FARMERS IN UGANDA: A CASE STUDY OF MASINDI DISTRICT OF UGANDA

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Abstract

The Ugandan government, NGOs and the private sector in recent years have embarked on supporting poor small-scale farmers to alleviate poverty through transformation of low input/output subsistence farming to commercially competitive agriculture. Support included extension services, input subsidies and demonstration plots of specific crops including maize. However, there is little information on the impact of such support on technical efficiency of maize farmers in Uganda, especially in Masindi District where the crop is a major source of income among poor rural households. Therefore, this study estimated technical efficiency (T.E) and its' determinants in three sub counties in Masindi District were selected namely, Kigumba, Pakanyi and Miria, covering a total sample of 170 maize farmers. Findings indicated that most farmer were men with an average age of 41 years, mean household size of 7 people, married and primary school dropouts. On average, they owned 2.48 ha of land, planted improved maize varieties, harvested 1860.77 Kg/ha and sold their produce at the farm gate. On average, 57% of smallholder maize farmers were operating above 60% technical efficiency. Determinants that had positive relationship with T.E included group membership, household size, respondent's spouse education level, respondent's spouse major occupation and variety of seed planted. Selling at the farm gate was found to have a significant negative relationship with technical efficiency. Therefore, among other factors, there is need to consider all determinants of T.E based on the signs and magnitude of coefficients for increased productivity of maize farmers in Masindi and hence, improved incomes and livelihoods.

Keywords: Stochastic production function, Technical Efficiency, Maize production, APEP-USAID.

INTRODUCTION

Uganda's Plan for Modernization of Agriculture (PMA) stresses the involvement of all stakeholders in decision making as one of the major strategies for achieving the government policy of eradicating poverty (MAAIF, 1998). With the aim of eradicating poverty, NGOs and the private sector designed program mainly to catalyze the transformation of agriculture from low input/output subsistence to commercially competitive farming. Among efforts to catalyze the transformation, National Agricultural and Advisory Services (NAADS), production-to-market transactions, improvements in input distribution, and the development of competitive rural agricultural enterprises were dominant. Other measures included advice on better agronomic practices and input use for increased agricultural output. Masindi district received support mainly focused on boosting maize production because of its high competency in this enterprise (Private Sector Foundation Uganda PSFU, 2005).

Maize being one of the major crops regionally exported and rising in value from about US$6.0 million in 1990 to US$10.4 million in Uganda, it was thought to be a stepping-stone towards poverty eradication (Private Sector Foundation Uganda (PSFU), 2005). Based on the availability of such substantial maize market regionally, interested stakeholders engaged in developing maize production technologies to benefit from such opportunity. The technology package included; demonstration farms, improved agronomic practices, subsidized improved seed varieties, fertilizer, herbicide use and post-harvest handling techniques (APEP, 2004). These technologies are all incentives known for increased production efficiency (Rahman, 2003).

Empirical studies suggest that most developing countries are still facing the problem of high poverty levels. In addition to poverty, Uganda's population growth rate is very high at 3.4%. Yet agricultural resources notably arable land is limited, e.g. arable land. This calls for improving yields of major staples, such as maize for better food security and livelihoods of rural households. To achieve this objective, resources need to be used in the most efficient way possible. Further, improved efficiency is expected to improve food security by reducing hunger and contribute to achievement of the MDG-1 of halving hunger by 2015 (Amos, 2007).

Most rural farmers in developing countries practice subsistence farming with low productivity. This may be attributed to high inefficiencies (technical) because farmers lack access or less information on efficiency, and low literacy levels limiting interpretation of such information to guide them in commercial production. Further, less access to such information may be attributed to the few studies carried out in these areas. In order to realize increased production and efficiency, small-scale farmers in developing countries need to technically utilize the limited resources available for improved food security and farm income generation (Amos, 2007).

There are no known studies that have been done to determine the technical efficiency of smallholder maize farmers in Masindi District. Thus, this study was carried out to establish technical efficiency and its determinants and to clarify the impact of government, NGOs and the private sector services on maize farming in Masindi district. These results have important practical implications for policy formulation to address the looking food crisis in Uganda.

