FARM SIZE AND PRODUCTION EFFICIENCY: EVIDENCE FROM MAIZE PRODUCTION IN BABATI DISTRICT

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ABSTRACT

A decrease in maize yield for producers in Babati District provoked the present study on farm size and production efficiency. The overall image that exists in the literature, offers three kinds of relationships between these variables an inverse, a reverse and both inverse and reverse. Using a cross sectional data obtained through a multistage sampling technique the relationship was estimated. Further the production efficiency and its determinants among maize crop producers in the district were examined. A purposive sampling technique was used to select four wards under maize production with a simple random sampling used to select six villages out of the four wards. Stratified sampling was to select 122 farmers who cultivated maize in the study area. Stochastic frontier model determined the relationship proposed by this study. The mean technical efficiency was 62.3% suggesting that 37.7% of the inefficiency in maize production in study area results from combination of both technical and allocative inefficiency. Besides, study findings revealed farm size as an important factor in increasing maize production efficiency in Babati district. This study concludes that, there is room for increasing efficiency by increasing farm size. The Lack of formal education, number of plots owned by a farmer, frequency of contacts with extension officers, use of insect sides, and the use of hand hoes or otherwise was also found to have a negative sign and therefore increase maize production efficiency. In association with the solutions to problems facing farmers, this study recommends intensified training to farmers to increase efficiency and creation of environment for increasing farm plot size using the current level of inputs to enhance agricultural transformation which will include an integrated soil fertility alternative.

DECLARATION

I, **MICHAEL RAPHAEL BAHA,** do hereby declare to the Senate of Sokoine University of Agriculture that this dissertation is my own original work done within the period of registration and that has neither been submitted nor being concurrently submitted in any other Institution.

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DEDICATION

This dissertation is dedicated to my father Raphael Bura Baha and my mother Victoria Raumu Baloho, for their heartfelt love, care and constant encouragement. You have done your part, may God bless you abundantly.

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LIST OF ABBREVIATIONS AND SYMBOLS

AERC	African Economic Research Consortium
AEZ	Agro Ecological Zones
CFSVA	Comprehensive Food Security and Vulnerability Analysis
CIA	Central Intelligence Agency
CIMMYT	*Centro Internacional de Mejoramiento de Maizy Trigo*
CSAE	Centre for the Study of African Economies
DALDO	District Agricultural and Livestock Development Officer
DEA	Data Envelopment Analysis
FAO	Food and Agriculture Organization
GM	Gross Margin
Ha	Hectare
IRSA	International Rural Sociology Association
LAMP	Land Management Program
MAFC	Ministry of Agriculture, Food and Cooperatives
MLE	Maximum Likelihood Estimation
MPRA	Munich Personal RePEc Archive
MT	Metric Tonne
OLS	Ordinary Least Square
PASS	Private Agriculture Sector Support
SACCAR	Southern Africa Centre for Cooperation in Agricultural Research
SAGE	Center for Sustainability and the Global Environment
SFA	Stochastic Frontier Analysis
TE	Technical Efficiency
TFP	Total Factor Productivity

UK	United Kingdom
URT	United Republic of Tanzania
WB	World Bank
WFP	World Food Programme

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background Information

Maize is one of the important food crops in Tanzania. It accounts for more than 75% of the cereal consumption making it one of the strategic crops for food security in the country (Msuya, 2009). The crop provides about 60% of dietary calories to the Tanzanian population (Kaliba *et al.*, 1998). The crop is widely cultivated in the country due to reliable climatic conditions. Maize is grown in almost every region in Tanzania, but highly performing in two agro-ecological zones which include southern and western highlands and the semi – arid lands in the country (WB, 1994).

Despite being widely cultivated and the role it plays as a food crop in the country, its yield per hectare has been decreasing. The available data indicate that the average crop yield per hectare in the country has decreased from 14 071.24 kg/ha in 2007/08 production season to 1 122.536kg/ha in 2009/10 production season (FAO, 2011).

The situation has continued to be worse in major producing regions (with exception of Rukwa region where the average yield per hectare has been increasing); data available indicate that yield per hectare has been decreasing in the same period from 1 823.2kg/ha to 1 265.3kg/ha in Mbeya region, 1584.4kg/ha to 15 065.7kg/ha in Ruvuma region, 1 556.3kg/ha to 1 231.7 in Iringa region and 1 530.2kg/ha to 13 363kg/ha in Manyara region (MAFC, 2011).

Babati district, which is the main crop producing district in Manyara region, has also not been outstanding on this; the crop yield per hectare has been showing the same trend despite the increase in area under the crop from 35 070 hectares to 35 280 hectares in 2006/07 and 2009/10 seasons respectively (URT, 2011). The yield per hectare has been decreasing continuously from 1 362.5kg/ha in 2006/07 to 1124.8kg/ha in 2008/09 (URT, 2011).

1.2 Problem Statement and Justification

Maize yield decrease is a pervasive problem, which threatens not only the economic well being of the farmers but also the efforts by the government to ensure food security (URT, 2011). This implies that if special attention is not paid to reverse the situation, the country stands a chance of facing severe food insecurity and negative outcomes from rural poverty alleviation efforts by the government through *Kilimo Kwanza*. It follows that understanding the effects of farm plot size and other related variables on yield is imperative. It involved clarifying questions like what is the level of efficiency of maize farmers in the study area. What are the factors affecting maize production efficiency in the study area? And how farm sizes and productivity are related in study area? These are the important policy issues that need to be understood by policy makers and project planners on the ground for achieving country objectives and millennium development goals.

It follows that this study provides an understanding of the aforementioned questions, by filling in the information gaps on the effect of farm plot sizes and other factors of production on maize yield and efficiency. Consequently, this study was designed to generate this information by the research conducted in Babati District.

1.3 Study Objectives and Hypothesis

1.3.1 Overall objective

The overall objective of this study is to examine the influence of farm size on Production Efficiency and hence food security among maize producers in Babati District.

1.3.2 Specific objectives

i) To estimate maize production efficiency in Babati District

ii) To determine factors affecting maize production efficiency in Babati District

iii) To assess the influence of farm size on maize production efficiency in Babati District

1.3.3 Hypothesis

H_1: Maize farmers in Babati district are inefficient

H_2: Farm size has no influence on production efficiency among maize producers in Babati District.

1.4 Organization of the Study

The present study has five chapters. The first chapter provides a general background to the study, where amongst other things; it presents the problem statement, study objectives and hypotheses. The second chapter presents a critical review of literature relevant to the study. A detailed description of the methodology employed, study area and the data used by the present study is provided in chapter three. The fourth chapter presents results and discussion. Main policy recommendations and conclusion emanating from the present study are provided in chapter Five. The last section of the study contains a list of appendices and the literature cited in this study.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Overview of Maize Production in the World

Maize (*Zea mays*, *L.*, Poacea family), also known as corn, is a very versatile crop in the world, growing in all sorts of edaphic, altitudinal and fertility condition which explains its overall adaptability and its many types of varieties. The minimum temperature for germination is 10^0C and seedling growth before 13^0C is very slow so it is not adapted to cooler parts of the temperate zones. It has the C4 metabolic pathway and is photosynthetically highly efficient in conditions of high temperature and light intensity. The crop production was 822 million tons in over 160 million hectares by 2008 (FAO, 2010). Maize crop is used as a staple food source especially in Latin America and Africa. However, because of its low price and worldwide distribution, it has become the most important raw material for animal feed and several industrial processes.

2.1.2 Maize production in Tanzania

Maize production is done almost in every region in Tanzania. This makes the country one of the main producers in Africa. The crop was cultivated on an average two million hectares in 2005, which was about 45% of cultivated area in Tanzania (MAFC, 2011). The area under maize production from 2001/02 season to 2008/09 is provided in Fig. 1.

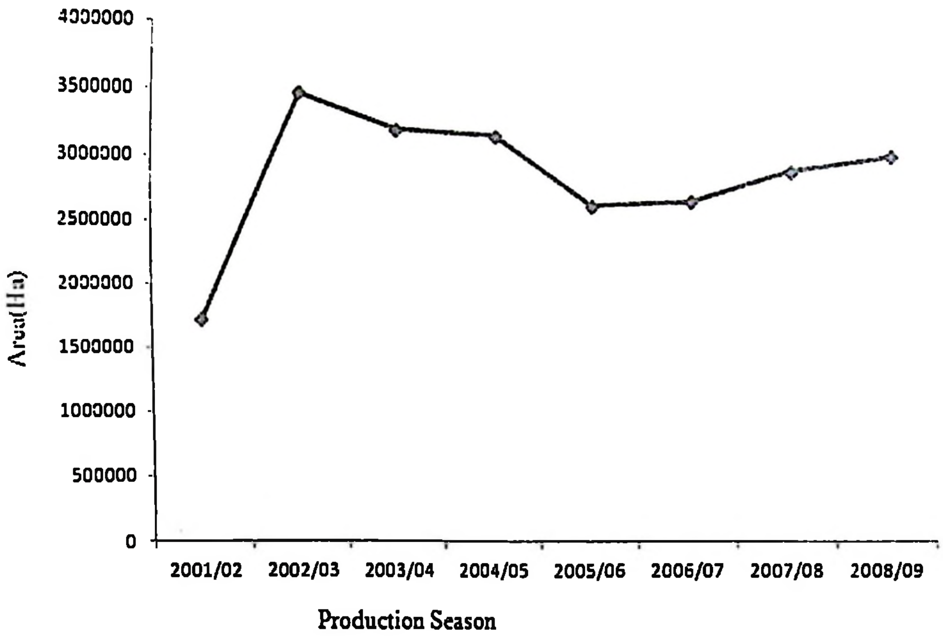

Figure 1: Area under Maize Production in Tanzania

Source: URT (2010)

The planting of maize crop and other cereals in the Country takes place between January and March while harvesting takes place between April and August (FAO, 2011). For the detailed figure that depict both planting and harvesting season in the country see Appendix 1. However harvesting of the maize crop requires sound and timely management to realize maximum economic yield. Duncan and Thompson (1962) stated, "Maize harvest should not be viewed as an event that just happens but be planned at the beginning of the production season with hybrid and planting date selections". The production of maize in the country have been varying over the years with the observe decrease in the production of maize from 2004 to 2009 Season. The production of maize in Tanzania in'000'tones is summarized in Fig. 2.

