# ANALYSIS OF THE IMPACT OF THE AGRICULTURAL PRODUCTIVITY ENHANCEMENT PROGRAM ON THE TECHNICAL AND ALLOCATIVE EFFICIENCY OF MAIZE FARMERS IN MASINDI DISTRICT

BY

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# A THESIS SUBMITTED TO THE SCHOOL OF GRADUATE STUDIES IN PARTIAL FUFILMENT OF THE REQUIREMENT FOR THE AWARD OF A MASTER OF SCIENCE IN AGRICULTURAL AND APPLIED ECONOMICS OF MAKERERE UNIVERSITY KAMPALA

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# DECLARATION

I Kibirige Douglas declare that this dissertation has never been submitted to any institution including Post Graduate School, Makerere University.

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# DEDICATION

I dedicate this thesis to my mother Ms Grace Kawooya, my brothers Kirumira Simon Peter and Kalungi Godfrey James and Sister Nanfuka Sanyu Mildred. To my dearest wife Mrs. Kibirige Nampiima Scovia and all my fellow classmates of CMAAE in Kenya, Malawi, Zimbabwe and South Africa.

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## ABSTRACT

The Agricultural Productivity Enhancement Program (APEP) was established in Uganda in 2003 by the United States Agency for International Development (USAID). The program mainly aimed at transforming agriculture from low input/low output subsistence farming to commercially competitive agriculture. Among its various activities, the program extended its extension services to maize farmers in Masindi District. However, there is little information on the impact of APEP training on efficiency (technical and allocative) of maize farmers there. Therefore, this study estimated technical (T.E) and allocative efficiency (A.E) of these farmers and identified the determinants of technical efficiency among them as well as Non-APEP maize farmers in three selected sub counties of Masindi District i.e., Kigumba, Pakanyi and Miria. The sample size was 170 maize farmers.

Descriptive statistics indicated that APEP farmers devoted more land, had more experience, and spent more on improved seed and fertilizer purchase than the non-APEP farmers, and hence, resulting into better maize yields and gross margins. Elasticity of land used in maize production by APEP farmers was found to be greater than one and hence, elastic. There were 62% APEP and 53% non-APEP farmers found to operate at a level of 60% and above in technical efficiency. Non-APEP farmers (31%) were technically inefficient operating at < 40 percent T.E while only 21% APEP farmers were operating at the same level of technical efficiency.

In addition, there was a significant mean difference between technical efficiency of APEP and non-APEP farmers at 1% level. APEP farmers were more average technically efficient (67%) compared with 49% average technical efficiency of Non-APEP farmers. Determinants of T.E were estimated using econometric linear model with robust standard errors. The positively related factors with T.E included membership to APEP, household size, variety of seed planted. Selling at home at the farm gate and years farmer spent in maize farming was found to be negatively related to technical efficiency scores. Allocative efficiency was estimated for both APEP and Non APEP farmers. APEP farmers were allocating more efficiently seed input (A.E=0.92) than all inputs used. Non-APEP farmers were allocating inefficiently all inputs (labour, animal draught power and seed input).

Therefore, based on the above results, APEP farmers performed better than non-APEP farmers indicating a positive response to training received from APEP. Thus, it is concluded and recommended that if both APEP and non-APEP farmers are to increase maize output, more training on the usage of inputs especially land and improved seeds in maize production should be considered.

## **CHAPTER ONE**

## INTRODUCTION

# 1.1 Background

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 among rural farmers, a five-year USAID-funded project, The Uganda Agricultural Productivity Enhancement Program (APEP) was established in 2003. The program mainly targeted catalyzing the transformation of agriculture from low input/low output subsistence farming to commercially competitive agriculture. Within the targeted commodities, APEP addressed production-to-market transactions, improvements in input distribution, and the development of competitive agricultural and rural enterprises (Michigan State University, 2007). Among the targeted commercial crops included grains namely maize, cotton, coffee, bananas (Matoke), spices and floriculture. In addition to the efforts of its predecessor (IDEA project) efforts in Masindi District, APEP continued to give pieces of advice on better agronomic practices and input use to raise maize output.

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 it would be a stepping stone towards poverty eradication (Private Sector Foundation Uganda (PSFU), 2005). Based on the availability of such substantial maize market regionally, APEP came up with demonstration sites to expose farmers to improved maize production technologies. Among the technologies APEP demonstrated included improved agronomic practices, improved

seed varieties, fertilizer and herbicide use and post harvest handling techniques. In 2004, 291 demonstration sites were established exposing 4,227 farmers to these techniques (APEP, 2004). These technologies are all incentives known for increased production efficiency (Rahman, 2003).

# **1.2 Problem Statement**

Empirical studies suggest that most under developed and developing countries are still facing the problem of high poverty levels. In addition to poverty, Uganda's population growth rate is 3.4%, very high; yet agricultural resources are limited, e.g. arable land. This calls for improving yields of major staples, such as maize for better food security & livelihoods of rural households. Thus, resources need to be used in the most efficient way to achieve this objective. Further, improved efficiency is expected to improve food security by cutting hunger halfway in 2015 (Amos, 2007).

Most farmers in these countries practice subsistence farming with low productivity. This may be attributed to high inefficiencies (technical and allocative) 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 efficiently utilize the limited resources accessed for improved food security and farm income generation (Amos, 2007). In the light to boost productivity, APEP provided technical services to farmers in Masindi District. APEP (2005) indicated a positive response amongst its maize farmers; with higher yields compared to non-APEP farmers. Though farmers applied the production techniques given by APEP and realized increased production, it is not clear whether they were relatively more efficient both allocatively and technically compared with those who did not use the APEP advisory services.

There are no known studies that have been done to determine the technical and allocative efficiency of APEP maize farmers in Masindi District. Thus, this study was carried out to establish technical and allocative efficiency and factors affecting technical efficiency of APEP in comparison with non-APEP farmers. Results from this study were used to establish the impact of APEP services among maize farmers in Masindi district.

# **1.3** Objectives of the Study

## **1.3.1 Main Objective**

The overall objective of this study was to establish the impact of APEP on the efficiency of maize farmers in Masindi District, Uganda.

# 1.3.2 Specific Objectives

- To characterize APEP and Non-APEP maize farmers in Masindi District.
- ii) To determine and compare the level of farm input allocative and technical efficiency in maize production between APEP and non-APEP farmers.
- iii) To determine the factors affecting technical efficiency among maize farmers.

# 1.4 Hypotheses

- There is a significant difference in the level of allocative efficiency between APEP and Non-APEP maize farmers.
- ii) There is a significant difference in the level of technical efficiency between APEP and non-APEP maize farmers.
- iii) Membership to APEP, education, household size and age of farmer positively affect the level of technical efficiency among maize farmers.

# **1.5.** Significance of the study

Findings from the monitoring and evaluation of many previous studies done on the performance of farmers who accessed services from different Non Governmental Organizations (NGOs) in Uganda clearly show a positive response in adopting the introduced technologies (DANIDA, 2003). However, less if any is known on their technical and allocative efficiency of services provided. This may result into less contribution realized in terms of resource use efficiency and household incomes in Uganda (Roothaert, 2007). This study sought to provide information about production/technical and allocative efficiency to stakeholders involved in the APEP program.

## **1.6.** Scope of the study

The study was limited to measuring the technical/production and allocative efficiency of APEP supported and non-APEP maize farmers. In addition, the study determined the factors affecting technical efficiency of the above mentioned farmers. Geographically the study was carried out in Masindi as one of the APEP intervened districts. The study collected demographic information, production information and market information for only maize

crop because one of the prioritized APEP crops. Results from this study could be used to generalize the performance of maize farmers who were trained by APEP visa-vis those who had not received any training from APEP in Masindi District.

# **CHAPTER TWO**

#### LITERATURE REVIEW

## 2.1 Introduction

This chapter presents relevant literature about allocative and technical efficiency of maize. It presents studies that are related to the study and the theory upon which it is based. The final section presents factors that affect technical efficiency.

Relatively most Africa's population lives in rural areas and characterized by subsistence farming, poor roads and other poor infrastructure, poor market information, low literacy levels and relatively high levels of poverty levels. In addition to poverty, rural farmers use little or do not use some inputs important for increased productivity (Chukwuji, *et al.*, 2006). Sub Saharan African (SSA) countries have drawn strategies of supporting poor farmers to eradicate poverty. Among strategies, include increased agricultural output (productivity) through new technologies and innovations like high yielding and disease resistant crops (Sentumbwe, 2007). New technologies were further designed to enhance incomes of rural poor farmers and hence as a means of accelerating economic development.

However, according to Wambui (2005), output growth is not only achieved by new technological innovations but also through efficiency use of these technologies. Few studies have been carried out to assess the allocative and technical efficiency of the rural farmers. Due to scarce information and low literacy levels, most farmers in SSA may be still allocating resources (inputs) in less appropriate way.