OBJECTIVE AND HYPOTHESIS

The broader objective of this study was to clarify the impact of government, NGOs and private services on farmer's technical efficiency and its determinants in Masindi District, Uganda. The specific objectives include determining the level of farm input technical efficiency in maize production; determining the factors affecting technical efficiency among maize farmers and to make recommendations for policy on the basis of results.

The null hypothesis (Ho) of this study included;

(i) amount of seed planted, capital invested and land under maize production do not have significant influence on the value of maize output;

(ii) farmers education level, household size and age of respondent do not have significant influence on technical efficiency of maize production in Masindi District.

CONCEPTUAL FRAMEWORK

The majority of Africa's population lives in rural areas and characterized by subsistence farming, resource poor, low literacy levels and relatively high levels of poverty levels. In addition, rural farmers use little or do not use some inputs important for increased productivity (Chukwuji, *et al*., 2006). Most countries in Sub Saharan Africa (SSA) drawn up strategies of supporting poor farmers to eradicate poverty by improving their productivity through introduction of new technologies and innovations such as high yielding and disease resistant crops (Eicher and Staatz, 1985; Sentumbwe, 2007). However, according to Wambui (2005), output growth is not only achieved by new technological innovations but also through efficiency in the use of these technologies. This calls for more information to understand the existing and prospective patterns of available resource use before more new technologies are introduced.

In economic theory, a production function is described in terms of maximum output that can be produced from a specified set of inputs, given the existing technology available to the farm (Battese, 1992). To achieve the maximum output, farmers need to be efficient and efficiency is defined as the ability to produce at a given level of output at the lowest cost (Farrell 1957). Efficiency can be achieved technically, allocatively or both (economic efficiency). Technical efficiency is the ability of the farm to produce a maximum level of output given a similar level of production inputs. Allocative efficiency is the extent to which farmers equate the marginal value product of a factor of production to its price (Chukwuji, *et al.,* 2006). In order to promote commercialization of agriculture from subsistence farming, farmers have to be technically efficient. Technical efficiency is achieved when a high level of output is realized given a similar level of inputs. It is therefore concerned with the efficiency of the input to output transformation.

There are two general paths of estimating production frontier. These include the full frontier, where all observations are assumed to be along the frontier and the deviation from the frontier is considered inefficient, and the stochastic frontier estimation where the deviation from the frontier is attributed to the random component reflecting measurement error and statistical noise and an inefficiency component (Ogundele and Okoruwa, 2006). Stochastic production was chosen to be used in this paper. The stochastic parametric method incorporates the random error of regression. The random error therefore captures the effect of unimportant left out variables and errors of dependent variables as well as the farm specific inefficiencies. It is because of this decomposition of error that makes this method of estimation superior to others. It provides the farm efficiency estimates with much lower variability than any other method due to the error term decomposition (Neff et al., 1994).

However, increased productivity through technical efficiency can be disrupted by some random factors such as bad weather, animal destruction and/ or farm specific factors, which lead to producing below the expected output frontier (Battese and Coelli, 1995). Such challenges are decomposed in the error term when estimating the stochastic production frontier. The Ordinary Least Square (OLS) linear model sometimes is used to ascertain socio-economic and managerial factors responsible for technical inefficiencies. Based research results carried out by different groups and individuals, such factors include, household education, non-farm employment and credit constraint and late delivery of farm inputs, late planting (Mubarik, et al., 1989; Obwona, 2000). Other factors include age and farming experience, extension service access and farm assets contributed to overall technical efficiency (Ogundele and Okoruwa, 2006; Ogundari and Ojoo, 2005; Obwona, 2000).

RESEARCH METHODOLOGY

Study Area

The study area, Masindi District is located in the Western Region of Uganda between 1^{o} 22'-2^{o} 20' N and 31o 22'-32o 23' E. The district has 1 town council, four counties (Bujenje, Bullisa, Buruli and Kibanda), 13 sub counties, 43 parishes, and about 156 villages and 96,706 households. The average household size is about 4.86 persons, lower than the regional average of 5.2. The district lies at an altitude range of 621m to 1,158m above sea level. It comprises a total area of 9,326 sq km, of which 8,087 sq km is land, 2,843 sq km wildlife-protected area, 1,031 sq km forest reserves, and 799.6 sq km water. The district is divided into three major climatic (rainfall) zones: high rainfall (>1000mm), medium rainfall (800-1000mm) and low rainfall (<800mm). On average, the district receives about 1,304 mm of rainfall annually. The climate (annual average temperature of 25ºC) and soils are favorable for agriculture (Foodnet, 2004).