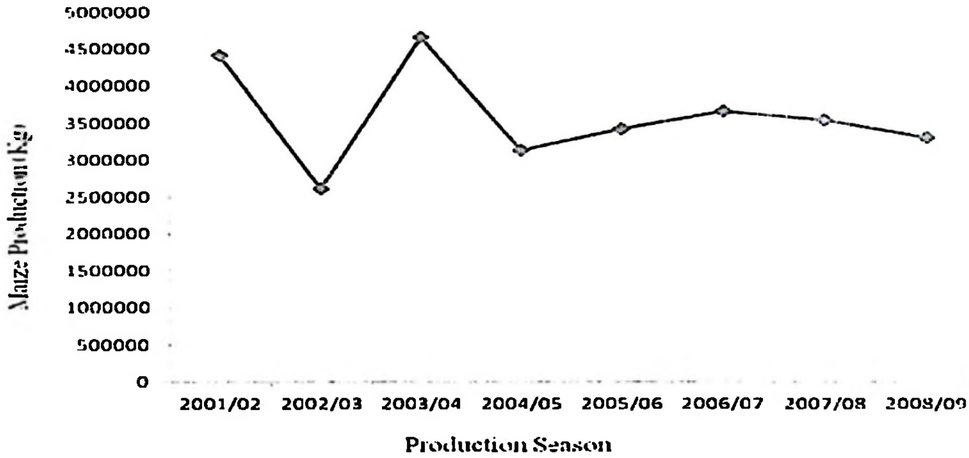

Figure 2: Maize production in '000'Kilograms in Tanzania
Source: URT (2010)

2.1.3 Potential for Maize in Tanzania

White maize is the most important grain in the country and is preferred as a primary staple in rural and urban areas. The demand for the crop is high in the country both as a staple and as an industrial material. Over 85% of all maize produced in the country is consumed as food and the remaining 15% is used in various industries including brewing of opaque beer (*Kibuku*) and in local brewing establishments in rural areas. Maize is also used to manufacture animal and poultry feeds (PASS, 2010).

2.1.4 Maize Production in Manyara Region

The Production of Maize in Manyara region takes place in all five Districts of Babati, Mbulu, Hanang, Kiteto and Simanjiro. The available data show that area under Maize production has been increasing from 18 790 hectares in 1998/99 to 222 200 hectares in 2004/05 (MAFC, 2005).However, the production of maize in the region has experienced a substantial decline from 285 400 tones in 2003/04 tones to 26 690 tones in 2004/05 season.

2.1.5 Maize Production in Babati District

Maize production in Babati District has been varying with the available data showing both an increment and declining tendency. In the 2005/06 farming season the District maize production was 129 176 tones followed by a decrease in production to 63 439 tonnes in 2006/07 season. In 2007/08 season there production of maize increased to 98 728 tonnes of which thereafter stated to decline in the next season up to 16 000 tonnes in 2009/10 season (URT, 2010).While the production of maize in the District experienced variation the area under maize has been increasing from 36 220 hectares in 2003 season to 59 700 hectares. Fig. 3 depicts the trend in both area and maize production in the district.

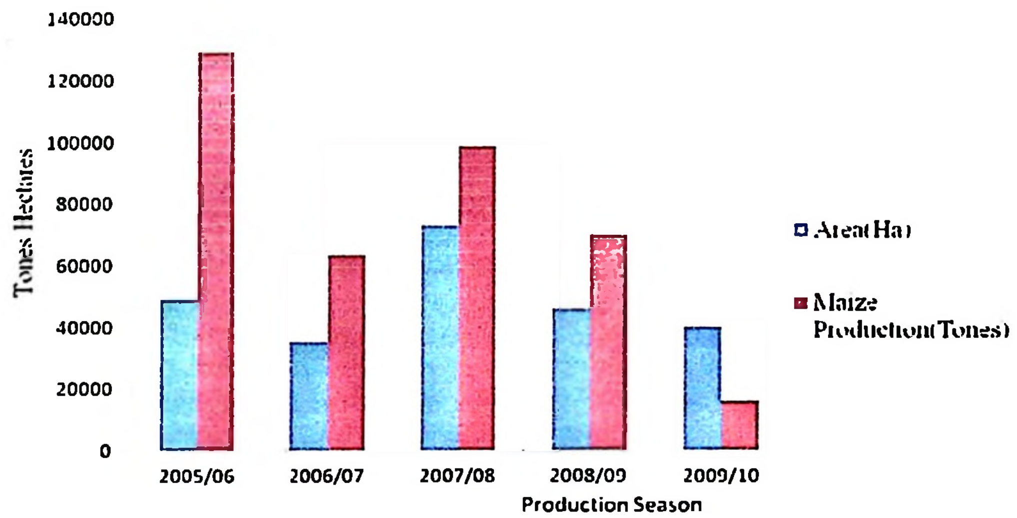

Figure 3: Area and Production of Maize in Babati District

Source: URT (2010)

2.2 Approach and Methods for Measuring Productive Efficiency

The efficiency of a firm is its ability to produce the greatest amount of output possible from a fixed amount of inputs. Another way of putting this is, an efficient firm is one that given a state of technical know-how, can produce a given quantity of goods by using the least quantity of inputs possible. The concept of efficiency is derived from a particular interpretation of the notion of production frontier, which in its classical sense is the relationship between output, on the one hand, and the quantity of the inputs used in the production process to obtain that output, on the other. In estimation methods of efficiency frontiers, the production function becomes the production frontier.

The efficiency of a production unit can be categorized into two components, *i.e.* technical and allocative efficiency. Technical efficiency refers to the ability of a firm to minimize input use in the production of a given output vector or to obtain the maximum output from a given input vector while allocative efficiency refers to the ability of a firm to use inputs in optimal proportions, given their respective prices. The product of these two measures of efficiency gives the economic efficiency. There are four major approaches to measure efficiency (Coelli *et al.*, 1998).These include the parametric programming approach on parametric programming approach, the deterministic statistics approach and productivity indices based on growth accounting and index theory principles. Among these, the stochastic frontier and non-parametric programming, known as Data Envelopment Analysis (DEA), are the most popular approaches (Baten *et al.*, 2009 and Philip, 2007).

2.2.1 The Theoretical Foundation for the Data Envelope Analysis

Data envelope Analysis approach uses linear programming to construct a piece-wise frontier that envelops the observations of all firms. DEA approach allows to measure technical and allocation efficiencies without imposing any functional form on the production function. As it does not allow testing direct hypothesis, two steps should be used: to get the inefficiency measures using DEA and then regress it on the set of explanatory (farm specific characteristics). This approach advantage over the parametric approach is that, it can be used to analyze technical frontiers for multiple inputs and outputs. However, this study will not be used in this study because it does not lend itself to standard statistical tests of significance. Onward this approach is not able to take into account non constant returns to scale and the uneconomic areas of production function where inefficiency index is undefined. Moreover, standard DEA produces efficiency "measures" which are point estimates: there is no scope for statistical inference and therefore it is not possible to construct standard errors and confidence intervals (Mastromaco, 2008).

2.2.2 The Theoretical Foundation for the Stochastic Frontier Analysis

The stochastic frontier production function was independently proposed by Aigner, Lovell and Schmidt (1977) and Meeusen and van den Broeck (1977).The data originally specification involved production function specified for cross – sectional data which had an error term which had two components, one is symmetric representing random effects and the other is one sided that captures technical inefficiency such as mistakes related to farm management.

This approach is used in this study due to its strength in capturing measurement errors and other noises in the data. Moreover, with this approach, standard statistical tests can be used to test hypotheses on model specification and significance of the variables included in the model. It is also more amenable to modeling effects of other variables, like land quality and variations in weather conditions. This approach is pronounced to be mostly used recently as a technical efficiency measure. Although today the model is modified to account for panel data, originally it was developed to handle cross-sectional data (Msuya, 2009).

The combination of the two explained efficiency estimation methods is used in many recent works for different countries, where the hypothesis of inverse relationship between farm size and productivity was tested: Helfand and Levine (2004) for Brazil, Masterson (2007) for Paraguay, Terymenko (2008) and many others. But for the purpose of this study, stochastic frontier analysis which is detailed in the methodology section was used.

2.3 Studies on Farm Size, Production Efficiency and Productivity

In this section, the study reviewed the existing literature made on farm size, production efficiency and productivity. The hypothesis about the inverse relationship between farm size and production efficiency has been tested by many researches in different countries of the world. The debate is still of current importance because no final conclusion has been reached so far. The review of literature from different scholars on farm size, productivity and production efficiency is provided as follows;

Carter (1984) is among the scholars who studied the relationship between farm size and Productivity. He did his study in India. Using a small household sample (376 holdings) confirmed the inverse relationship. The data was pooled because of its poor quality, as farmers recorded the required observations not properly. He suggested that the inverse relationship have happened not because of sample selection bias or misidentification of village effect', but because of 'capitalistic mode of production'. He cites as an explanation to inverse relationship quite controversial argument the impact of which is decided to be opposite by many researches; 'intra village soil quality difference' partly explains the negative relationship between farm size and its productivity. He completely confides in the empirical part, pointing out that 'overall statistical analysis strongly supports' his beliefs.

Goksel *et al.* (2007) determined the total factor productivity using Cobb – Douglas production function in Turkey. They used port used by farms fuel, other (fertilizer, seed, chemical etc) variable inputs and labour as independent variables. Dependent variable was taken to as the gross value of production per farm. Their findings showed that TFP increased with increase in the size of the farm. The TFP coefficient was found significant only in the third group enterprise which was 100 and 101da. Also the study revealed that the affect of the surveyed plots on the gross value of production value is negative in group I (smaller than 30ha) and positive in Group II and III (*i.e.* between 31 and 100 and 101ha of more) respectively. Meaning that total factor productivity increase as the size of the plot increases.