# 2.2 Efficiency in Production

Efficiency, as defined by the pioneering work of Farrell (1957), is the ability to produce at a given level of output at the lowest cost. 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. Economic efficiency combines both allocative and technical efficiency. It is achieved when the producer combines resources in the least combination to generate maximum output (technical) as well as ensuring least cost to obtain maximum revenue (allocative) (Chukwuji, *et al.*, 2006). This study aims at estimating technical and allocative efficiency.

If the farm is technically and allocativelly efficient, then that firm is said to be cost effective (Chukwuji, *et al.*, 2006). In order to promote commercialization of Agriculture from subsistence farming, these farmers have therefore to be both technically and allocatively efficient. The ultimate goal of training farmers to be both allocatively and technically efficiency is to boost their incomes by maximizing profits especially in poverty pressed countries. Thus, this study aims to know whether there is any impact of APEP based on their major objective of transforming agriculture from subsistence to commercial production.

# 2.3. Allocative Efficiency

For the firm to realize allocative efficiency, the following questions need to be answered; what is the optimal combination of inputs so that output is produced at minimal cost? How

much profit could be increased by simply reallocating resources? Therefore, the firm has to choose a combination of inputs to be used in right proportions and technically efficient at low prices so that output is produced at minimal costs (Shahooth, *et al.*, 2006). This results into profit maximization. Though there are new methods used to estimate allocative efficiency, traditionally it has been hard to estimate allocative efficiency without input and output prices. Based on this argument, some scholars like Farrell called it price efficiency, referring to the ability of a firm to choose the optimal combination of inputs given input prices (Badunenko, *et al.*, 2006).

## **2.3.1** Theoretical concepts of Allocative Efficiency

Allocative efficiency is a measure of how an enterprise uses production inputs optimally in the right combination to maximize profits (Inoni, 2007). Thus, the allocatively efficient level of production is where the farm operates at the least-cost combination of inputs. Most studies have been using gains obtained by varying the input ratios based on assumptions about the future price structure of products say maize output and factor markets. This study follows Chukwuji, *et al.*, (2006) reviewed assumptions used by farmers to allocate resources for profit maximization. Such assumptions included, farmers choose the best combination (low costs) of inputs to produce profit maximizing output level; there is perfect competition in input and output markets; producers are price takers and assumed to have perfect market information; all inputs are of the same quality from all producers in the market.

Allocative efficiency can also be defined as the ratio between total costs of producing a unit of output using actual factor proportions in a technically efficient manner, and total costs of producing a unit of output using optimal factor proportions in a technically efficient manner (Inoni, 2007). Thus for the farm to maximize profit, under perfectly competitive markets, which requires that the extra revenue (Marginal Value Product) generated from the employment of an extra unit of a resource must be equal to its unit cost (Marginal Cost = unit price of input) (Chukwuji, *et al.*, 2006). In summary if the farm is to allocate resources efficiently and maximize its profits, the condition of MVP = MC should be achieved. Based on this theoretical framework, allocative efficiencies of APEP and non-APEP maize farmers were established.

## 2.3.3 Recent studies estimating allocative efficiency

Some studies carried out to estimate allocative efficiency include the following;

Inoni, (2007) carried out the study to examine efficient resource utilization in pond fish production in Delta State, Nigeria. The estimated allocative efficiency of production resources employed were 3.22, 0.0025, 0.00064, –0.00017, and 0.00025 respectively for pond size, feed resources, fingerlings, labour, and fixed costs. With exception of pond size which was under-utilized, all inputs used in fish farming were said to be over-utilized implying sub-optimal resource allocation in fish production. Based on results, fish farmers in Delta state of Nigeria needed to reduce on the use of over-utilized resources to achieve optimal resource allocation and this would raise productivity of resources, increase output and hence increase revenues and net returns.

Chukwuji, *et al.*, (2006) carried a quantitative study to determine allocative efficiency of broiler production in Delta state of Nigeria. Results from this study estimated allocative efficiency for stock size, feed expenses, variable expenses and fixed capital inputs as 24.9, 24.8, – 4.6 and 11.9 respectively. In accordance to these results, farmers were said to be

allocatively efficient and needed to increase the quantity of the inputs to enable them to maximize profits since marginal value product was greater than marginal costs or unit price of inputs. Other studies carried out included Bravo-Ureta, *et al.*, (1997) to estimate economic, technical and allocative efficiencies of peasant farming in the Dominican Republic. Results indicated that farmers were 0.44 efficient. These results were said to be in line with a 0.43 allocative efficiency for a sample of wheat and maize farmers in Pakistan, though peasant farms in Paraguay were said to be more efficient with 0.70 and 0.88 allocatively efficient compared with peasant farmers in the Dominican Republic.

#### 2.4 Technical Efficiency

This is the engineering concept for measuring the performance of the system given the available resources. Technical efficiency is associated with behavioral objectives of maximization of output (Battese and Coelli, 1995). However, this production objective can not be carried out in isolation since a farm can be considered as an economic unit with scarce resources. When a producer with the aim of maximizing profit makes allocation mistakes that result in inefficiency, then the farmer is considered allocatively inefficient (Kumbhakar, 1994). Therefore, technical efficiency can not be achieved in isolation but other considerations (efficiencies) are always at play.

According to Esparon and Sturgess (1989), technical efficiency deals with efficiency in relation to factor- product transformation. For a farm to be called technically efficient, it has to produce at the production frontier level. However, this is not always the case due to 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). Efficiency

measurement therefore attempts to identify those factors that are farm specific which hinder production along the frontier. Technical efficiency goes beyond evaluation based on average production to one that is based on best performance among a given category (Battese and Coelli, 1995) though it is related to productivity where inputs are transformed into outputs. Secondly, efficiency measurement provides an opportunity to separate production effects from managerial weakness (Ogundari and Ojoo, 2005). This study therefore proceeded to measure technical efficiency given its benefits over productivity measurement.

#### 2.4.1 Theoretical Framework for technical efficiency

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). When the farm produces at the best production frontier, it is considered efficient. The most common assumption is that the goal of the producers is profit maximization, however, it is believed that the objectives and goals of the producer are intertwined with farmers' psychological makeup (Debertin, 1992). Therefore, this study assumes that producers aim at maximizing output subject to existing constraints. 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. The main function of this technical efficiency research is to understand factors that shift production function upwards (Esparon and Sturgess, 1989).

#### 2.4.2 Technical Efficiency Measurement

The pioneer work on efficiency was begun by Farrell in 1957 to which the present estimation method originated. Over time estimation of the production frontier has tended to follow two general paths; the full frontier where all observations are assumed to be along the frontier and the deviation from the frontier considered being inefficient. The other path has been 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)

The estimation of full frontier has been based on either non-parametric approach where technical efficiency is estimated by solving the linear programming for each individual farm/firm or through parametric approach where the estimation is by statistical techniques. Under the parametric approach, there are two methods namely; deterministic and stochastic frontier method. The deterministic method just like the non-parametric approach envelops all of the data of the firm (Neff *et al.*, 1994). The major drawback of these methods is that since it forces all outputs to a frontier it is sensitive to outliers that, if large distort efficiency measurements (Ogundele and Okoruwa, 2006).

The stochastic parametric method however 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). What should have been its major weakness as opposed to non-parametric measurements was its inability to construct different frontier for every observation (Neff *et al.*, 1994, Ogundele and Okoruwa, 2006).

However, this was later overcome by measuring the mean of the conditional distribution of inefficiency ( $\mu$ i) given the random error ( $\epsilon$ i) (Jondrow *et al.*, 1982). Neff *et al.*, (1994) who stated thus "while the ability of stochastic frontier to incorporate random disturbance term to account for events beyond management's control is appealing, the need to use an estimate to measure inefficiency may result in very similar farm efficiency estimates" however point out the weakness of the stochastic measurement though, according to several studies that have used this method, such a weakness seems not to occur. This study therefore will use the stochastic frontier method to analyse the technical efficiency of maize farmers in APEP and Out of APEP in Masindi District due to its stated advantages.

Production function estimation has been criticized in recent times that it results into simultaneous equation bias leading to wrong conclusions (Akinwumi and Kouakou, 1997). In such cases, estimation of technical efficiency using product and input prices has been advocated. It is because of the above proposition that this study adopted production function analysis to estimate technical efficiency and allocative efficiency. However, Neff *et al.*, (1994), contends that prices in a given region are always homogeneous and uniform across farms. And as such, "differences in efficiency measures are likely to reflect quantity, not price difference."

#### **2.4.3 Factors Determining Technical Efficiency**

A number of studies have been carried out to determine factors that influence efficiency of farmers especially on rice. Farrel's (1957) pioneer work on production efficiency that assumed constant returns to scale has been under going further improvements to increase the power of estimation (Ogundele and Okoruwa, 2006). Further modification of measurement went on to include other factors that were presumed to affect efficiency. Lau and Yotopolous (1971) estimated a profit function to determine differences in efficiency between large and small farms in India and found an inverse relationship. Kalirajan (1981) used a normalized profit function in estimating the economic efficiency of farmers growing high yielding irrigated rice in India. He compared large and small farmers and concluded that there was no significant difference between the groups. This implied that when small farmers access inputs they respond the same way to economic opportunities as large farmers. However, he cautioned that this is only possible when institutions ensure equal access to these inputs. This is rare since institutions themselves may not solve the problem of inequalities due to influence peddling of individuals (Kumbhakar, 1994).