Masindi district was purposively selected for this study. A multi-stage sampling technique was used in this study where three maize growing sub-counties were randomly selected from two counties namely Buruli and Kibanda. The three selected sub counties included Pakanyi, Miria, and Kigumba. From each sub-county 2 parishes were selected, and from each parish 29 farmers were interviewed. This made a sub total of 58 farmers interviewed from each sub-county and overall sample of 170 respondents interviewed from the 3 sub-counties.

The Data

Primary data were collected from farmers using a survey method involving a structured questionnaire.

Table 1. Data used in Definition of empirical model variables and their hypothesized relationship to level of technical efficiency

Variable	Description	Unit	Hypothesized sign
Age	Age of respondent and Spouse	years	+/-
Gender	Gender of Household head (Male = 1, Female = 0)	Dummy variable	+
Marital Status	Marital status of respondent Married = 1, Single =2, separated = 3, Widow =4	Non-continuous variable	+
Formal Education	Education level of respondent and spouse (years in School)	Years	+
Household Size	Number of people in a household	Number	+
Farming Experience	Farming experience of both respondent and spouse	Years	+
Major occupation	Major occupation of both respondent and spouse (Farming =1 Otherwise =0)	Dummy Variable	+/-
Farm land size	Size of farm land accessed by household	hectares	+
Land under maize	Size of land under maize production	hectares	+
Labour	Number of days devoted to farming	Personal days/ha	+
Type of Seed planted	Type of seed planted (improved seeds = 1, recycled seeds =0)	Dummy Variable	+/-
Amount of Seed planted	Amount of maize seed planted	Kg/ha	+
Amount of fertilizers	Amount of fertilizer used	Kg/ha	+
Prices of inputs	Prices of all inputs used in production	Ugandan Shillings/ US-dollars	-
Amount of maize output	Amount of output harvested	Kg/ha	+
Output market place	Where farmer always sell his produce farm gate = 1 and others =0	Dummy variable	-
Extension Services	Number of Extension services visits received by respondent	Number	+
Amount of credit received	Amount of credit received by respondent	Ugandan Shillings/ US-dollars	+
Group Membership	Whether respondent belong to farmer group (Yes = 1, No =0)	Dummy	+

Model and Analytical Framework

Descriptive statistics is generated and presented in tables of frequencies, percentages, standard deviation, and means. Estimation of technical efficiency was attained by using a Cobb Douglas production function and a stochastic production frontier function derived from a Cobb Douglas function respectively. Then determinants of technical efficiency were attained by estimating a robust linear regression. STATA and SPSS packages were used to estimate the models. Analysis of technical efficiency and determinants of technical efficiency are described below.

The stochastic frontier production function assumes the presence of technical inefficiency of maize production. Following Battese (1992) and Raham (2003), technical efficiency of maize production is estimated using a stochastic production frontier, which is specified as

$Y_i = f\ (X_i; \beta_i)\ Exp\ (V_i - U_i),\ i = 1, 2, \ldots, n$ ………………………………………………….. (1)

Where; Y_i is the output of farmer i, X_i is the input variables, β_i are production coefficients, the Vi is a random error, which is associated with random factors not under the control of the farmers (e.g., weather, natural disasters, and luck), measurement errors, and other statistical noise, while U_i is the efficiency measure. Sometimes the error term [Exp (V_i - U_i)] is considered "composite" (Sharma and Leung, 2000; Bravo-Ureta and Pinheiro 1997; Raham, 2003; Chavas *et al.,* 2005).

Thus,

$\ell = V_i - U_i$……………………………………………………………………………………(2)

WhereV_i is a two-sided ($-\infty < V_i < \infty$) normally distributed random error [$V_i \approx N(0,\sigma_v^2)$]. The term U_i is a one-sided ($U_i \geq 0$) efficiency that measures the shortfall in output Y_i from its maximum value given by the stochastic frontier $f\ (X_i; \beta i) + v$ We assume U_i has an exponential distribution [$U_i \approx N(0,\sigma_u^2)$]. The two components V_i and U_i are also assumed to be independent of each other..