Kiani (2008) determined the relationship between different farm size and productivity of various crops (Wheat, Cotton, Maize and Sugar cane) whereby a Cobb-Douglas production function model was used in Pakistan. Value of output was used as a dependent variable while total area cultivated, cultivated area irrigated, fertilizer, labour, tractors, seed, cropping intensity and farm size were the independent variables. The study revealed that there was a negative but insignificant correlation between the value of output per cultivated acre and farm size defined in terms of value of production. The study results showed that smallest and largest farm size have the highest land productivities, while the middle size farms have relatively been less productivity the reason is that the middle farm size is using inefficient combinations of inputs that yield lower marginal productivities.

Philip (2006) re - examined the inverse relationship hypothesis by using data collected from sugar cane farmers in Morogoro, Tanzania. Data was collected from 23 villages of sugarcane out growers in Mtibwa and Kilombero, Tanzania. The study used Data Envelope Analysis (DEA) to measure technical efficiency among sugarcane outgrowers. To examine the relationship which exists between productivity and farm size, the study determined the variations in the computed average profit figures and efficiency score for different farm size categories. The results showed that technical efficiency does not decrease monotonically with increasing farm size for the very small farms surveyed rather land productivity drops steadily as one move into larger farm size categories, until farms larger than 3-6ha after which it rises again. This is similar with what Kiani (2008) found and contrary to what Kimhi (2003) found, a non – monotonic relationship.

Mahesh (2000) examined the relation between farm size and productivity in Kerala, India in the post land reforms era. The study used linear regression model, with the gross yield of several crops (Rice, Vegetables, Tapioca, Banana, Pepper, Coconut and Rubber) per acre being the dependent variable and farm plot size as the independent variable. The results of the study show that productivity of farms does not show any clear relationship with farm size. It is possible that productivity is related to a variety of factors like crop mix, input use, labour employed, management of crop-related activities and other related items in addition to farm size. In that case, the study recommended the enquiry should aim at identifying the key factors and establishing the relation between a composite index of such factors and farm productivity.

Kimhi (2003), examined the relationship between maize productivity and plot size in Zambia, by using a censored regression model of the fraction of land allocated to maize. He used the 1993-1994 data from the Central Statistical office of Zambia. The findings of the study shows that, After accounting for the endogeneity of plot size (to correct for measurement errors), they found that the inverse relationship between plot size and productivity dominates the economies of scale in all plots up to 3 ha, which constitute 86% of their sample. In contrast, when considering plot size as an exogenous explanatory variable (therefore corrects for the measurement error), they found a monotonic positive relationship between the yield of maize and plot size, indicating that economies of scale are dominant throughout the size distribution.

Assuҫão and Ghatak (2003), explained the inverse relationship between farm size and productivity in the absence of diminishing returns using endogenous occupational choice and heterogeneity with respect to farming skills in Brazil. They relaxed the assumption of constant returns because they thought it was more plausible, but simply because they wanted to highlight an effect that has been ignored in different literatures that is farmer quality and self selection. Their results showed that the well – known inverse relationship between farm size and productivity could be a result of imperfect in credit markets and heterogeneity in farmer's skills even if there is diminishing returns with respect any input.

In the light of above-mentioned studies it is very clear that farm plot size and productivity are highly correlated but in different directions in some cases negative and in some cases positive depending on variables used in the survey and the methodologies. Farm plot sizes vary from country to country. The same applies to productivity. Another important observation is that in most of the studies Cobb Douglas production function was used for estimation, the strong point being its ability to account for measurement errors and other noise in the data influencing the shape and position of the production frontier (Bourguignon and Morrison, 1998, Msuya, 2008).

CHAPTER THREE

3.0 METHODOLOGY

3.1 Conceptual Framework

As stated in the background information, the overall objective of the present study is to determine the relationship between farm size and productive efficiency for food security in Babati District. I assume that, any effort to increase food security via maize should result from increased maize crop production. Increased maize production results from increased farm size/productivity/efficiency. Increased farm size depends on institutional and unfavorable weather, pests and Diseases, and recursive decision by the farmer on the optimal resources which under this context depend on factors of production.

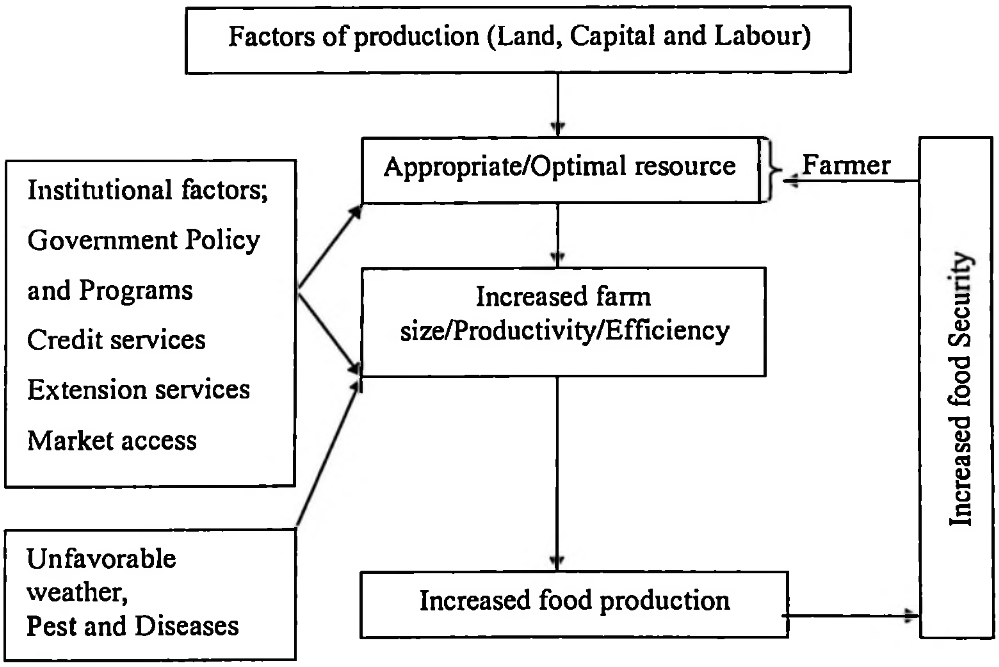

Figure 1: Conceptual Framework

Source: Modified from Philip, (2007)

3.3 Location of the Study Area

The study was conducted in Babati District, which is one of the five districts in Manyara Region, located below the Equator between 3^0 and 4^0 latitude and longitude 35^0 and 36^0 of Greenwich. Neighbouring districts are Monduli in the North, Karatu in the Northwest, Mbulu in the West, Hanang in the Southwest, Kondoa in the South and Simanjiro in the East. The district population is estimated to be 303 013 people in 2002 of which 156 169 are male and 146 844 (URT, 2002). The study area was regarded best for studying the mentioned relationships between farm size and productive efficiency as villagers from the district primarily rely on maize production for their livelihoods, although in recent years, the study area has experienced some expansion of non-farm activities. Increasing population growth and density has also led to fragmentation of landholdings for some families so that the distribution is not homogeneous hence the difference in farm plots. Therefore, most of the farmers in the study area operate as smallholders or sharecroppers. Furthermore accessibility of the area and good agronomic practices were also main drivers for selection of this study area. The map of the study area is shown in Fig. 5.

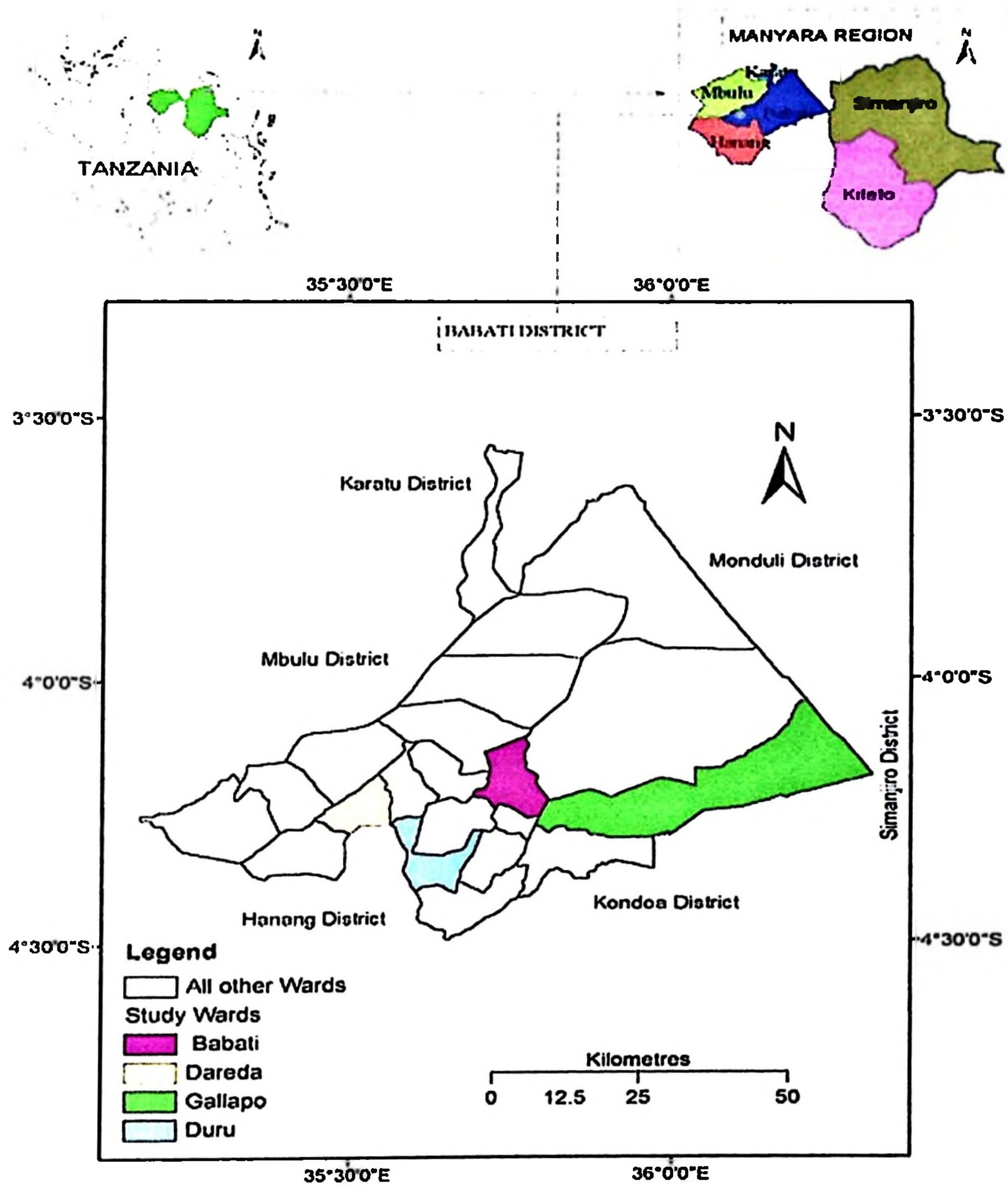

Figure 5: Map of Babati District, showing the surveyed areas

3.4 Climate and rainfall characteristics

The climate varies in the different parts of the district, with higher altitude areas having lower temperatures but with more precipitation than the lower altitudes. The climatic conditions vary from semi-arid lowlands to humid highlands.