Mubarik *et al.*, 1989, using an ordinary least squares estimated profit efficiency among Basmati rice growers in Pakistan. They found that there was general inefficiency of between 5 - 87% and socio-economic factors like household education, non-farm employment and credit constraint and institutional constraint affected farm efficiency. Institutional constraints identified were late delivery of fertilizers and thus late planting which impacted on technical efficiency of farmers. This method adopted a stochastic frontier approach for efficiency analysis, which accounts for random and farm specific errors. However, this study did not consider institutional factors because they are sometimes elusive (Kirsten and Vink, 2006).

In their study of relative efficiency of women and men as farm managers in Cote D' Ivoire, using a normalized profit function, Akinwumi and Kouakou (1997), found that they both had similar capabilities in farm management given equal opportunities. They also found out that capital and land factors in rice production were highly inelastic (0.04 and 0.2,respectively). Results have a strong message to Uganda's upland rice farmers especially as regard to capital (seed) that is being extended to farmers. This study therefore also seeks to find whether such inputs to farmers provide an incentive to improve maize production efficiencies. Kumbhakar and Bhattacharyya (1992), used a Cobb Douglas and adopted a restricted profit function in estimation of price distortions and resource use efficiency in India. They found that efficiency estimation based on market prices was not adequate because of existence of price distortions leading to imperfect markets and allocative inefficiency. They contended that opportunity cost of resources is not always reflected by market prices and the estimations based on such prices are bound to lead to wrong conclusions. As such, it can be said that prices may not lead to significant differences in estimation since they may be uniform in a given location (Neff et al., 1994).

The presence of government support or incentive may affect efficiency of farmers in one way or the other. Zaibet *et al.* (1999), studying on efficiency of government support in horticulture in Oman using both the stochastic production function (SPF) and Data envelopment analysis (DEA), found out that the percentage of efficiency was as low as 17%

while using SPF and 46% with DEA. This study only analysed technical efficiency and it dealt with a situation where the support was cross cutting. It therefore gives little room for comparison. The two methods used on the same data however give different outcomes, which makes it inconclusive. Kumbhakar (1994), estimated technical efficiency of Bengal farmers and found that the best farmers were only efficient to a level of 85.8% and that the majority of farmers were under users of exogenous inputs such as fertilizer, seeds. The under use of resources was related to distortion of markets resulting from government regulations. This study apart from mentioning the effects of distortions did not indicate the percentage of inefficiency that was attributed to state regulations.

#### 2.4.4 Recent Studies that used Stochastic Frontier Method

Hyuha (2006) estimated a translog profit function to determine the profit efficiency of rice farmers in Uganda. The study revealed wide variation in efficiency of between 2 and 100 % and the mean of 66%. This study also found that increase in profit would be achieved through increased expansion of land, a factor that may not be sustainable since rice production took place in wetlands. Ogundele and Okoruwa (2006) estimated a stochastic production frontier (SPF) to determine the technical efficiency differential in rice production in Nigeria. They found that farmers cultivating traditional rice and improved varieties shared relatively the same socio-economic characteristics except for farming experience and the number of extension visits. In terms of efficiency, the distribution was highly skewed with over 75% and 60% of the farmers having their technical efficiency above 90% in the traditional and improved technology groups, respectively. The results were never conclusive, attributed to variety mix up. Ogundari Ojo (2005) estimated a stochastic production function in mixed crop food production in Nigeria. They found that

farmers were 82% efficient and that age and farming experience contributed to overall technical efficiency.

Sharma and Leung (2000), also used stochastic production frontier (SPF) to estimate the technical efficiency of carp production and compared extensive and semi- intensive producers in India. They found that extensive producers were inefficient at 0.658 compared to semi- intensive producers at 0.805. This study however did not determine the model for socio- economic factors that contributed to observed farm inefficiency. Obwona (2000) also estimated a translog production function to determine technical efficiency differential between small and medium scale tobacco farmers in Uganda who did and did not adopt new technologies. Results showed that credit accessibility, extension service access and farm assets contributed positively to technical efficiency. The differences in efficiency between farmer groups were explained with only socio-economic and demographic factors. From the foregoing discussion, it can be deduced that not so many efficiency studies have been conducted in Uganda let alone on a few crops like rice crop. Most studies therefore are broad in nature and not specific to maize production in Uganda, which thus calls for a study to consider technical and allocative efficiency of maize farmers in Uganda.

# 2.4.5 Reasons for Choosing Stochastic Frontier Production Model

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 et al., 2006).

Both methods of estimating technical efficiency using stochastic frontier production function and price efficiency to measure allocative efficiency have been wildly used and yielded results. A robust Ordinary Least Squares (OLS) was used instead of Tobit Model in second stage of stochastic frontier production efficiency estimation because it's unbiased, consistent estimator

# 2.5 Graphical Explanation of Allocative and Technical Efficiency

The concepts of producing maximum output with available inputs (technical efficiency) and optimal use of these resources to maximize profits given the inputs prices (allocative efficiency) can be illustrated graphically as shown in figure 1 below. This can be explaned using a simple example of a two input  $(x_1, x_2)$ -two output  $(y_1, y_2)$  production process (Figures 1.1&1.2). Efficiency can be considered in terms of the optimal combination of inputs to achieve a given level of output (an input-orientation), or the optimal output that could be produced given a set of inputs (an output-orientation) (Sentumbwe, 2007).

# Figure 1.

## **Input Oriented Efficiency Measures**



Source: Kumbhaker and Lovell (2000)

The firm is producing a given level of output  $(y1^*, y2^*)$  using an input combination defined by point A in Figure 1 The same level of output could have been produced by radially contracting the use of both inputs back to point B, which lies on the isoquant associated with the minimum level of inputs required to produce  $(y1^*, y2^*)$  (Isoquant $(y1^*, y2^*)$ ). The input-oriented level of technical efficiency (TEI(y, x)) is defined by 0B/0A. However, the least-cost combination of inputs that produces  $(y1^*, y2^*)$  is given by point C (the point where the marginal rate of technical substitution is equal to the input price ratio w2/w1). To achieve the same level of cost (expenditure on inputs), the inputs would need to be further contracted to point D. The cost efficiency (CE(y, x, w)) is therefore defined by 0D/0A. The input allocative efficiency (AEI(y, w, w)) is subsequently given by CE(y, x, w)/TEI(y, x), or 0D/0B (Coelli, 1995).

In Figure 2. illustrated the production possibility frontier for a given set of inputs. If the inputs employed by the firm were used efficiently, the output of the firm, producing at point A, can be

expanded radially to point B. Hence, the output oriented measure of technical efficiency (TEO(y, x)), can be given by 0A/0B. While point B is technically efficient, in the sense that it lays on the production possibility frontier, higher revenue could be achieved by producing at point C (the point where the marginal rate of transformation is equal to the price ratio (p2/p1). In this case, more of y1 should be produced and less of y2 in order to maximize revenue. To achieve the same level of revenue as at point C while maintaining the same input and output combination, output of the firm would need to be expanded to point D. Hence, the revenue efficiency (RE(y, x, p)) is given by 0A/0D. Output allocative efficiency (AEO(y, w, w)) is given by RE(y, x, w)/TEI(y, x), or 0B/0D in Figure 1.2 (Coelli, 1995)





Source: Kumbhaker and Lovell (2000)

#### **CHAPTER THREE**

#### **METHODOLOGY**

## **3.1 FIELD METHODS**

# 3.1.1 The Study Area

Masindi District is located in the Western Region of Uganda between 1° 22'-2° 20' N and 310 22'-320 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 25°C) and soils are favorable for agriculture (Foodnet, 2004).

# 3.1.2 Sampling Procedure and Sample Size

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. Then from each sub-county a list of APEP farmers was received from APEP official operating within that area. From the provided list, 29 farmers were selected within 2 parishes. At least 14 APEP maize farmers were interviewed from

each parish. Randomly 29 non-APEP farmers producing the same crops were selected from the same sub-counties. Like for APEP farmers, of the 29 randomly selected non-APEP farmers from 2 parishes, at least 14 farmers were selected per parish. This made a sub total of 58 farmers interviewed where 29 were APEP farmers and the other 29 non-APEP farmers. When the 3 sub-counties were combined, they made an overall number of 175 farmers but 170 questionnaires were used in analysis of which 81 farmers were APEP and 89 non-APEP maize farmers.