Further, technical efficiency can be estimated as;

$TE = Y_i / Y_i^* = f\ (X_i, \beta i)\ Exp\ (V_i - U_i) / f\ (X_i, \beta i)\ exp\ (V_i) = exp\ (-U_i)$………………….. (3)

The parameters are estimated by the maximum likelihood method following Bravo-Ureta and Pinheiro (1997) and Bi (2004). Following Ojo (2003), this study specified the stochastic frontier production function using the flexible log linear Cobb- Douglas production function. Estimating technical efficiency using stochastic frontier production function to estimate technical efficiency has been wildly used and yielded results. The stochastic parametric method decomposes random errors into error of farmer's uncontrollable factors, dependent variable as well as farm specific inefficiencies. While Deterministic and non-parametric methods have drawbacks since it forces all outputs to a frontier yet sensitive to outliers if large, it distorts efficiency measurements (Ogundele and Okoruwa, 2006).

Determinants of technical efficiency were estimated using a robust Ordinary Least Squares (OLS) because it's unbiased, consistent estimator. Following Bravo-Ureta and Rieger (1990), Bravo-Ureta, and Pinheiro (1997) second step estimation adapted from the relationship between technical efficiency and the different farm/farmer characteristics are determined. To estimate these factors, a linear model is used with estimates. The linear model is estimated as shown below for each farmer.

$T.E = \beta i Xi + e_i$……………………………………………………………………………………(4)

Where *T.E* = level of technical efficiency; X_i is a vector of explanatory variables that include; Age of household head; Gender of respondent; Household size; Education level of respondent's spouse; Major occupation of Respondent's spouse; Extension services; Type of maize seed planted; farming experience; selling place (market); membership to farmer group, βi = Coefficients and e is the error term.

RESULTS AND DISCUSSIONS

This section discusses results generated from primary data. The section first discusses socio-demographic characteristics of farmers, followed by stochastic production frontier results, technical efficiencies and determinants of technical efficiency respectively.

Socio-Demographic Variables

Results in Table 2 indicate that most maize farmers (87%) were men. The difference in the numbers of men and women involved in maize production may be attributed to the common cultural norms in Uganda and Africa, which limit women ownership of resources. These norms discriminate against women in resource allocation and participating in main income earning activities.

As shown in Table 2, the average age of the farmers' was found to be 41.5 years and thus, most maize farmers in Masindi District were in their productive ages as defined by Ogundele and Okoruwa (2006). Increase in age sometimes may be an indication of number of years spent in farming (experience) and sometimes indirectly affects production. The average years of experience in maize production was found to be 16.43 years. The more experienced the farmer the better for positive yields since the farmer may know more methods of reducing production risks.

Results further showed that 94% of the respondents interviewed were married, 3% single and 3% were widowed. Marital status in most cases is considered important in household decision making where married people have always succeeded in decision-making. The average household size was found to be 7 people (Table 2). Further, household size sometimes in village setting indicates that there is relatively more farm and off-farm labour (Sentumbwe, 2007).

Table 2: Demographic Characteristics of Maize Farmers in Masindi Districts

Characteristics	**Description**	**Total (n= 170) (%)**
Gender of farmer	Female	13
	Male	87
Marital status of farmer	Married	92
	Single	4
	Widowed	4
Type of Seeds used	Recycled	35
	Improved	65
Output Market Place	Farm gate	88
	Elsewhere	12
		Average Mean value
Age of farmer (Years)		41. 5
Household size		7
Education level of farmer (yrs)		6.5
Spouse Education		4.9
Size of land owned (ha)		2.5

Most farmers were primary school graduates (7 years of school) and most spouses of respondents have generally spent only about 4.9 years in school, see Table 2. Farmers with primary school education need continuous extension services to re-enforce better use of other factors of production especially labour, and management. Education also plays an important role in adoption of most new technologies that normally call for better management including consistent record keeping and proper use of the various inputs in maize production (Cheryl *et al,* 2003).