Rainfall also varies throughout the district. The annual cycle consists of one long dry period between June and September and two rain periods, *i.e.* short and long periods. The short rains occur most commonly from October to December and sometimes in January, and the long rains between February and May. The dry period between June and September is characterized by low temperatures in June and July. By mid August the temperature rises again. Sometimes a short dry spell is noted at the end of the short rains. This dry spell has posed negative impact on crop production (Jonsson *et al.*, 1992). 3.5 Agro Ecological Zones and Production Systems in Babati

In explaining the natural settings of an area specifically for agricultural production, rainfall, temperature and soils are essential. Based on this, an explanation on the essence of agro ecological zones (AEZ) seems to be the best way to review the natural conditions of an area (Senkondo, 2000). AEZ is normally based on rainfall, temperature, altitude and evapotranspiration or the length of the growing period. A summary of Agro ecological zones and production system found in the district is summarized in Appendix 2.

3.6 Research Design

The research used the cross sectional research design by collecting data from farmers at one point in time. The design allows data to be collected without repetition from the target population (Babbie, 2010). The data for this survey was collected at the beginning of the season of production. This exercise was done purposely so as to enable farmer retrieve the information of previous season using the current season.

3.7 Sources of Data

The study used primary data to achieve its objectives; primary data were collected from January 2010 to March 2011 by using structured questionnaire, tailored to obtain information on input – output production activities of each farm sampled. The inputs information included land, labour, and materials which were used by the farmer during the last season while the output information included the amount of maize that were obtained from the area of land that which fall under maize in that particular season. The same information were also collected alternative crops (Pigeon Peas and Sunflower) found in the study area.

3.8 Sampling Procedure

Selection of wards and villages for the study was done with staffs' assistance from the office of the DALDO through listing of the respective wards and villages basing on accessibility, good agronomic practices and land management program which is still operating in the district. Babati district has 18 wards; four wards were selected from each district as follows, Dareda, Duru, Galapo and Mamire. A total of 6 villages were selected for the survey (Table 1). There after stratified random sampling was carried out on each ward for selection of respondents who participated in the study *i.e.* people who own maize farm plots at different sizes.

Table 1: Villages Selected from the Study Area

District	Ward	Type	Village
	Mamire	Rural	Mamire
	Galapo	Mixed	Galapo
Babati			Orongadida
	Dareda	Rural	Bermi
			Dareda Kati
	Duru	Rural	Duru

3.9 Data Analysis

In order to estimate maize farm productive efficiency, the study used a parametric (econometric) approach stochastic frontier analysis. This model is adopted from the work of Battese and Coelli (1995). The model proposed a stochastic frontier production function, which has firm effects assumed to be distributed as a truncated normal random variable, in which the inefficiency effects are directly influenced by a number of variables. Given the objectives this study the Cobb-Douglas production functions and the stochastic frontier is applied and thus expressed as:

$$\ln(Maizeout) = \beta_0 + \beta_1 \ln(Labour) + \beta_2 \ln(Land) + \beta_3 \ln(Material) + V_i - U_i \quad \text{........}(i)$$

Where:

$\ln$: Denotes Natural logarithms;

Maizeout: Total amount of maize harvested in 2009/2010 season expressed in tons;

Labour: Both family and hired labour utilized in various farm activities expressed in man-day equivalents;

Land: Land area under maize cultivation in the 2009/2010 season expressed in hectares;

Material: Expenditures on intermediate materials (seeds, fertilizer, hiring tractor and ox-plough) expressed in Tanzanian shillings

β_i's: Unknown parameters to be estimated;

V_i: Represents independently and identically distributed random errors $N(0,\sigma_v^2)$. These are factors outside the control of the smallholder; and

U_i: Represents non-negative random variables which are independently and identically distributed as $N(0,\sigma_u^2)$ i.e. the distribution of U_i is half normal. $|U_i| > 0$ reflects the technical efficiency relative to the frontier production function. $|U_i| = 0$ for a farm whose production lies on the frontier and $|U_i| > 0$ for a farm whose production lies below the frontier.

Knowing that farmers are technically inefficient might not be useful unless the sources of the inefficiency are identified. Thus, in the second stage of this analysis we investigate farm- and farmer-specific attributes that have impact on maize farmers' technical efficiency. The inefficiency function can be written as:

$$U_i = \delta_0 + \delta_1 Noforma + \delta_2 Hhsize + \delta_3 Plonnumber + \delta_4 Distplot + \delta_5 Gender + \delta_6 Nocoext + \delta_7 Traseva + \delta_8 Credito + \delta_9 Usefert + \delta_{10} Useinsect + \delta_{11} Hhoe + \delta_{12} Maizeland_i \text{........(ii)}$$

Where:

Noforma : Dummy variable for smallholder level of education, assuming a value of 1 if the farmer has no formal education and 0 if otherwise;

Useinfer : Dummy variable showing value of 1 if the smallholder indicated to have used fertilizers, otherwise zero;

Useinsec: Dummy variable showing value of 1 if the smallholder indicated to have used agrochemicals, otherwise zero;

Hhsize: Household size, (number of people staying together and utilizing scare resources together)

Plonumber: Measure land fragmentation (number of plots owned by smallholder under maize cultivation);

Distplot : Distance to the plots from homestead expressed in Km;

Hanhoe: Dummy variable showing value of 1 if the smallholder indicated to have used a hand hoe, otherwise zero;

Traseva: Dummy variable showing value of 1 if the smallholder indicated to have used traditional maize seed variety, otherwise zero;

Nocoext: Dummy variable showing value of 1 if the smallholder indicated has never had contact with extension officers, otherwise zero;

Maizlan : Land area under maize cultivation in the 2009/2010 season expressed in hectares;

Gender: Gender Dummy variable showing value of 1 if the smallholder is a male, otherwise zero;

Credito: Dummy variable showing value of 1 if the smallholder has obtained any form of agricultural input credit, otherwise zero;

W_i: An error term that follows a truncated normal distribution; and

δ_i's: Inefficiency parameters to be estimated

The C-D production frontier function defined by equation (iv) and the inefficiency model defined by equation above will jointly estimated by the maximum-likelihood (ML) method using FRONTIER 4.1 (Coelli 1996). The FRONTIER software uses a three-step estimation method to obtain the final maximum-likelihood estimates. First, estimates of the α-parameters are obtained by OLS. A two-phase grid search for γ is conducted in the second step with α-estimates set to the OLS values and other parameters set to zero. The third step involves an iterative procedure, using the Davidon-Fletcher-Powell Quasi-Newton method to obtain final maximum-likelihood estimates with the values selected in the grid search as starting values.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Socio - economic Characteristics of the Respondent

The socio-economic characteristics discussed in this section include, sex, marital status, education level, occupation, farm size, and household size.

4.1.1 Age of the respondent

The household age distributions are presented in Table 2. About half of the interviewed households' heads were aged between 31 and 51 years. Households' heads aged 30 and below years constitutes 4.9% of the total number of respondents of this study. It could be further noted that respondents aged more than 51 years accounts for 31.2%. The small proportion of respondents aged below 30 years could be attributed to several factors. One of the most likely reasons is the rural urban migration which in most cases involves the youth. Mlambiti, (1994), showed that age structure can be used to facilitate an understanding about labour potential of a specific population. This means that the majority of maize farmers were within the working age group, implying that maize production is performed by the economically active group in the population.

Table 2: Household's Age Distribution

Age Category	Number	Percent
30 and Below	6	4.9
31 - 40	32	26.2
41 – 50	46	37.7
51 – 60	25	20.5
61 and above	13	10.7
Total	122	100

4.1.2 Education of the respondents

The results presented in Table 3 shows that 91% of the respondents reported to have attained formal education. This is more than the national literacy rate of 69.4 % (CIA, 2011). Also, Table 4 shows that only 9.8% of those who reported to have acquired formal education had attained secondary education. The high percentage observed in formal education might be attributed to obligatory primary school education system in the country. This implies that maize farmers in the study area have a basic knowledge that can be used to improve the production level of maize in the study area.

Table 3: Education Level of the Respondents

Level of education	Number	Percent
No formal education	10	8.2
Adult education	1	0.8
Primary education	99	81.1
Secondary education	12	9.8
Total	122	100

4.1.3 Sex of the respondent

The sexes of the respondents are presented in Table 4. The findings from the present study indicate 64% of respondents were male while 36% were female. The female headed households in the study area are more than double of the female headed households in Manyara region which is 15.1 % (WFP, 2006).

For majority to be men it is probably because, in most poor Tanzanians' families, men are in charge of family activities involving cash transactions while women are in charge of taking care of their homes and children and therefore, spending most of the times at home. In addition, access to capital might be another reason for this pattern since women especially in developing countries, do not have access to means of production farms and support services such as credit as compared to men.