## **3.1.3 Data Collection and Type of Data**

Primary data were collected from farmers using a survey method involving a structured questionnaire. The socio-economic data collected included sex of respondent, age, marital status and formal education levels. Production information collected included size of farmland owned, land tenure system, size of land under maize production, type of labour used in production, varieties of seed planted, amount of seed planted, fertilizer application, and seasonal yields. Amount of credit, access to extension services were also among production information (number of visits), amount of fertilizers used. Market information was also collected which included prices of seeds, seasonal quantities produced, incomes earned from maize farm sales. Data about constraints faced by maize farmers and suggestions to increase their outputs was also collected.

#### 3.2 ANALYTICAL METHODS

The first objective is attained by using descriptive statistics presented in tables of frequencies, percentages, standard deviation, and means. The second objective is attained by estimating allocative efficiency and technical efficiency using a Cobb Douglas

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production function and a stochastic production frontier function derived from a Cobb Douglas function respectively. The third objective is attained by estimating a robust linear regression. Analysis of allocative and technical efficiency and determinants of technical efficiency are described below.

## **3.2.1 Estimation of Allocative Efficiency (A.E)**

The first part of the second objective is attained by estimating allocative efficiency using a Cobb Douglas production function. This study assumes that maize production is dependent on human labour, fertilizers applied, amount of seed planted, size of land allocated, animal draught power and capital invested (expenses incurred purchasing Variable inputs). Therefore, allocative efficiency is estimated following physical production relationships derived from the Cobb – Douglas production function of Equation (1). Thus, the specific model estimated is given by

(1) 
$$Y = AX_1^{\alpha_1} X_2^{\alpha_2} \dots X_n^{\alpha_n} v$$

# Where

Y = Amount of maize produced per farm household (kg)

 $X_1$  = Human labour used by a given household in maize production (person days).

- $X_2$  = Animal power used by a given household in maize production (hours)
- $X_3$  = value of fertilizers (DAP and Urea) applied in maize by a household
- $X_4$  = Amount of seed planted (kg) by a given household
- $X_5$  = Land allocated to maize production (ha) by a given household

 $X_6$  = Capital (estimated as amount of money invested in maize production)

$$A = \text{Constant}$$

$$v =$$
Random error term

From (1) the linear production function can be re-written as

(2) 
$$LnY = LnA + \sum_{i=1}^{5} \beta_i LnX_i + \varepsilon$$

Where A,  $\alpha$  and  $\beta_i$  are parameters to be estimated. Following Chukwuji and his counterparts (2006), allocative efficiency analysis is done by estimating a Cobb-Douglas function using OLS. It is followed by computing the value of marginal product (*VMP<sub>i</sub>*) for each factor of production, which then is compared with the marginal input cost (*MIC<sub>i</sub>*). Results from (2) give Beta ( $\beta_i$ )

(3) 
$$\frac{\partial \ln Y}{\partial \ln X} = \left(\frac{\frac{1}{Y} * \partial Y}{\frac{1}{X} * \partial X}\right) = \left(\frac{X}{Y} * \frac{\partial Y}{\partial X}\right) = \beta_i$$

Using the coefficient estimates from (3), the marginal product  $MP_i$  of the  $i^{th}$  factor X is calculated as

(4) 
$$MP_i = \frac{\partial Y}{\partial X_i} = \beta_i \frac{Y}{X_i}$$

But 
$$AP = \frac{Y}{X_i}$$

Where Y is the geometrical mean of maize output (mean of natural logarithm); X<sub>i</sub> is the geometrical mean of input*i*;  $\beta_i$  is the OLS estimated coefficient of input*i*. The value of

marginal product of input *i* (*VMP<sub>i</sub>*) can be obtained by multiplying marginal physical product (*MP<sub>i</sub>*) by the price of output (*P<sub>y</sub>*). Thus,

(5) 
$$VMP_i = MP_i * P_v$$
.

(6) Allocative Efficiency (A.E) =  $\frac{VMPi}{Pi}$  but Pi = Marginal cost of the i<sup>th</sup> input.

Allocative efficiency is determined by comparing the value of marginal product of input *i*  $(VMP_i)$  with the marginal factor cost  $(MIC_i)$ . Since farmers are price takers in the input market, the marginal cost of input *i* approximates the price of the factor i,  $P_{xi}$  (Grazhdaninova and Lerman, 2004). Hence, if  $VMP_i > P_{xi}$ , the input is underused and farm profit can be raised by increasing the use of this input. Conversely, if  $VMP_i < P_{xi}$ , the input is overused and to raise farm profits its use should be reduced. The point of allocative efficiency (maximum profit) is reached when  $VMP_i = P_{xi}$  (Chavas *et al.*, 2005). The same method is used for both APEP and Non-APEP members separately.

#### **3.2.2** Estimation of Technical Efficiency (T.E)

Technical efficiency is estimated to achieve the second part of the second objective. Results are used to compare APEP with non-APEP maize farmers in terms of production efficiency. These results are used to establish whether APEP farmers were more or less technically efficient compared with non-APEP farmers. Following Battese (1992) and Raham (2003), technical efficiency of maize production is estimated using a stochastic production frontier, which is specified as

(7)  $Y = f(X_i; \beta) + \ell$ 

As earlier defined, Y,  $X_i$  and  $\beta_i$  are vectors of output, input levels and estimated parameters, respectively. The error term is "composite" (Ali and Flin, 1989; Sharma and Leung, 2000; Bravo-Ureta and Pinheiro 1993; Raham, 2003; Chavas *et al.*, 2005). Thus,

$$(8) \quad \ell = V - U$$

Where *v* is a two-sided  $(-\infty < v < \infty)$  normally distributed random error  $[V \approx N(0, \sigma_v^2)]$  that captures the stochastic effects outside the farmer's control (e.g., weather, natural disasters, and luck), measurement errors, and other statistical noise. The term *u* is a one-sided  $(u \ge 0)$ efficiency component that captures the technical inefficiency of the farmer. It measures the shortfall in output *Y* from its maximum value given by the stochastic frontier  $f(X_i; \beta) + v$ . We assume *u* has an exponential distribution  $[U \approx N(0, \sigma_u^2)]$ . The two components *v* and *u* are also assumed to be independent of each other. The parameters are estimated by the maximum likelihood method following Bravo-Ureta and Pinheiro (1993) and Bi (2004). Technical efficiency levels are predicted from the stochastic frontier production function estimation. Following Ojo (2003), this study specified the stochastic frontier production function using the flexible log linear Cobb- Douglas production function.

#### 3.2.3 Estimation of Factors Affecting Technical Efficiency

Objective number three is attained by determining factors that affect the level of technical inefficiencies by establishing the relationship between farm/farmer characteristics and the computed technical efficiency indices. Following Bravo-Ureta and Rieger (1990), Bravo-Ureta, and Pinheiro (1993) 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. A Robust regression is performed to solve the heteroskedasticity problem. The linear model is estimated as shown below for each farmer.

(9)  $T.E = \beta X + e$ 

Where TE = level of technical efficiency; X is a vector of explanatory variables that include number household members above 13 years of age; maize acreage; amount of credit; level of education household head (years, formal education); education level of respondent's spouse; major occupation of Respondent's spouse; age of household head; access to extension services (number of visits); type of maize seed planted (1= farmer used improved seed from input dealer and 0 = farmer used recycled or saved seed from previous season); work experience in maize production (years); sex of respondent (1=female; 0 = male); quantity of chemical fertilizers applied (kg/hectare); hours put into farm work for maize production per season; whether farmer sold maize from their homes = 1 or otherwise = 0:  $D_{ip}$  a dummy represent membership to APEP (1 = member; 0 = non-member) ).
#### **CHAPTER FOUR**

#### **RESULTS AND DISCUSSIONS**

#### 4.1 Socio-economic Characteristics of the Farmers

The descriptive statistics of maize farmers' characteristics is shown in Table 1 below. Such characteristics include, sex, age, marital status, and household size, level of formal education in years spent in school, farm experience in years, size of farm land used for maize production, spouse age and education level and are systematically discussed below.

#### 4.1.1 Socio-Demographic Variables:

In general, 13% of the respondents interviewed were women and 87% were men. Among women interviewed, 16% belonged to APEP groups and 11% were Non APEP members and, then among men interviewed, 84% were APEP members and 89% were non-members (Table 1). There were no significant differences the number of male or female between APEP and non-APEP farmers. In both groups, men dominated the number of people interviewed and few women. The overall difference in the numbers of women and men involved in maize production may be attributed to the common cultural norms in Uganda and Africa, which deny women ownership of resources and big businesses especially, which earns relatively big sums of incomes.

Results in Table 1 below shows that 96% of APEP members interviewed were married, 1% single and 3% were widowed, for non-APEP, 88% were married, 7% single and 5% were widowed. Overall there were 92% married farmers, 4% single and 4% widowed farmers interviewed. Both groups APEP and non-APEP had a big number of people married and

few single and widowed farmers. However, there was no significant difference between the marital status. Marital status in most cases is considered important in household decision making where married people have always succeeded in decision-making.