Farmers owned small pieces of land estimated to be 2.5 ha on average. Of the 2.5 ha, farmers dedicated at least 1.04 ha under maize production (Table 3). The average number of person days worked was 44.33 days in a season. Further, farmers harvested on average 1860.98 kg of maize per hectare and made average losses worth -3,113.49 Ugandan Shillings (UGX)/ha (equivalent to $1.64 US-dollars/ha) see Table 3. This may be due to low farm gate prices and high costs of production.

Table 3: Input Use and Output among Smallholder Maize Farmers

Item	Mean
Land under maize production (Ha)	1.04
Years farmer has been growing maize	16.43
Total number of person days worked (days/season)	44.33
Expenditure on seeds and fertilizers purchase (UGX/hectare)	28,701.04
Quantity harvested (kg)	1,935.42
Yields (Kg/hectare)	1860.98
Output prices UGX/kg	203.375
Gross profits (UGX/hectare)	-3,113.49
Off-farm incomes (UGX)	191,625.05

Note: UGX= Ugandan Shillings, Kg =Kilogram, $1 US-dollar = 1900 UGX in 2007

The Stochastic Production Frontier

Technical efficiency scores were generated from this estimation as shown in Table 4. Estimated stochastic frontier production function indicates that amount of seeds planted, amount of land under maize production, and capital had a positive and significant influence on maize output at 1% level.

Table 4: Estimates of the Stochastic Frontier Production Function

	Maize Output 2nd season (Y) = Dependent Variable			
Independent Variables	**Coefficient**	**S.E**	**Z**	**P-value**
Labour used (Person days)	0.07	0.05	1.58	0.113
Animal draught power used (day/acre)	0.07	0.05	1.47	0.140
Amount of seeds used (Kg)	0.17***	0.05	3.26	0.001
Amount of land under maize (ha)	0.75***	0.15	5.11	0.000
Amount of money (Capital) invested (UGX)	0.24***	0.05	4.54	0.000
Cons	3.19***	0.54	5.89	0.000
sigma_v	0.28	0.04		
sigma_u	0.73	0.08		
sigma2	0.61	0.10		
Lambda	2.63	0.10		
Log likelihood = -170.74				
Wald chi2(5) = 427.35				
Number of observations (n) = 170				

Note: *** = significance levels at 1% respectively.

Estimation of Technical Efficiency

Technical efficiency was obtained using the estimated parameters from the log linear Cobb Douglas stochastic production frontier. Technical efficiency computed for each household later was disaggregated into ranges of efficiencies in terms of percentages. The minimum estimated efficiency score was 4 percent, the maximum was 92 percent and the overall mean was 58 percent (Table 5).

Table 5: Range of Technical Efficiency for Smallholder maize farmers

Ranges of Efficiency (%)	Overall (n=170) (%)
<20	9
20- 39	17
40-59	17
60-79	36
80-99	21
Total	100

Most farmers (57%) were operating above 60% technical efficiency. Of the 57% farmers, 36% were operating between 60% and 79% efficiency and the 21% farmers were operating between 80% and 99%. 25% of farmers were operating at low efficiency of less than 40%. On average, smallholder farmers in Masindi have to increase their efficiency by at least 41% to be 99% efficient. Farmers operating below 20% of technical efficiency were considered technically inefficient.

Factors Affecting the Level of Technical Efficiency

Table 6 below shows the linear regression results of T.E scores against explanatory variables. A robust standard error regression was done to address heteroskedasticity. Results indicate that membership to farmer group (APEP), household size; education of respondent's spouse, occupation of respondent's spouse, type of seeds planted and maize market significantly affected the level of technical efficiency. Among the six above-mentioned significant factors, it is only output market that had a negative relationship with technical efficiency.