Table 4: Sex of the Respondents in the Study Area

Sex	Number	Percent
Female	44	36.1
Male	78	63.9
Total	122	100

4.1.4 Average household size

The variable household size here in referred to all members (number of people) dwelling and eating in the same pot for each household interviewed. The average household size by this study is also found to be higher compared to the average household size reported in 2002 national census which ranged from 5.2 to 4.9 in the country and between regions that ranged from 3.8 – 6.9. The higher household size in the area might be attributed to the tendency of accommodating extended families and little knowledge in family planning.

4.1.5 Farm size distribution

Farmers whose farm plots were less than three hectares account for 80.3% of the total number of respondents. However, the large proportion of respondents who had farms less than three hectares is not surprising. This is because the national average farm size is less than one hectare (URT, 2006). The summaries of farm size distribution are provided in Table 5.

Table 5: Average Farm Size and Farm size Distribution among Respondents

Average farm size	6.6ha	
Farm Size Categories (ha)	Number of farms	Percent
Below 3	98	80.3
3 - 6	20	16.4
6 - 9	1	0.8
9 - 12	1	0.8
Above 12	2	1.7
Total	122	100

The average farm size among the maize farmers is about 6.6 ha. This is very high if compared to the national average of 0.7ha. The relatively larger farms among the respondents could be attributed to the land distribution policy in 1990s and the land inheritance character by majority of the respondents.

4.1.6 Average farm size for other crops in the study area

The average farm size for alternative crops grown in the area of study is found to be 4.1 ha. The average farm size for other crops is shown to be less than the size used for maize production which is averaging about 6.6 ha. This has an implication in food security since farmers are keeping more land for maize mainly for subsistence.

4.2 Farmers Access to Institutions

4.2.1 Access to extension services

Access to extension services is provided in Fig. 7. The results show that more than 69% of the maize farmers in the study area have contacted the extension agents. This implies that the study area is reasonable tuned to extension services. Moreover, results show that 46% of the farmers surveyed had attended training workshops on various issues related to crop production. However, it is shown that only 33.6% of the respondents got the access to extension materials. The low exposure to extension materials depicted by Fig. 7 may be as a result of lack of farmers associations.

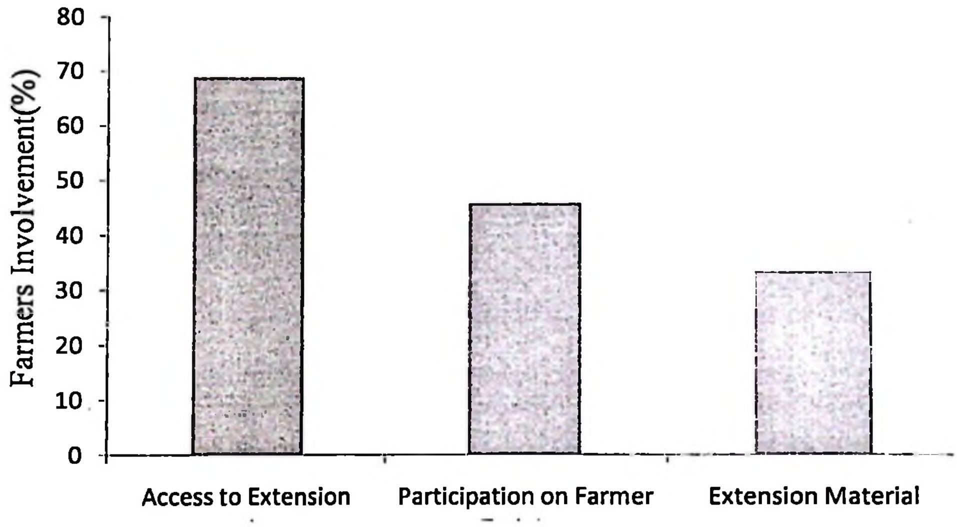

Figure 2: Farmers Access to Extension Services

4.2.2 Access to Credit Services in the Study Area

This section provides a brief discussion on the results of the assessment of the availability of credit services for maize producers in the study area. Among smallholder maize farmers surveyed 60% did not apply for credit. Those who applied for credits were 40%the low percent observed during this study has been attributed by a number of factors among others are high risk (crop risk) which account for 34.4%.

4.3 Production Frontier and Technical Efficiency

4.3.1 Hypothesis Testing and Model Robustness

Before proceeding to examine the parameter estimates of the production frontier and the factors that affect the production efficiency of the maize farmers, this study investigated the validity of the model $((i)\, and\, (ii)\, section\, 3.7)$ used in the analysis. Tests of null hypotheses for the parameters in the frontier production functions and in the inefficiency models were performed using the generalized likelihood-ratio test statistic defined by: $\lambda = -2(\log[L(H_0) - \log(H_1)])$ where $L(H_0)$ and $L(H_1)$ denote the values of the likelihood function under the null (H_0) and alternative (H_2) hypotheses, respectively. If the null hypothesis is true, the LR test statistic has an approximately a chi-square or a mixed chi-square distribution with degrees of freedom equal to the difference between the number of parameters in the unrestricted and restricted models.

First the null hypothesis which specifies that there are no technical inefficiency effects in the model was tested *i.e.* $H_0 = \gamma = \delta_0 = \delta_1 = ...\delta_{18}$. The hypothesis was rejected as gamma parameter (Table 7) is 0.94 and significant at 5% probability level, which means about 94 percent of the disturbance term is due to inefficiency. Thus, the inclusion of the technical inefficiency term is a significant addition to the model. In addition, a stochastic translog production frontier was estimated as a test of robustness in the choice of functional form. The form of this model encompasses the Cobb-Douglas form, so test of preference for one form over the other can be undertaken by analyzing significance of cross terms in the translog form. The ML estimates of the translog production frontier are given in Table 8.

Table 6: Parameter Estimates of the C-D Production Frontier

		OLS		MLE	
Variables	Parameters	Coefficient	t-ratio	Coefficient	t - ratio
Constant	β_0	-6.8873***	-2.7844	-7.0936***	-3.6963
Ln(Mandays)	β_1	0.07014	0.7093	0.1393**	1.7581
Ln(Land)	β_2	0.4427**	1.8701	0.3293**	1.8643
Ln(Materials)	β_3	0.5204***	2.6825	0.55***	3.6064
	σ^2			1.3967	
	γ			0.94	
Log – likelihood		-143.1195		-129.255	
LR - Test of the one-sided error				27.73	

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

Table 7: MLE for Parameters of the Stochastic Frontier and Inefficiency Model

Variables	Parameters	Coefficient	Standard error	t-ratio
Frontier Model				
Constant	β_0	-88.6749***	1.1766	-75.3668
Ln(Mandays)	β_1	1.2323	2.7624	0.4461
Ln(Land)	β_2	-8.2751***	2.2736	-3.6396
In(Material)	β_3	12.7257***	2.4241	5.2497
InMandays^2	β_4	-0.1193*	0.1037	-1.1504
LnLand^2	β_5	-0.1171	0.2591	-0.4518
LnMaterial^2	β_6	-0.5728***	0.1609	-3.5594
LnMandays*LnLand	β_7	-0.1919	0.2731	-0.7029
LnMandays*LnMaterials	β_8	0.1522	0.1735	0.8771
LnLand*LnMaterial	β_9	0.8733**	0.3788	2.3056
Inefficiency Model				
Constant	δ_0	-1.6821**	0.9698	-1.7344
Noforma	δ_1	-0.1818	0.9816	-0.1852
Hhsize	δ_2	0.25894***	0.0928	2.7901
Plonnumber	δ_3	-1.6603***	0.4796	-3.4616
Distplot	δ_4	0.2322***	0.0898	2.5867
Gender	δ_5	2.0357***	0.7228	2.8163
Nocoext	δ_6	-0.2179*	0.1344	-1.6209
Traseva	δ_7	0.7066*	0.4649	1.5196
Credito	δ_8	1.3414**	0.5783	2.3197
Usefert	δ_9	1.4414**	0.8008	1.7999
Useinsec	δ_{10}	-3.2638***	0.1167	-2.7961
Hhoe	δ_{11}	-0.1682**	0.9698	-1.7344

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

Table 8, shows that only coefficient of a constant, land, material, mandays square, material square and product of land and material shows significant effect on output. But the coefficient of a constant, land, mandays square, material and Material Square are negative. Ten of the parameters in the inefficiency model showed significant effect on inefficiency. Furthermore, all cross products have *t*-values less than one or close to zero except the product of land and material. This suggests that there are only interactions between these later variables. Robustness of the estimated models can also be indicated by the value of the log-likelihood function. The model that best fits the data is the one with a higher log-likelihood function. The values of the log-likelihood function for the estimated models are -143.1195 and -129.255 for C-D model and translog model respectively. Given that the C–D frontier model best fits the data the study conclude it to be more appropriate than translog model specification.

The second null hypothesis which is tested is H0: $H_0 = \delta_1 = ...\delta_{11}$ implying that the farm-level technical inefficiencies are not affected by the farm - farmer-oriented variables, policy variables and/or socio-economic variables included in the inefficiency model. This hypothesis is also rejected, implying the variables present in the inefficiency model have collectively significant contribution in explaining technical inefficiency effects for the maize farmers. The results of a likelihood ratio test (LR = 27.73) confirms that farmers' low production efficiency mainly relate to the variance in farm management.