Characteristics	Description	APEP Members (n =81)	Non APEP members (n = 89)	Total (n= 170)	Chi- Square Test
Sex of farmer	Female Male	16% 84%	11% 89%	13% 87%	0.947
Marital status of farmer	Married Single Widowed	96% 1% 3%	88% 7% 5%	92% 4% 4%	4.374
Type of Seeds used	Recycled Improved	29% 71%	42% 58%	35% 65%	3.286*
Output Market Place	Farm gate Elsewhere	87% 13%	89% 11%	88% 12%	0.283
		Mean- value	Mean- value	Average Mean value	T-Test
Age of farmer (Years)		43	38	41.5	28. 12***
Household size		7	7	7	1.53
Education level of farmer (yrs)		6	7	6.5	-1. 433
Size of land owned (acre)		6	6.2	6.1	-0.1

 Table 1:
 Demographic Characteristics of Maize Farmers in Masindi Districts

**Source:** Survey Data 2007

As shown in Table 1, APEP farmers were older (43 years on average) than a non-APEP farmer whose average age was 38 years and the difference in average age was found to be significant between the two groups. The reason as to why APEP members have higher proportion of farmers in such age brackets may be due to reducing farm labour, which calls

for group support or collective action. Such services were said to be some of the benefits of belonging to APEP groups. Increase in age sometimes may be an indication of number of years spent in farming (experience), which is one of the indirect factors that affect production. In comparison with Ogundele and Okoruwa, (2006) on average, maize farmers in masindi were in their productive ages.

Further, household size sometimes in village setting is known to be a source of farm and offfarm income generating activities (Sentumbwe, 2007). Both APEP and non-APEP farmers on average had the same number of people living in their homes. (Table 1). At the peak of the season, family labour is thought to be a remedy especially during second weeding and harvesting. In addition to availability of family labour, education also plays a big role in farming especially during trainings and putting in practice knowledge gained. Results indicate that there is no significant difference in the education levels between APEP members and nonmembers. On average APEP farmers spent 6 years in school and non-APEP farmers on average 7 years spent in school and thus most had were primary dropouts. Therefore, there is need of continuous extension services to re-enforce better use of other factors of production. Education plays a great role in adoption of most new technologies that normally calls for better management including consistent record keeping and proper use of the various inputs in maize production (Cheryl *et al*, 2003).

Land is one of the major factors used in agricultural production. The average land owned by both APEP and non-APEP was almost the same because results indicate no significant difference in the size of land owned. Furthermore, few APEP farmers (29%) were using recycled maize seeds when compared with the 42% of non-APEP farmers who use the same type of seeds and thus most (71%) APEP farmers were using improved seed varieties and only 58% of non-APEP farmers were using improved seed. Such difference between the average numbers of farmers using recycled or improved for both was reported to be significant at 10% level. APEP farmers were using more of the improved seed than the recycled seed may be due to the training attended that discourages them from using recycled and encouraged to use improved seeds because of its advantages.

Generally, 88% of both APEP and non-APEP sell their produce at home and only on average 12% take their produces to urban markets. APEP farmers selling at farm gate were 87% and 13% of APEP farmers were selling their produce in urban markets. In contrast, 89% of non-APEP farmers were selling produce at farm gate while only 11% of these farmers were selling their maize in urban markets. Results indicate a slightly bigger number of APEP farmers selling in urban areas compared with the 11% of non-APEP farmers, though the difference is not significant. Such a slight difference may be due to increased yields of APEP farmers and though little, some market information about the buyers and urban market prices. However, the major reasons to why farmers sell their produce mainly at farm gate may be due to poor transport system for farmers produce to urban market; lack of market information and lack of storage facilities.

# 4.1.2 Input use, Productivity and T-test Mean Differences among Farmers in Masindi District

Non-APE	Р			
	APEP Members (n=81) Mean	Non-APEP Members (n=89) Mean	Overall Mean	t-value
Land under maize production (Ha)	1.12 (5.62)	0.96 (3.18)	1.04	-0.58
Years farmer has been growing maize	18.36 (10.19)	14.50 (10.13)	16.43	-2.47**
Total number of person days worked (days/season)	37.25 (35.55)	51.41 (48.53)	44.33	2.15**
Cost spent on seeds and fertilizers purchase (UGX/hectare)	37,752.26 (71,168.93)	19, 649.82 (32,967.97)	28,701.04	-1. 79*
Quantity harvested (kg)	2,615. 30 (6,508. 52)	1,255.54 (2,009.53)	1,935.42	-1. 88*
Yields (Kg/hectare)	367.52 (467.60)	230.08 (353.95)	298.80	- 5.37***
Output prices UGX/kg	206.73 (47.85)	200.02 (55.07)	203.375	-0. 85
Gross profits (UGX/hectare)	20,581.70 (148,601.85)	-23,695.19 (83,855.84)	-3,113.49	-2.18**
Off-farm incomes (UGX)	93,703.70 (216,270.6)	195,842.70 (518,716.86)	191,625.05	-1.70*

## Table 2: T-test for Mean Difference in Input Use and Output among APEP and

Source: Survey Data 2007, Figures in parentheses/brackets are standard deviations

\*, \*\*, \*\*\* = significance levels at 10%, 5% and 1% respectively. SD is standard deviation. UGX= Ugandan Shillings, Kg =Kilogram

Results indicate that farmers belonging to APEP were allocating a bigger proportion of land owned to maize production (1.119 hectares on average) compared to non-APEP members who were allocating 0.995 average hectares to maize production. However, there was no significant difference between mean land size allocated for maize production both categories.

In addition, results revealed that APEP members on average had more years (18) of experience compared with non-members who had 15 years of experience. The difference in years of experience is significant at 5% level. The more experienced the farmer the better for positive yields since the farmer may know more methods of reducing production risks. Furthermore, results indicated that there was a significant difference in the total number of person days employed in maize production in the second season at a 5% level. Non-APEP members had more person days worked (51.4 days/season) compared with APEP members who worked for 37. 25 days/season. There was a significant difference between APEP and non-APEP members in terms of costs /hectare incurred in buying improved maize seeds and fertilizers at 10% level. APEP members spent 37,752 /= Ugandan shillings almost doubling costs (19, 650/= Ugandan shillings) incurred by non-members. This is because farmers belonging to APEP used improved seeds and fertilizers compared with non-members.

More experience and use of improved seeds, and fertilizers may be the reason as to why farmers in APEP groups had a significantly higher average quantities of maize produced. The difference in the quantity of maize produced was significant at 10% level in second season with total output of 2615 Kg and 1255Kg produced by APEP members and nonmembers respectively. Though there was no significant difference between average land size allocated to maize production by both groups, results indicate a significant difference in the yields (Kg/hectares) at 1%. Amount of maize produced per acre by APEP farmers was 367.521Kg/hectare and this greater than for non-APEP members who produced 230.1Kg/hectare. There was no significant mean difference between prices received by both APEP and non-APEP maize farmers in the second season of year 2007. The only difference was that APEP farmers were earning 6.7/= Uganda shillings more than non-APEP farmers. The unit price of maize sold by APEP farmers was 206/= Ugandan shillings while non-APEP farmers sold their maize produced at 200/= Ugandan shillings. The small difference may be dependent on good post-harvest handling techniques for clean and big grain sizes since are mostly produced from improved/hybrid seeds. Such attributes are translated into improved quality of maize grains.

Further, the good performance of APEP farmers in terms of quantities and yields of maize was translated into more gross profits per hectare compared with non-members. Results indicated that there was a significant difference in gross margins earned at 5% level. APEP farmers seemed to earn more average profits (Shs 20,582) compared with non-members who were making losses of Shs -23,695 on average. However, non-APEP farmers earned more average incomes (Shs 195,842) from off-farm employment compared with the members who on average earned Shs 93,703 in the second season of year 2007. The difference in off-farm incomes earned in second season of 2007 was significant at the level of 10%. This may be due to less labour committed to farming because of losses incurred and hence

preferring to commit their labour to off-farm employment where they earn more incomes for survival (Sentumbwe, 2007). The common off farm employment opportunities available in the area included, trading, brick making and charcoal burning.

#### 4.2. Estimation of Allocative and Technical Efficiency of Farmers

#### **4.2.1 Input Elasticities**

In order to achieve the second objective of this study of estimating the allocative efficiency, elasticities ( $\beta_i$ ) need to be calculated. The Cobb-Douglas production function was estimated for both APEP members and non-APEP members. The Cobb-Douglas production function was estimated using Ordinary Least Squares (OLS) and the coefficients estimated represented individual elasticities. The elasticities associated with all inputs were less than one except land under maize production used by APEP members. Thus, for inputs with elasticity less than one, a unit increase in the respective input would result in less than a unit increase in maize output. In contrast, a unit increase in land would result in more than a unit increase in maize output among APEP farmers. Estimated elasticities are shown in the table below for both groups, APEP and non-APEP members (Table 3).