Table 6: Determinants of Technical Efficiency Among Maize Farmers

Variable	Coefficient	Robust S.E	T-value	P-value
Household size	0.01*	0.01	1.69	0.09
Education level of Spouse	0.01**	0.01	1.99	0.05
Spouse work	0.32**	0.16	2.08	0.04
Type of seed planted	0.08*	0.04	1.81	0.07
Output market place	-0.15***	0.06	-2.48	0.01
Membership to farmer group	0.15***	0.04	4.43	0.00
Constant	0.13	0.17	0.74	0.46
Number of Observation = 148				
F-value = 7.03***				
Adjusted R^2 = 0.25				

Note: ***, **, * denote significance at 1%, 5% and 10% levels

In most African rural settings, increased household size means increased labour force. This study found that household size had a positive and significant influence on technical efficiency of maize farmers at 10% alpha level with a t-value of 1.69. The positive sign means that, as household members increase, there will be a more equitable labour distribution among farming activities especially during peak periods. Improved farm labour distribution will lead to higher concentration on the given task and thus improve production efficiency. A study carried out by Jema (2007) also indicated a positive and significant effect of family size among small-scale vegetable farming households in Ethiopia. Results of this study match with Amos (2007) findings where family size was also found to have a positive and significant effect on technical efficiency among cocoa producing households in Nigeria.

Belonging to farmers groups (APEP groups), was found to be positively and significantly influence the level of technical efficiency at 1% alpha level. This implies that there was a positive contribution of extension programmes offered by stakeholders on maize farmers' production efficiency. These results match with Sentumbwe (2007) study that found that farmers who adopted new technologies and received technical advice from IPM-systems were technically more efficient than farmers who relied only on traditional methods.

Education level of respondent's spouse was found to have a positive relationship with technical efficiency and significant at 5% alpha level. Demographic results indicate that 87% of people interviewed are men and 92% of people interviewed are married, thus most people regarded as spouse in this study are women. With the exception of ploughing and marketing of produce, women carry out most activities involved in maize production. Education is believed to have a positive relationship with adoption of new technologies, resulting in improved efficiency (Amos, 2007). Hyuha (2006) study results also support results from this study in respect to education. Thus, improving education of women in Masindi district will probably results in increased technical efficiency. This calls for more attention in promoting girl child education in such areas as a pre-condition for improved output and efficiency.

Further, out of 143 spouses, 88% were employed in farming as their major occupation. Major occupation of spouse was found to be positively related and significantly affecting technical efficiency at 5% alpha level. Thus, technical efficiency increases as spouses become more involved or employed in farming. Most women in Africa contribute 70 – 80 percent farm labour. Such labour is mainly allocated to planting, weeding and harvesting and men mainly plough and sell produce (marketing activities) (Johnson, 2005). Thus, for increased/improved efficiency women should be encouraged to get more involved in farming and attend farm trainings.

Since it has been established that improved technologies positively influence productivity, it is not surprising that type of maize seeds planted by farmers had a positive and significant effect on technical efficiency at 5% alpha level. The results of the estimated log linear Cobb-Douglas production function indicated that amount of seed planted had a positive and significant influence on maize output. Thus, increased use of improved maize seeds will increase productivity as well as efficiency.

Since it has been shown earlier in Table 2 that most farmers (82%) were selling their maize at home, meaning that only a few had access to markets in trading centers and big towns. However, results from Table 5 indicated that selling from home had a negative relationship and significantly affected technical efficiency. Thus, farmers selling from home are less efficient than those accessing markets in towns and peri-urban areas. This may be due to low farm gate prices compared to price prevailing in markets. Farmers often lack market access for their produce and limited storage facilities meaning that high postharvest losses are incurred. This discourages these farmers from increasing production of the maize crop.

CONCLUSION

The predominantly male maize farmers in Masindi District had an average age of 41.48 years, owned 2.48 ha of land, planted improved seed varieties and had seasonal harvest of 1860.77 kg/ha of maize during the study period. On estimating the stochastic production function, results indicated that land under maize, amount of seed planted and capital invested had a positive and significant influence on maize output.

Of the 170 farmers interviewed, 57% were operating above 60% technical efficiency and 26% farmers were more inefficient operating below 40% technical efficiency. Thus, on average most maize farmers in Masindi District need to improve on their efficiency by 40% to make it 100% efficient. Selling at farm gate had a negative and significant impact on technical efficiency implying that the more the farmer sold at farm gate, the less efficient she/he was during the study period. Farmers' group membership, household size, spouse's education, spouse's major occupation, and variety or type of seeds planted had a positive and significant relationship with technical efficiency.