4.4 The Production Efficiency and Distribution

The distribution of production efficiency of maize farmers in the study area is presented in Table 11. Farmers technical efficiency vary from 0.008 to 0.92 with the average production efficiency score is 62.3% implying that the average farm producing maize could increase production for 37.7% by improving their technical and allocative efficiency. This average TE does not differ significantly with that of 60.6% of Kiteto and Mbozi as presented by Msuya, (2008) and that of Weir (1999) and Weir and Knight (2000) find mean efficiency levels of 55% among Ethiopian cereal crop producers. The observed wide variation on production is not surprising, similar variation in production efficiency in maize farmers are also observed in from Kenya and Malawi with the mean technical efficiency of 49% (range of 8 to 98%) and 46.23% (with a range of 8.12 to 93.95%) respectively.. Despite the observed variation in production efficiency, more than 36% of farmers have less than 60% efficiency level; hence most of farmers seem to be skewed towards production efficiency of less than 60%. However, the results indicate there is a room for increasing production by improving technical and allocative efficiency for maize farmers in the study area. The volatile distribution of efficiency indexes among smallholder maize farmers are depicted by Fig. 8

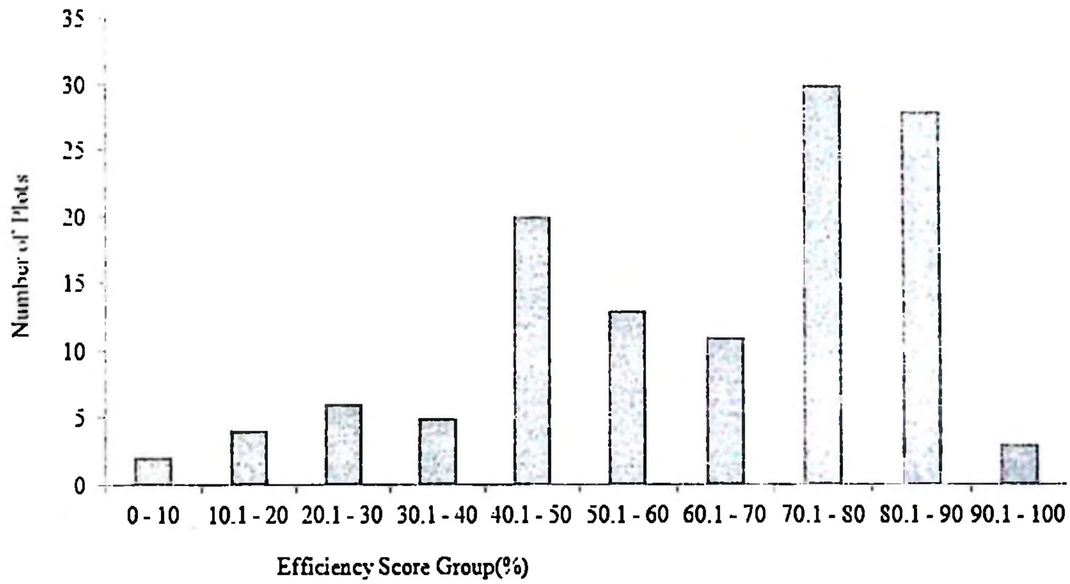

Figure 3: The Distribution of Efficiency indexes among smallholder maize farmers

4.5 Determinants of Inefficiency

This section reports on sources of inefficiency also estimated in the model. A negative sign on a coefficient inefficiencies means that the variable increases technical efficiency and a positive effect on productivity, while a positive sign reduces technical efficiency. The results on Table 9 reveal that the number of years in farming, number of plots owned, number of contacts with extension officer, means of land acquisition, use of insect sides, the use of hand hoes dummy variables and the area under maize production have a negative sign and therefore increase technical efficiency. These results appear plausible. To interpret the coefficients it is recommended to use marginal effect (Battese and Coelli, 1993).

Table 8: Inefficiency Model

Variables	Parameter	Coefficients	Standard error	t- ratio
Constant	δ_0	-1.9908**	1.0951	-1.8179
Noforma	δ_1	-0.4073	1.2358	-0.3296
HHsize	δ_2	0.3087***	0.0953	3.2402
Plonnumber	δ_3	-1.9369***	0.3084	-6.2797
Distplot	δ_4	0.3066***	0.0907	3.3798
Gender	δ_5	2.0867***	0.6255	3.3363
Nocoext	δ_6	-0.2414**	0.1264	-1.9089
Traseva	δ_7	0.8874*	0.549	1.6163
Credito	δ_8	1.3399***	0.544	2.4629
Usefert	δ_9	2.2294*	0.8443	2.6406
Useininsect	δ_{10}	-2.9224***	0.83	-3.5209
Hhoe	δ_{11}	-1.9906**	1.0951	-1.8179
Maizeland	δ_{12}	-0.4595**	0.2441	-1.8822

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

Results on gender (sex) show male farmers were more efficient. This is contrary to results by Masterson (2007) and Tchale and Sauer (2007) who found gender to have no significant impact on efficiency but similar to the results by Msuya (2008) among maize farmers in Tanzania and Kibaara (2005) among maize smallholders in Kenya. Consequently, this work is evidence to the ongoing debate on the role of gender in maize farmers' efficiency by providing more results showing how gender has a significant impact on efficiency.

The coefficient for use of agrochemicals variable is negative and statistically significant. This implies that, farmers who use agrochemicals are more efficient compared to farmers who do not spray their farms. However, coefficient for the use of fertilizers variable is positive and statistically significant at 10% level of significance. This implies that smallholders who use fertilizers are less efficient compared to those who do not use fertilizers. This is contrary to the current influence and subsidization policy by the government of fertilizers to the farmers.

The estimated coefficient of house hold size is positive and significant at 1% level of significance. This implies that maize farmers with more family size tend to be technically efficient in maize production. This result is not exceptional but similar to the results by Oyewo (2011) for maize farmers in Oyo State who found more family size tend to be technically efficient.

The negative but insignificant coefficient for lack of formal education variable indicates that farmers' education is less important factor in enhancing agricultural productivity in the study area similar to the results by Chirwa (2007) in southern Malawi maize farmers. An explanation to this is that, maize is mainly produced for subsistence using traditional methods and the education of farmers does not play a role in the optimal combination of inputs. However these results are unlike the results by Msuya (2008), for maize farmers in Tanzania who found the opposite. The coefficients for credits and plot distance from the homesteads also have similar sings as this of lack of formal education.

Another found to be interesting is that; estimated coefficient for the use of traditional seed variety is positive and significant at 10% level of significance. This implies that farmers who use traditional seed varieties are less efficient compared to those who use improved seeds. The results of similar nature were also found by Chirwa (2007) to maize farmers in Southern Malawi.

4.6 SFA Technical Efficiency Indices and farm Size Relationship

Fig. 9 provides a description of the relationship between the stochastic frontier analysis technical efficiency scores and farm size categories. It can be noted that very small farms (with farms measuring less than two hectares) were relatively more efficient than farms measuring between two and four hectares. Furthermore, results show that farms which had areas of more than four hectares showed an increase in technical efficiency score. The observed tendency of declining farm productive efficiency when moving from very small farm size to relatively large size could be attributed to changes in the land – labour ratio which forces the household to make use of hired labour when farm sizes increases from very small size and other factors in Table 12.

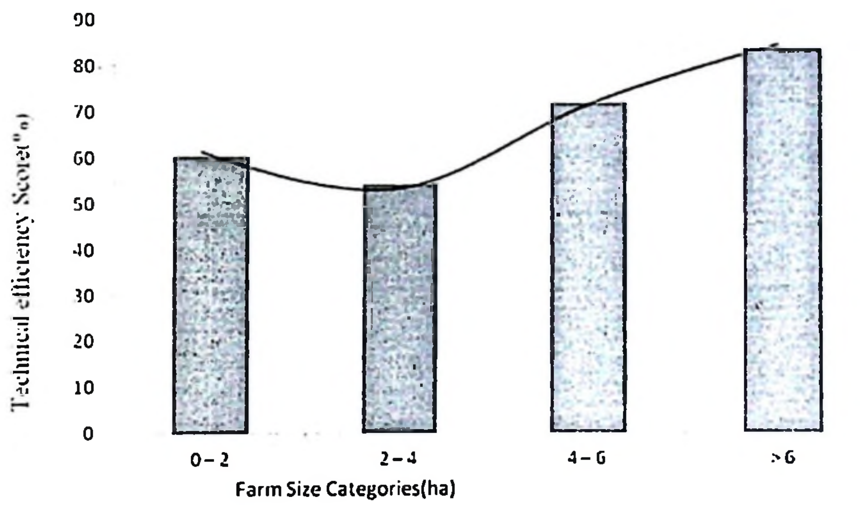

Figure 4: SFA Technical efficiency Scores Vs Farm Size Categories

Conversely, the increase in efficiency score for farms with areas of more than four hectares could be endorsed to improvements in supervision of labourers hired by a farm. Large farm plots which normally hire many labourers are expected to employ extension officers or field supervisors. The employment of field supervisors does not change with slight changes in the number of hired labourers, farmers who employ many hired labourers are likely to gain from size economies in hired labour supervision.

Another most important reason for U – shaped relationship results, could be attributed to the access by large farms to institutions and services (such as technical assistance and sometimes credit) that help lower inefficiency as well more intensive use of the technologies and inputs that raise productivity. If one could create an environment in which small to medium size farms had equal access to productivity enhancing institutions, and improved access to modern technologies and inputs, then these farms could still produce more efficiently than farms above six hectares.

4.7 Problems Facing Maize Farmers in the Study Area

Fig. 10 presents a summary of the main problems encountered by maize crop producers of in their day-to-day farming activities. The figure shows that there are 10 main obstacles which have been reported by the interviewed farmers. In order to establish the significance of each of the eleven problems, the farmers' responses were divided into four categories (Very important, Important, not sure and not important) and percentages were computed for each category.