—		
Dependent = maize output	APEP	Non-APEP members
	members	
Variable	Elasticity	Elasticity
Labour	0.10	0.0002
Animal Draught power	0.057	-0.064
Seed planted	0.047	0.2730*
Fertilizers	-0.022	-0.037
Land	1.009***	0.8030***
Capital	0.187*	0.073

Table 3:Input Elasticities

\*, \*\*\* = significance levels at 10% and 1% respectively.

A unit increase in labour would result in 0.01 and 0.0002 unit of maize output for APEP and non-APEP members respectively. Though the increase in output is not significant for both groups, there is higher increase output among APEP members than non-members. Elasticity of non-APEP members was negatively related to maize output and hence a unit increase in animal draught power resulted into 0.064 decrease in maize output. Nevertheless, among APEP farmers, the elasticity had a positive relationship with output and hence a unit increase in the context increase in Animal draught resulted into 0.057 units of maize produced.

A unit increase in seed planted would result in an increase of 0.047 and 0.273 unit of maize output for both APEP and non-APEP farmers respectively. However, a unit increase in seed planted by non-APEP farmers was found to be significant. This may be due to more usage of recycled seeds, which lose some potential of better yields compared with APEP farmers who mostly use improved seeds with full potential of better yields. Fertilizer in both scenarios was found to have a negative relationship with the output thus a unit increase in fertilizers result into 0.022 and 0.037 decreases in maize output for APEP and non-APEP farmers respectively.

Elasticities of land under maize production and capital invested in terms of total variable costs invested in the second season of 2007 both had a positive relationship with output and found to be significant for APEP farmers at 0.001 levels with exception of capital used by the non-APEP farmers was not significant. A unit increase in land and capital used by APEP farmers result into 1.009 and 0.187 increase in maize output and a unit increase in the same inputs result into 0.803 and 0.073 increase in maize output. Thus, both APEP and non-

APEP farmers if they increase on land size under maize cultivation will result into increased maize output. In addition, both groups should use less fertilizers for increased maize output.

#### 4.2.2 Allocative Efficiency Estimation

For profit to be maximized VMP should be equal to the respective unit factor price. Though APEP farmers were found to be technically more efficient than non-APEP farmers, results indicate that both groups were not quite efficient in allocating the inputs with exception of improved seed used by APEP members (0.92). However, overall, APEP farmers were relatively more efficient in allocating of these inputs compared to the non-APEP members (Table 4).

Variable	Coefficients $(\beta)$	APP	MPP	Output unit	VMP <sub>i</sub> (UGX)	Pi	Allocative efficiency
	$(\mathcal{P}_i)$			prices (Py) (UGX)	、 <i>,</i>	(UGX)	(VMP <sub>i</sub> / P <sub>i</sub> ) Scores
APEP							
Labour (person days)	0.10	9828	9.83	206	2,024.98	3,000	0.68
Seed (Kg)	0.05	148.10	7.41	206	1,526.46	1,666	0.92
Animal Draught power (person days)	0.06	537.00	32.22	206	6,637.32	30,000	0.22
Non-APEP							
Labour (person days)	0.0002	40.28	0.0081	200	1.62	3,000	0.001
Seed (Kg)	0.27	74.69	20.17	200	4,034	1,666	2.42
Animal Draught power (person days)	0.06	310.89	18.65	200	3,730	30,000	0.12

Table 4:Estimation of Allocative Efficiency

Where MPP= APP\*input elasticity ( $\beta_i$ ) (MPP and APP = Marginal and Average Physical Product)

MVP=MPP\*output price (Py) (MVP = Marginal Value Product),

Alloctive Efficiency  $(A.E) = MVP/P_i$ 

If A.E = 1 then the input is optimally/efficiently used and if A.E < or > 1 then input is inefficiently used

Results in Table 4 above indicated that APEP farmers were relatively more allocatively efficient in terms of human labour and animal draft compared with non-APEP farmers. APEP farmers scored allocative efficiency levels of 0.68, 0.92, and 0.22 for inputs human labour, seeds planted and animal draught power respectively. However non- APEP farmers' efficiency scores for human labour (0.001) and animal draught power (0.12) and seed input (2.42) were very far away from a score of 1 hence were inefficiently allocated. These inputs were over-utilized in maize farming and sub optimal utilization of seed input among non-APEP farmers. Such performance may be due to limited training or extension services responsible for disseminating technical knowledge.

One of the objectives of APEP was to transform subsistence to commercial farming. Based on this objective, APEP farmers were trained on the use of some of these inputs. APEP farmers had relatively improved allocative efficiency in the use of labour and animal draught compared with non-APEP farmers because they are tending to commercialization and invest based on trainings from APEP (Nelson *et al.*, 1991). Non-APEP farmers may be more challenged with family labour allocation which is readily available in most poor rural areas so they over utilize it compared with the APEP farmers who also face the same problem but relatively improved allocative efficiency. Amounts of all inputs used by APEP farmers need to be reduced in order to optimize resource allocation though at a relatively small magnitude compared with non-APEP that need to reduce use of labour and animal draught power at a relatively big magnitude.

#### 4.2.3 The Stochastic Production Frontier

The stochastic production frontier was estimated using the STATA software. The dependent variable of the estimated model was maize output in the second season of 2007 and the independent variables include; land under maize, labour in person days, animal draught power in days, amount of seeds planted in kilograms and capital invested in Ugandan Shillings (UGX). Technical efficiency scores were thus generated from this estimation as shown in table 5 below.

	Maize Output 2 <sup>nd</sup> 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	0.24***	0.05	4.54	0.000
(UGX)				
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 $(n) = 170$				

 Table 5:
 Estimates of the Stochastic Frontier Production Function

\*, \*\*, \*\*\* = significance levels at 10%, 5% and 1% respectively.

#### 4.2.4 Estimation of Technical Efficiency

Technical efficiency was obtained using the estimated parameters from the log linear Cobb Douglas stochastic production frontier. T.E. computed for each household later was disaggregated into two farmer groups, i.e. the APEP and Non APEP farmers. The minimum estimated efficiency score was 4 percent, the maximum 92 percent and the overall mean was 58 percent (Table 6).

Ranges of Efficiency	APEP (n=81)	Non-APEP (n=89)	Overall (n=170)
<20%	6%	12%	9%
20-39%	15%	19%	17%
40-59%	17%	16%	17%
60-79%	36%	37%	36%
80-99%	26%	16%	21%
Total	100%	100%	100%

 Table 6:
 Range of Technical Efficiency for APEP and Non-APEP farmers

Source: Survey Data 2007

On Average 62 percent of APEP and 53 percent of Non-APEP farmers operated at over 60 percent technical efficiency level. This may be attributed to skills obtained from APEP extension services. On the other hand 6% of APEP farmers and 12% of Non-APEP farmers were operating below 20% of technical efficiency and thus, considered technically inefficient. Further, 31 percent of Non APEP farmers were operating below 40 percent of TE level compared with the 21 percent APEP farmers who operated below the same T.E level.

#### 4.2.5 The T-Test of Technical Efficiency for APEP and Non-APEP Farmers

The STATA software was used to test and compare efficiency levels of farmers belonging to APEP and non-APEP members (Table 7 below).

Membership to APEP	Sample size	Mean efficiency	Standard Error	Standard Deviation	
Members (y)	81	0.67	0.022	0.20	
Non members (x)	89	0.49	0.026	0.25	
Combined	170	0.58	0.20	0.24	
Source: survey data 2008					
Satterthwaite's degrees of	freedom = 168		t = -5.20	64	
Ho: $mean(x) - mean(y) = 0$ (no mean difference)					
Ha: diff $< 0$	Ha: diff $\neq 0$	Н	Ia: diff $> 0$		
Prob (T < t) = 0.0000	Prob $(T > t) = 0.0$	000 Pro	(T > t) = 1.0000		

 Table 7:
 Difference in efficiency levels of APEP and Non-APEP Members

The results show that there was a significant difference in T.E scores between APEP and non-APEP members at 1% level. APEP farmers had a relatively higher level of mean technical efficiency (67%) than the non-APEP farmers (49%). The overall efficiency was found to be 58% for the whole sample. These results indicate the positive impact of APEP training and pieces of advice adopted by farmers. Sentumbwe (2007) and Glenville (2000) also found out in their studies that farmers who had got training in better agronomic practices were technically more efficient than farmers who lacked such training.

#### 4.3 Factors Affecting the Level of Technical Efficiency

Table 8 below shows the linear regression results of T.E scores against explanatory variables. A robust standard errors regression was done to address heteroskedasticity. The F-value indicates that the explanatory variables combined, significantly influence changes in the dependent variable. Results indicate that membership to APEP, household size, type of seeds planted (improved = 1 and otherwise =0) and maize market (selling at farm gate = 1 and otherwise = 0) 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.