RECOMMENDATIONS

Due to inefficiencies realized, there should be more efforts by the government and NGOs to step up extension services rendered to farmers for efficient input use. Further, maize farmers should concentrate more on intensive farming and efficient resource use.

Since amount and use of improved seed varieties had a positive and significant influence on maize output and technical efficiency, innovations, research and new technology should be prioritized in government/NGOs budgets and programmes. Farmers should be encouraged to adopt new technologies for improved productivity. Increased marketable maize output and incomes have been shown to improve rural livelihood and hence poverty alleviation.

More farm-oriented incentives should target women especially in maize production. In addition, training programmes should include women since results showed that their participation increases efficiency. Furthermore, improving women's education should be done especially through promoting girl child education in rural areas for easier adoption of technologies and hence increased efficiency. Since women do all the production tasks with exception of ploughing and marketing, they need to be empowered with knowledge and skills for increased farm productivity. Furthermore, to improve on technical efficiency, education policies should be strengthened and where possible, adult education should be introduced in areas.

Most interventions by government and NGOs have been aiming at increasing farmers output (productivity) and less focus on output/input markets/prices. To improve farmers access to markets and market information, the governments, NGOs and private sector should focus on investing in infrastructure development (like roads, buildings etc.) in Masindi District. This is because; selling at farm gate negatively and significantly was affecting technical efficiency. Thus, farmers lack of access to better markets with good prices acts as a disincentive to efficiency and productivity.

Further studies should be carried out to estimate the profit function of maize farmers in Masindi and other livelihood strategies that can strengthen this sector. A study that seeks to establish transaction costs associated with maize markets in Masindi district and the value chain should be carried out. All this will be added knowledge to this study.

REFERENCES

Agricultural Productivity Enhancement Program (APEP), Uganda (2004): Second Annual Progress Report October 2004 to September 2005

Amos. T.T. (2007): "An Analysis of Productivity and Technical Efficiency of Smallholder Cocoa Farmers in Nigeria"; Department of Agricultural Economics and Extension, Federal University of Technology, PMB 704, Akure, 340001. Nigeria: Kamla Raj 2007: J. Soc. Sci., 15(2): 127-133 (2007)

Battesse, G. E, (1992). Frontier production functions and technical efficiency: a survey of empirical applications in agricultural economics. Agricultural Economics 7 pp 185-208

Battese, G. E and T. J Coelli, (1995). A model for technical inefficiency effect in stochastic frontier production for panal data. Emperical Economics Vol 20 pp 325-345

Bi, H. 2004. "Stochastic Frontier Analysis of a Classic Self-thinning Experiment". Austral Ecology 29: 408–417.

Bravo-ureta, B. E. and A.E. Pinheiro. 1997. "Technical, Economic, and Allocative Efficiency in Peasant Farming: Evidence from the Dominican Republic. The Developing Economies, XXXV (1):48–67.

Bravo-Ureta, B.E., and L. Rieger. 1990. "Alternative Production Frontier Methodologies and Dairy Farm Efficiency." Journal of Agricultural Economics 41(2): 215–26

Cranfield University, NETWAS, KNUST, TREND, WSA (2012): Synthesis report on stakeholder baseline studies on technology selection process and the stakeholders' attitudes Deliverable 7.1; Cranfield University

Chavas, J. P., Petrie, R. and Roth, M. 2005 "Farm Household Production Efficiency: Evidence from The Gambia". American Journal of Agricultural Economics 87(1): 160-179.

Cheryl, D.R., W.Mwangi, H. Verkuijl, and De Groote, (2003). Adoption of Maize and wheat Technologies in Eastern Africa. A synthesis of the Findings of 22 case studies. CIMMYT Economics Working Paper 03-06. Mexico, D.F: CIMMYT.