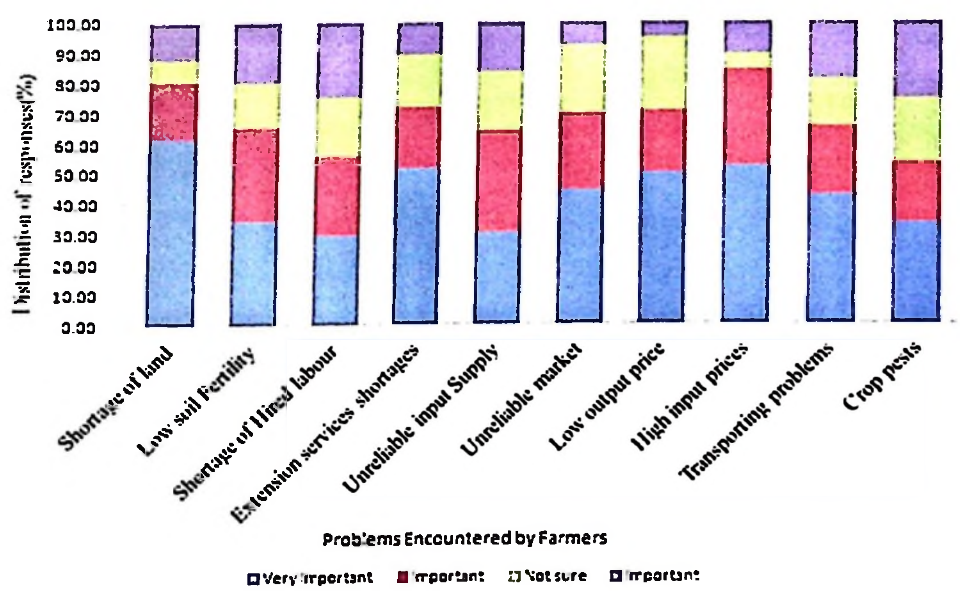

Figure 5: Distribution of Ranks of Problems Encountered by Maize Farmers in the Study Area

Concerning the land shortage problem, 80% of the respondents reported it as a very important obstacle to their farming activities. The high percentage of respondents considering land shortage as a very important problem could be attributed to factors such as conservation area of Tarangire National Park for the Mamire and Galapo wards and the Haitemba forest reserve which is a neighbour to Duru ward. Thus, generally the 'land shortage' problem has a lot to do with the conservation programmes. Therefore, the most appropriate solution for this problem is to use the available land intensively but with attention to good agronomic practices.

It can be further noted, from Fig. 10, that 65% of the interviewed maize producers in the district think that low soil fertility is an important problem in the area. Given the low prevalence of fertilizer use among maize farmers and the relatively high average yields, the farmers' perception that the land is reasonably fertile might be plausible.

Moreover, Fig. 10 shows that the number of respondents who consider shortage of hired labour to be an important problem account for less than 50% of the interviewees. The low percentage of farmers who consider shortage of hired labour to be a significant problem might be attributed to the large number of people who derive their livelihoods from labour selling. The large number of people who rely on labour selling for their livelihoods means that farmers are not likely to encounter any problems in finding hired labourers to work on their farms.

Onward maize farmers in study area were also asked whether they had encountered any problems in accessing extension services. Fig. 10 shows that 72% of the respondents consider the extension services provided to be insufficient. This is not surprising as the present study found that there was an average of one extension in an average of three villages for each ward surveyed who are employed by the local government. Fig. 10 shows that only 60% of the respondents consider unreliable input supply to be an important problem. The high percentage of farmers reporting unreliable input supply as a significant obstacle can be attributed to the fact that most of the maize producers are currently introduced to external input agriculture.

The result from the present study indicates 73% of farmers in the study area do not use agrochemicals and fertilizers; they also make use of their own seeds. Thus, in a way they are the suppliers of most of the inputs they need to produce the various crops they grow. The fact that most farmers have decided to be suppliers of most of the inputs required for the production of the various crops they grow might be attributed to high input prices in the study area. This argument is based on the fact that about 56% of the respondents reported high input prices among the key problems in their day-to-day farming activities. The high input prices can be attributed to a very limited subsidy for an acre of land that is provided to a farmer and remaining amount of land cost to be taken by a farmer at his/her own.

The present study also tried to assess the farmers' perceptions regarding the availability of markets for their major crops. The survey conducted in the area revealed that apart from maize, which is bought by local sugar factories, farmers depend on small traders for selling other crops. This makes the market for maize and Pigeon peas very unreliable, as when the production of those crops in the most accessible parts of the country is high, the traders rarely set foot in remote areas. Thus, it is not surprising to have about 69% of the respondents reporting unreliable markets for their crops among the main problems in their farming activities.

Furthermore, Fig. 10 shows that 70.5% of the respondents reported low crop prices as a significant problem. The price of maize crops are normally low during the harvesting period Since most of the small-scale farmers cannot afford to store their crops, then they normally sell most of their harvest soon after harvesting. The low price also applies to Pigeon peas in harvesting season since if the crop is stored its weight declines.

Fig. 10 shows that 65.5% of the respondents mentioned harvest transport problems among the key obstacles for their farming activities. The high proportion of farmers considering difficulties in transporting their crops as an important problem could be attributed to the fact that transport services for maize at the expense of a farmer through hired labour and ox - cat. However sometimes due to the small amount that is sold to the traders farmers normally carry those crops to where the traders are or designated market.

It can be noted further, from Fig. 10, that 52% of the interviewed producers of maize consider damages caused by crop pests to be an important obstacle. Although some animals such elephant destroy most of the crops grown in the study area, the most affected crops are maize and Pigeon peas and Sunflower. Moreover the changes in weather have attributed drought and therefore a decline in pasture that make cattle to be another obstacle facing farmers in study area.

4.8 Comparison in Relative Profitability for Some of the Crops in the Study Area

The gross margin of different crops is shown in Table 10. Returns to labour and gross margins vary among different crops. A comparison between these crops shows that in average GM Per ha of Maize crop was significantly ($P < 0.05$) higher than that of Sorghum (Tsh 11 691versus Tsh 9375). The study found that, even though GM Per ha of Maize was significantly higher than that of Sorghum ($P < 0.05$), it was found to be less than that of Pigeon Peas (Tsh 11 691 versus Tsh 14 753.70). In terms of variable costs, maize is the cheaper but its relative high output per unit (2.51 t/ha versus 1.97t/ha and 1.66t/ha of Sorghum and Pigeon Peas Respectively) makes it a more important in terms of returns to land despite the fact that Pigeon Peas are likely to be the first crop in relative profitability.

Table 9: Gross margins across different crops in Babati District

Items	Crops		
	Maize	Sorghum	Pigeon peas
Receipt			
average area (ha)	1.8	1.48	2.54
Yield(Mt/ha)	2.51	1.97	1.66
Average Price	42 500	26 400	71 684
Revenue	106 675	52 008	119 216.2
Variable Costs			
Land Preparation	12500	10500	15 500
Seeds	28511	10800	9 625.5
Planting	11500	7800	16 837
Weeding	18473	1533	30 600
Harvesting	24000	12000	31900
Total variable Costs	94984	42633	104462.5
Gross Margin	11691	9375	14753.7
	Gross Margin(Mean)		
Maize Vs Sorghum: t = 7.386*	Maize Vs Pigeon Peas: t = 1.029*	Sorghum Vs Pigeon Peas: t = 2.220*	

*P < 0.05

CHAPTER FIVE

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

The main objective of the research was to examine farm size and Production efficiency for food security among maize producers in Babati. The Stochastic production frontier functions were used in the analysis for this study. Using comprehensive survey data obtained from 122 maize farms in 2010 the study obtained production efficiency with wide variation among maize farmers in the district. The mean level of efficiency for maize farming is 0.623 indicating that there remains considerable scope to increase maize production by improving both technical and allocative efficiency.

The farm-specific variables used to explain inefficiencies indicate that those farmers who have farming experience, number of farm plots they own, contacts with extension officers, those who had hired or bought land, the ones who use hand hoe and insect sides to be more efficient. Due to the gap of 37.7% inefficiency level, resulting from the above mentioned factors there is a need for proper policy to eliminate this gap.

Onward study results showed that the technical efficiency does not decrease monotonously with increasing farm size for very small farms. Thus it can be concluded the data from smallholder maize farmers in Babati does not suggest the existence of inverse relationship between farm size and productive efficiency. Also it is shown that although farm size was among the important determinants of farm productivity; its effects on productivity were not fixed, i.e. the effects of increasing farm size by one hectare on farm productivity on prevailing farm size. Whereas increasing farm size from one to two hectares is almost certainly going to increase average farm production, increasing farm size from more than seven hectares will at best result in no change in average production.

Inefficiency in maize farming can be reduced significantly by relatively increasing farm size to around six hectares. Increasing size of farms could not only increase farms production efficiency but also eradicating poverty among farmers. Moreover, strengthening extension services, extension materials and farmers training will improve efficiency.

5.2 Recommendations

In view of the major findings of the study and the above conclusions, the following recommendations are drawn.

More efforts should be intensified on the part of extension agents in training and provision of extension materials to the farmers so as to boost their efficiencies in maize production, also results of better researches of improved agronomic practices should be extended to the farmers in this area by the extension agents. The extension services can be intensified by promoting the linkage between farmers, researchers and extension personnel. This will facilitate the flow of information from the researchers to the farmers and vice versa, which is important for the development of relevant technologies. An efficient extension system will ensure proper communication between farmers and researchers, which is important for the developed technologies to reach the end users, and for the researchers to have a clear knowledge of farmers' needs. To achieve this target, the government should enhance the support provided to extension agents and agricultural researchers.

The study confirmed that efficiency can be increased by increasing farm plot size in the study area with the current level of inputs used. This should be done by emphasizing favorable environment for increasing farm sizes among farmers to ensure transformation from agriculture sector dominated by very small farms to agriculture dominated by plausibly large farms. The relative increase in farm plot size will not only increase the food security in the country but also stimulate efforts by the government to move its citizens out of absolute poverty.

Given the escalating prices of inorganic fertilizers (taking the bigger share of the agriculture sector budget in the country), alternatives such as integrated soil fertility management which reduces the effective costs of soil fertility management options are recommended.

Furthermore, the results of the analysis of the main problems encountered by the producers of maize in the study area have revealed that an unreliable market is among the main obstacles. This problem can be reduced opening borders so as to allow farmers to fetch better price to the neighboring countries which are experiencing food shortages.

Land shortage is also found to be among the main obstacles encountered by a farmer in a study area. A close analysis has revealed that the main reason for the "land shortage" problem is the average household size. The result from this study indicates the average household size is composed of eight people. This is very large compared to the average farm size in the study area which course problems on accessibility of land. Thus to ease the "land shortage" problem, the government should invest more in family plan projects.