Variable	Coefficient	Robust S.E	T-value	P-value
Dummy (APEP Member $= 1$ )	0.18***	0.03	5.52	0.00
Household size	0.01**	0.01	2.06	0.04
Dummy (use improved seeds =1)	0.10***	0.04	2.54	0.01
Dummy (Sell maize at farm gate =1)	-0.09**	0.04	-2.08	0.04
years farmer has spent growing maize	-0.003*	0.002	-1.71	0.09
Years farmer spent in school	0.002	0.01	0.29	0.77
Constant	0.46***	0.08	6.00	0.00
Number of Observation = 170				
F-value $= 9.08^{***}$				
Adjusted $R^2 = 0.22$				

 Table 8: Determinants of Technical Efficiency among Maize Farmers

\*\*\*, \*\*, \* denote significance at 1%, 5% and 10% levels

Membership to APEP programs was found to be positively related and significantly affecting technical efficiency at 1% level. This implied that there was a positive contribution of APEP training on maize farmers' production efficiency. These results match with Sentumbwe (2007) study that found out that farmer who adopted new technologies and pieces of advice given to them by IPM -systems were technically more efficient than farmers who were using traditional methods. Another study done by Glenville (2000) also indicated that farmers who had got training in better agricultural practices were more technically efficient than those that had not participated.

Household size was found to be positively and significantly affecting technical efficiency of maize farmers at 5% level with t-value of 2.06. This 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 improving production efficiency. In most African rural settings, increased household size means increasing labour force. 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. A study carried out by Jema (2006) also indicated a positive and significant effect of family size among small-scale vegetable farming households in Ethiopia.

As expected earlier that new technologies positively have an effect on increased productivity, variety or type of maize seeds planted by these farmers had a positive and significant effect on the technical efficiency of farmers at 5% level. Most APEP farmers were using improved seeds and according to stochastic production frontier results indicate that they were technically more efficient (62%) compared to non APEP farmers (56% efficient). The use of improved seeds will also increase efficiency.

Selling from home or taking produce in urban or peri-urban market show that most farmers (82%) were selling their maize from home and a few had access to markets in trading centers and big towns. According to results, 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 selling at markets. Sometimes farmers lack market for their produce and storage facilities resulting into high post harvest losses and this discourages them from increasing production and concentration on maize crop.

In addition, results indicated that years the farmer has spent in maize production negatively and significantly affects technical efficiency. Increase in age sometimes may be an indication of number of years spent in farming (experience), which is one of the indirect factors that affect production. The negative sign may be due to reduced activeness of the farmer as he/she grows old, meaning that labour productivity reduces as age increases at a point of diminishing returns.

Though not significant, education level of farmer was found to be positively affecting technical efficiency. Thus, as years spent in school increases it results into increased technician efficient. Such results support findings of this study since education is believed to have a positive relationship with adoption of new technologies and advisory services resulting into improved efficiency (Amos, 2007). Hyuha, (2006) study results also support results from this study about education. Thus, improving education level of farmers in Masindi district results into increased technical efficiency.

#### **CHAPTER FIVE**

#### SUMMARY AND CONCLUSIONS

#### 5.1 Summary of the Findings

This study aimed at establishing the impact of Agricultural Productivity Enhancement Programme (APEP) advisory services on maize farmers in Masindi district. This overall objective was achieved by estimating and comparing allocative (A.E) and technical efficiency (T.E) of Both APEP and non-APEP maize farmers. Determinants of Technical Efficiency among APEP and non-APEP maize farmers in Masindi were also estimated. In additional to the set specific objectives, the study first characterized both categories of maize farmers in terms of social demographic factors, ownership of resources and production. The characterization was established using descriptive statistics generated by Statistical Package for Social Scientists (SPSS) computer software.

Descriptive statistics indicated that among APEP farmers interviewed; only 16% were women and 84% were men. For non-APEP members interviewed, 11% were women and 89% were men. The t-test results revealed that there was a significant difference of some input use among APEP and non-APEP members. APEP farmers spent more on purchase of fertilizers and improved seeds, compared with non-APEP farmers. More use of the mentioned inputs by APEP farmers may be the reason as to why they had more maize yields and incomes compared with the non-APEP. However, non-APEP members were using more of personal labour and earned more off farm incomes compared to APEP farmers. The difference may be due to less labour allocated to farming and more to off farm employment by non-APEP farmers for better wages compared with low incomes reaped from farming.

Low incomes from farming may be due to low productivity as results of poor technologies used and poor maize markets.

To attain the first part of the second objective, (Allocative efficiency), the elasticities of production were first estimated by simplifying a Cobb Douglas function in form of a log linear function. The SPSS results showed that land was positively related to maize output and significant at 0.01 levels for both APEP and non-APEP members. The coefficient of land was positive and greater than one meaning that a small increase in land allocated to maize result into more and more increase in maize output thus elastic ( $\beta = 1.01$ ) for APEP members. Another factor which was found significant was maize seed ( $\beta = 0.273$ ) used by non-APEP members at 0.1 level.

Both APEP and non-APEP farmers were not allocating resources efficiently overall. Seed input was the most efficiently allocated resource among APEP farmers since 0.92 is closer to 1 considered to be the most efficient resource allocation level. Animal draught was the least efficiently allocated input among APEP farmers. For non-APEP farmers, all resources were inefficiently allocated since their scores were very far away from a score of 1. APEP farmers were relatively more efficient in the usage of all inputs compared with non-APEP farmers. However, both groups need to reduce on the use of human labour and animal draught (ox-ploughs) in order to achieve optimal resource allocation.

The stochastic frontier production model results indicated that there was a significant difference between APEP and Non-APEP mean technical efficiency at 1% level. APEP farmers were more technically efficient with mean efficiency of 67% compared with non-

APEP farmers with 49%. Moreover, 62 percent of APEP and 53 percent of non-APEP farmers operated at over 60 percent technical efficiency level considered to be within the technical efficiency range. Furthermore, only 21% of APEP farmers were operating below 40% technical efficiency level compared with 31% of non APEP farmers operating at the same technical efficiency level. Thus, non APEP farmers were less efficient compared with APEP farmers.

Determinants of technical efficiency were identified and these included: membership to APEP, household size, variety of maize seed planted, market place of output and years farmer has spent in maize farming. These factors had a positive relationship with technical efficiency with exception of market place for maize and years farmer has spent in maize farming. Large household size was found to be important in crop production especially during peak seasons and this improves on efficiency of farmers. Use of new technology also in most cases positively affects technical efficiency and these technologies may include improved maize seeds among others (Wambui, 2005). Results further showed that APEP farmers were more technically efficient than non APEP and this may be attributed to the use of both pieces of advices given by APEP combined with improved seeds planted. Selling at home maize negatively and significantly affected technical efficiency calling for improved markets access among maize farmers. Number of years farmer has spent in maize farming was also significantly affecting technical efficiency of maize farmers though negatively.

#### 5.2 Conclusion

T-test results to characterize both APEP and non APEP farmers indicated that, APEP purchased more of the fertilizers and improved seeds than non-APEP farmers. This may be the reason to why APEP farmers had more maize yields in second season of 2007 translated into increased gross margins compared with non APEP farmers. Further, results from elasticities showed a positive and significant relationship between maize output and land size, and capital for APEP farmers and seeds used by non -APEP farmers. Hence increased use of these inputs increases maize output. Therefore to increase maize production, APEP farmers need to expand their land used for maize production and non APEP farmers need to use more of the improved seeds.

Farmers belonging to APEP did allocate more efficiently the use of seed than all other inputs. Non APEP farmers were allocating inefficiently all resources. However, both groups need to reduce on the use of labour and animal draft and more of seed inputs among Non APEP farmers to realise optimal resource allocation and hence maximising profits. There is need to train farmers on technical efficiency and resource allocation aspects in order to boost increased maize revenues. Also policies promoting better market information accessibility should be used so that the farmer knows what to buy and not to buy at a given output/input prices.

Based on technical efficiency, results from this study indicated that APEP farmers were more efficient than non-APEP farmers. This may be due to adoption of pieces of advices given by APEP farmers. Thus for improved production efficiency, farmers need to be trained on the use of these input. Further more, determinants of technical efficiency were estimated in this study. Most determinants estimated were positively with exception of selling maize at home at farm gates and years farm has spent in maize farming which had negatively effect. Positively related factors included membership to APEP, household size, and variety of seeds planted. Increase in APEP membership, household size and improved seeds planted results into improved technical efficiency. While increased sell of maize at home (farm gate) and years farmer spend in maize farming reduces T.E.

Both APEP and non-APEP maize producing farmers in Masindi district need to consider the above these factors in order to improve on their technical efficiency including factor not explained in details but mentioned in Table 8 above. Further, both groups need to improve on access to market information, more APEP type trainings about farming, use more of improved seeds and ensure that most family members engage in farming especially during peak seasons and encourage more youth to participate in farming. With the help of Uganda government and NGO, farmers need more search for markets of maize for realized profits. However, non APEP farmers need more efforts of using improved maize seed and also get more technical training to boost their production and catch up with the APEP farmers since both factors are seen to be positively effecting efficiency.