Chukwuji Christopher O., Odjuvwuederhie E. Inoni, O'raye D. Ogisi, William J. Oyaide (2006): "A Quantitative Determination of Allocative Efficiency in Broiler Production in Delta State, Nigeria": Department of Agricultural Economics and Extension, Delta State University, Asaba Campus, Asaba. Delta State, Nigeria: Agriculturae Conspectus Scientifi cus, Vol. 71 (2006) No. 1 (21-26)

Eicher C.K. and Staatz J.M. (1984): Agricultural development in the third world; The Johns Hopkins University Press; Baltimore and London

Esparon, N. M, and N. H Sturgess (1989). "The measurement of technical efficiency using frontier production functions of rice farms in west Java"; Bulletin of Indonesia Economic studies, Vol 25, No 23 Dec 1989

Farrel, M.J, (1957). "The measurement of productivity efficiency". Journal of Royal statistical society A120: 253-81

Hyuha, T.,(2006). Profit efficiency among rice farmersin Uganda. Unpublished Ph.D thesis, Makerere University.

Jema Haji, (2007). "Production Efficiency of Smallholders' Vegetable-dominated Mixed Farming System in Eastern Ethiopia": A Non-Parametric Approacha Department Of Economics, Swedish University of Agricultural Sciences (SLU), Uppsala, Sweden; Journal of African Economies 2007 16(1):1-27; doi:10.1093/jae/ejl044

Johnson, D. E., (2005). Weed management in smallholder production in the tropics. www.ipmworld.umn.educ . accessed on 24.8.07

Jondrow, J., C.A. Lovel, I Materov and P. Schmidt, (1982). "On the estimation of technical inefficiency in stochastic frontier production function model". Journal of Econometrics, 19: 233-38.

Kibirige D., B. Kiiza and G. Elepu 2010, Analysis of Technical and Allocative Efficiency of Agricultural Productivity Enhancement Program on Maize Farmers; Masindi District (U), monogram Book; ISBN: 978-3-8383-7163-4, Published by LAP-Lambert Academic Publishers and printed in the USA and UK.

Kirsten J. and V. Nick, (2005). The economics of Institutions: Theory and Application to Africa Agriculture. Page 23

Mubarik . A. and J. Flinn, (1989). Profit efficiency among Basmati rice producers in Pakistan Punjab America Journal of agricultural economics 71 (2) (1989) 303 – 10.

Ministry of Agriculture, Animal husbandry, and Fisheries (MAAIF) 1998. Operation of Mid-term Plan for Modernization of Agriculture in 1997/98-2001/2002.

Neff, D. L., P. Garcia and C. H. Nelson, (1994). Technical efficiency: A comparison of production frontier methods; University of Ohio

Obwona, M, (2000). Determinants of technical efficiency amoung small and medium scale farmers in Uganda: A case of tobacco growers. Final report presented at AERC Biannual Research Workshop, Nairobi, Kenya. 27 may – 2 June 2000.

Ogundari. K and S. O. Ojo, (2005). "The determinants of technical efficiency in mixed – crop food production in Nigeria": a stochastic parametric approach. East African Journal of Rural Development Vol 21, Dec 2005.

Ogundele O. O and O. O.Victor, (2006). Techical efficiency differential in rice production technologies in Nigeria. Africa Research Consortium. Research paper 154

Ojo S.O. (2003): "Productivity and Technical Efficiency of Poultry Egg Production in Nigeria"; Department of Agricultural Economics and Extension, Federal University of Technology, P.M.B. 704, Akure, Nigeria: International Journal of poultry Science 2 (6): pp 459-464.

Private Sector Foundation Uganda. (2005); Identifying Improvement Opportunities and Diagnosing Prospects for Uganda maize Foodnet 2004. Back ground information on Masindi, Hoima and Kabarole districts

Rahman, S. (2003). "Profit Efficiency Among Bangladeshi Rice Farmers". Food Policy 28:487-503.

Sentumbwe Samuel, (2007): Intra-House Labour Allocation and Technical Efficiency Among Groundnuts Producers in Eastern Uganda. MSc. Thesis, Makerere University Kampala Uganda. .

Sharma, K. R., and P. S. Leung, 2000. “Technical Efficiency of Carp Production in India: a Stochastic Frontier Production Function Analysis”. Aquaculture Research, 31: 937-947.

Wambui Kibaara Betty, (2005). Technical Efficiency in Kenyan’s Maize Production: An Application of the Stochastic Frontier Approach: Msc. Thesis Department of Agricultural and Resource Economics Colorado State University Fort Collins, Colorado: USA