Overall, the Agricultural Production Enhancement Programme (APEP) had a positive impact on maize farmers in Masindi district. The project trained farmers' better agricultural practice and farmer group formation. Better performance in terms of technical and allocative efficient of APEP maize farmers compared with producers outside APEP project was a reflection of the positive impact of the project. However, there is still need for more training in terms of allocative efficiency for improved investment in maize production.

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#### 5.3 Recommendations

Positive results achieved by both APEP and their trained farmers indicate that farmer training on the use of inputs is important. This calls for more efforts by the government and other NGOs to increase on farmer's trainings on better use of inputs, increased bargaining power through group dynamics for better produce prices and efficient use of land. If such knowledge is disseminated then farmers will improve on their technical and allocative efficiency resulting into increased maize output and incomes, hence poverty alleviation.

Furthermore, amount and type of seed planted were found to be vital for improved farmers' maize output. Therefore, the government of Uganda, APEP program and other NGOs should help in empowering farmers with inputs like improved seeds at subsidized prices for increased maize output. Most interventions by NGOs and government have been aiming at increasing farmers output (productivity) and less focus on output and input markets/prices. For improved technical and allocative efficiency, NGO and government should start devising means of improving on farm-gate maize prices by provision of the necessary infrastructure, market information, and promoting value addition among maize farmers.

Furthermore, stakeholders in agricultural sector need to design programs that attract more youth in agricultural production. Since increase in number of years farm spend in maize production is negatively affecting efficiency, thus they grow old they loose energy needed in accomplishing hard tasks in farming. This may result into reduced technical and allocative efficiency and hence low agricultural productivity further result into food insecurity both in rural and urban population.

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#### 5.4 Suggestions for further studies

Though this study has found out that increased land and amount of seeds planted will boost maize production, further studies should be carried out to know other factors that may affect land expansion and adoption of improved seed use in Masindi district among these groups. Such a study will help in suggesting better methods of farmers' expenditure on either to use more improved seeds or spend more on hiring land for increase maize output. This is because the farmer may not have a potential of accessing both inputs at a prices that suit his/her farm capital. Also studies on the effect of input and output price elasticity on maize output can be carried out for both groups. Other studies may include contribution of APEP groups on maize production in Masindi district.

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## APPENDICES

## **QUESTIONNAIRE**

## MAKERERE UNIVERSITY, FACULTY OF AGRIGULTURE, DEPARTMENT OF AGRICULTURAL ECONOMICS AND AGRIBUSINESS, MSC. FARM LEVEL SURVEY QUESTIONAIRE; ANALYSIS OF IMPACT OF APEP ON MAIZE FARMERS IN MASINDI DISTRICT, UGANDA

Questionnaire num	ber			
District	County		••••	
Sub-county	Parish			Village
Member of APEP f	farmer groups Yes ()	No (	)	

## A) BACKGROUND INFORMATION

1) Respondent's Names...... (2) Sex (a) Male (b) Female

3) Marital status (a) Married (b) single (c) Widowed

4) Age......(5) Education level and highest class attained.....

Age group		Sex			
	Male	Female			
0 - 7					
8 -18					
19 - 64					
64 +					
Total					

(8) For adults in the household

Member	Sex	Age	Education	Main occupation	No of years at work
of			level		
Household					

## 9) Which of the following form your major occupational activity?

Activity	Farming	Trading	Formal employment	Casual work
Ranking(1-4)				
Years in the				
activity				

10) Do you grow maize? A) Yes ( ) No ( )	
--	--

11) How long have been growing the above maize? .....

## **B) LAND UTILISATION**

What is the average price of land in this area.....Ushs/acre

What is the average cost of renting land in this Area.....Ushs/acre

13) Land allocation (all in acres)

1 <sup>st</sup> season o	f 2007 January	2 <sup>nd</sup> season of 2007 July - Dec									
Land	Land hired	Land rented	Total	land	Land owned	Land hired	Land	rented	Total	land	
owned		out	cultivated	1			out		cultivated		

(15) Land allocation to crops by order of preference

	1 <sup>st</sup> season Janua	ary – June 2007	7	2 <sup>nd</sup> season July – Dec 2007							
Crop	Owner's land	Hired land	Total cropped	Owner's land	Hired land used	Total cropped area					
	used (acres)	used (acres)	area (acres)	used (acres)	(acres)	(acres)					
1)											
2)											
3)											

## C) PRODUCTION INFORMATION ON MAIZE

## INPUT UTILISATION

16) Do you use the following inputs in your maize gardens? A) Improved seeds Yes () No () B) Fertilizer Yes () No () C) Agro-

chemicals Yes ( ) No ( ) (D) Heavy machinery Yes ( ) No ( ).

17) Do you access inputs from government agencies Yes ( ) No ( )

18) If yes, how much was received.....(Kg)

19) Input utilization in maize production for last year

1 <sup>st</sup> seaso	on 2007					2 <sup>nd</sup> season 2007										
Input	Quantity	Price	Distan	Source/	For credit	Quantity	Price/ unit	Distance	Source/	For	credit					
type	used	/ unit	ce to	Provider	amount to	used	(Ug. Shs)	to	Provider	amount	to be					
	(Kg/ lts)	(Ug.	source	indicate C for	be repaid	(Kg/ lts)		source	indicate C for	repaid						
		Shs)	(Kms)	cash and L for				(Kms)	cash and L for							
				credit					credit							

20) Have you received any form of training on use of input in maize production? A) Yes ( ) b) No ( )

21) If yes, who provided the training?

a) Extension agent ( b) NGO ( c) Farmer (d) other specify.....

22) For the above service provider, fill the table below on the number of times they rendered service per season.

Service provider	1 <sup>st</sup> season 2007	2 <sup>nd</sup> season 2007
Extension agent (Govt)		
NGO		
Farmer		
Others specify		

#### D) LABOUR INPUTS IN MAIZE PRODUCTION

23) What is the main source of labour for maize production?

a) Family labour (b) Hired labour (c) Both

24) How many labour units in total worked in the maize field in the last two seasons of 2007

		1 <sup>st</sup> sease	on		2 <sup>nd</sup> season								
Туре	Men	Women	children	Tractor	Men	Women	children	Tractor					
Family													
labour													
Hired													
labour													
Total													

Activity	Type of Worker														
	Men			Wom	en		Children	n		Tractor					
	No.	Days	Cost	No.	Days	Cost	No.	Days	Cost	No.	Days	Cost			
Land prep 1 <sup>st</sup> .															
2 <sup>nd</sup> ploughing															
Planting															
Fertilizer															
application															
1 <sup>st</sup> weeding															
2 <sup>nd</sup> weeding															
Spraying															
Scaring birds															
Harvesting															
Threshing (drying,															
packaging and															
storage)															
Transport to market															

25) Activity labour demands in maize for last season

Key: men/ women = > 18yrs, children <18. 1 Man- day = 6 person hours for a man = (0.75\*6) person hours for woman = 12 child hours.

## E) CROP OUTPUT

26) Do you sell maize produced on you farm a) Yes ( ) b) No ( )

27) If yes, please fill the table below.

season	Harvested	Quantity	Quantity	Price/	Point	Cost of	Quantity	Quantity
	area	harvested	sold	Kg	of	sale (tax,	consumed	given
	(acres)	(Kg)	(Kg)	(Ug.Shs)	sale	transport)	(Kg)	out as
						(Ug.Shs)		donation
1 <sup>st</sup> season								
2 <sup>nd</sup> season								

28) What problems do you face in marketing of maize?

••••		•••	•••		•••	•••	•••	•••		•••			•••	•••		•••			•••	•••		•••		••	•••	••	•••	•••	•••	•••	•••	•••	• • •	••	
•••					•••	• • •								•••					•••			•••		•••		•••					•••				
••••	•••	•••	•••		•••	• • •	•••			•••				••		• • •			•••			•••				•••	• • •		• • •	•••	••				
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## F) GENERAL INFORMATION

30) Do you belong to any group or Association? A) Yes ( ) b) No ( )
31) If yes, what service do you receive from such association?
32) How many times did you meet last month
33) What problems do you face while producing maize?

.....

34) Please estimate your total seasonal income (Ug.Shs) from the following source.

Sources	1 <sup>st</sup> season 2007 (Ug. Shs)	2 <sup>nd</sup> season 2007 (Ug. Shs)
Crop enterprise		
Livestock/		
products		
Non- farm		
income		
Remittance		

35) Which of the two seasons do you consider as favourable in this area?

.....

- 36) How do you rate rainfall in this area?
- (a) Reliable (b) Average (c) Unreliable

37) How do you rate the fertility of the soils on your farm as compared to other farms you

have visited?

(a) Poor (b) Good

Do you have access to credit yes..... No.....

Source (s) of credit	Amount	Interest rate	Total	Pay back	Use of credit
	received		Amount	period	received
			paid		

## THANK YOU