Further high input prices are found to be among obstacles to maize farmers in the study area. The problem can be tackled by introducing and strengthening farmers' associations and entrust them with the task of supplying farm inputs. This recommendation is based on the fact that inputs supplied by farmers' associations were found to be cheaper than those supplied by private traders. The large input price differential between farmers' associations and private traders could be attributed to fact that while the farmers' associations supply inputs on "no profit no loss" basis, private traders are oriented to profit maximization. Unfortunately, however, the farmers' associations are unable to meet the input requirements for all farmers. Thus the government should increase the ability of such associations to procure inputs by providing seed money. This would enhance their ability to provide input at a right quantity and at a right time.

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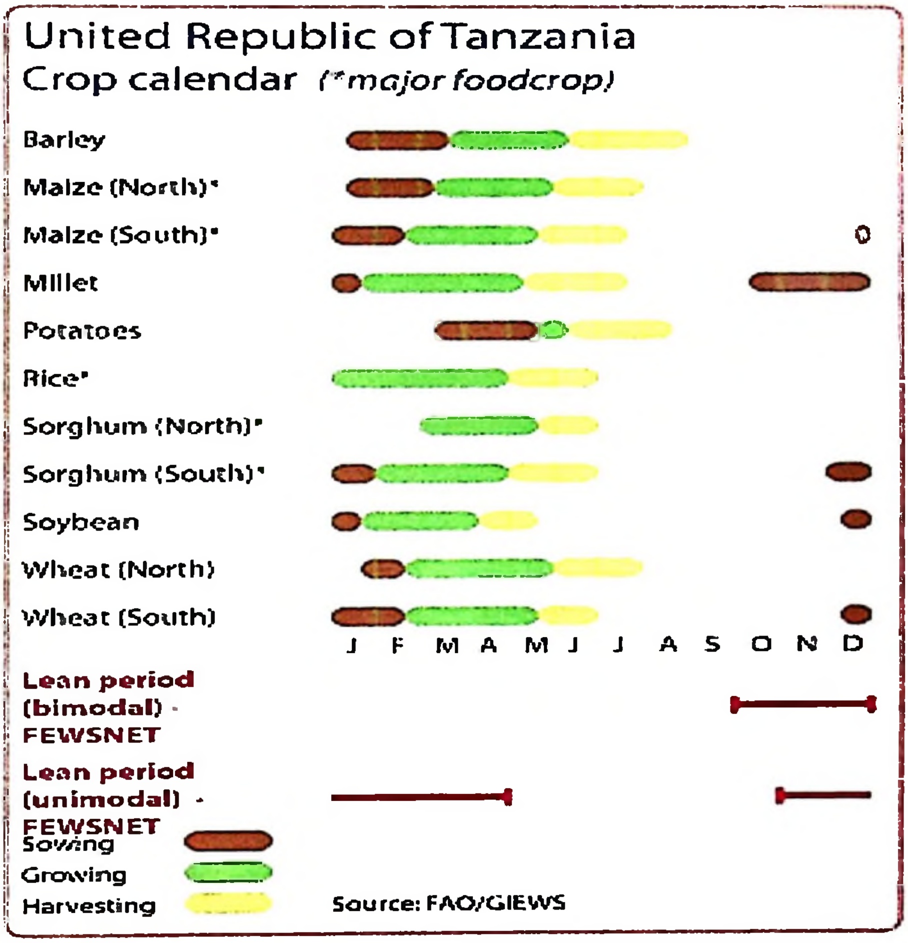
APPENDICES

Appendix 1: Tanzania Crop Calendar



Appendix 2: Agro ecological zones and Farming systems in Babati District

Agro – ecological zones	Altitude (Meters)	Rainfall (mm)	Temperature (°C)	Natural Vegetation	Production System
I Humid Highlands	2150-2450	1200+	14-16	Montane forest. *Cassipourea*, Cascaria spp., Ekebergia capensis, Fagaropsis angolensis, Olea africana, O. capensis and Podocarpus latifolius	Forest Reserve
II Sub Humid Highlands	1850-2150	1100-1200	16-18	Short grass land, e.g. Star grass *Cynodon dactylon* Kikuyu grass *Pennisetum clandestinum*, Themeda triandra, Chloris pythnotrox and Sporobulus qfricanus, Cyperus rigidifolius and legumes such as Khyrrchosia nimena, Cassia mimosoides, Trifoliummasaiense	Wheat, Livestock maize -potatoes- Acacia meamsii, (Agro pastoral)
III Semi Humid Uplands	1500-1850	900-1100	18-20	Dry forest/ woodland Brachystegia microphylla, B. spiciformis, Albizia versicolor and Tubemadia globiflora	Wheat- Barley, Maize- bananascoffee- Grevillea and livestock (Agro pastoral)
IV Semi-humid, semi-arid midlands (Transition)	1200-1500	750-900	20-22	Dry woodland/bushland *Acacia spp.*	Maize-Pigeon peas beans- Livestock, Grevillea-Cassia (Agrosilvopastoral)
V Semi-arid lowlands	950-1200	500-750	22-28	Bushland Vs Bushed tree grassland Acacia spp., Commifora spp., Combretwn spp., Adansonia digitata. Pennisetum spp., Panicum spp., Sporobolus and Digitaria spp. Open medium height grassland dominated by *Pennisetum spp.*, Digitaria spp., and Panicum spp.	Livestock- maizebeans- cotton- Cassia-Grevillea (Agropastoral) Pastoral livestockwildlife Pastoral livestockwildlife

Source: Mkonya *et al.* (2000)

Appendix 3: Farmers' questionnaire for farm size and productivity relations: evidence from maize production in Babati District.

A. Farm Household Characteristics

Questionnaire Number: ....

1. Date... Interviewer's Name...
2. District Division: ....Village...............................
3. Farmer's Name..................................Age:............................
4. Farmer's Gender:1 = Male ( ) 2 = Female ( )
5. Farmer's marital status: 1 = Single ( ) 2 = Married ( ) 3 = Divorced ( ) 4 = Widow ( ) 5 = Temporary separated ( )
6. Household Size ....
7. Household Composition

Age Category (Years)	Sex(Gender)	
	Male	Female
0 – 9		
10 – 14		
15 – 65		
>65		

8. Farmers Years in Maize farming [ ]
9. Farmer's(Household head) Level of education: 1 = No formal education ( ) 2 = Adult education ( ) 3 = Primary education ( ) 4 = Secondary education ( ) 5 = Other (Specify)
10. 'Main Occupation [ ] 1 = Farming 2 = Non – Farming
11. What are your non – farm income generating activities?
    Employment [ ] 1 = Yes 2 = No Handcraft [ ] 1 = Yes 2 = No
    Petty trade [ ] 1 = Yes 2 = No Big Business [ ] 1 = Yes 2 = No
    Others [ ] 1 = Yes 2 = No (if Yes mention...)

B. Farm and Crop Production information

12. Do you own the entire land you are currently using for crop production activities?
    1 = Yes 2 = No

13. What is the total size of land that is owned by the household?(Acres) [ ]
14. How was the land (owned by the household) obtained?
    1 = Inherited ( ) 2 = Bought ( ) 3 = given by the village government ( )

    4 = Accessed free land ( )

15. If you bought land, then when was it bought, and what was the price per acre
    ( ) (TZS) [When] [Price/acre...............]
16. If you do not own the entire land you are using for farming, then whose land do you use for crop production activities?
    1 = Relative's land (free use) ( ) 2 = Hired (Monetary payments) ( ) 3 = Hired

    (Payments in produce form) ( )

17. If you paid in cash, then what was the rent for hiring one acre of land? Provide Values in TZS for the last year:

2009/10	

18. If Payments were in produce form then how much of the produce was required per acre?

2009/10	

19. If you were to buy this land today how much would it cost?(Plot market price)

    .... (TAS)

20. In how many plots is the farm segmented [ ]
21. What is the average distance to the plots [ ] (in Kilometers)
22. Which crops did you grow the last season (Consider all your plots)?

No ↓	Crop grown	Distribution of crops to the land		Area under Cultivation(acres)	Yield(Kg)
		Hired	Own	2009/10	2009/10
1					
2					
3					
4					

C. Maize technology and Inputs – most recent season

23. What type of technology did you use to cultivate the farm during the most recent season? [ ]

    1 = Hand hoe 2 = Plough 3 = Tractor

24. What maize variety did you grow 2009/10 season? [ ] 1 = Traditional 2 = Improved variaties
25. Where did you obtain the seeds from? [ ] 1 = Own stock , 2 = from neighbour/relatives,3 = buy from market, 4 = buy from agro dealers,5 = given by extension officers/NGOs
26. Were artificial fertilizers used on fields planted by maize? [ ] 1= Yes 2 = No
27. Were pesticides applied on growing crops? [ ] 1 = Yes 2 = No
28. Where did you buy most of your inputs(fertilizer & chemicals) during 2009/2010 farming season?

    Nearby shop [ ] 1 = Yes 2 = No, Marketplace [ ] 1 = Yes 2 = No, Others [ ]

    1 = Yes 2 = No .If Yes Mention..............................

D. Household Income

Income from Farming Activities

29. Out of the various crops produced, which ones did you sell? Provide amounts and average Prices for the last season

Season →	2009/10		
Crop ↓	Amount(T/bag)	Price per T/sack	Total Income
1.			
2.			
3.			
4.			
Total			

E. Income from Off – Farm Activities

30. Apart from crop farming activities, what other activities bring income into your household? How much did you get from those activities last season (2009/10)? And what problems do you encounter in your off – farm income generating activities?

Source of Income	Average Monthly Income	Average Annual Income	Problems encountered
Formal Employment			
Brewing and selling local brew			
Carpentry			
Selling charcoal/firewood			
Small business			
Brick making			
Mansory			
Lumbering			
Others(Specify)			
Total			

F. Labour and Other Input Use Information

31. What is the average labour requirement (man days per acre) for various operations?

Average labour Requirements for Various Farm Operations (per acre)					
Crop ⟶	Maize	Sorghum	Pigeon Peas	Other crops	Total
Land Preparation					
Planting					
Weeding					
Agrochemicals Application					
Harvesting					
Transporting					
Bird Scaring					
Other					
Total					

32. If hired labour was used, indicate the average cost per operation per acre for Crops production for the last season

	2009/10								
	Maize			Sorghum			Pigeon Peas		
Operation	**Size (acre/T)**	**Unit cost**	**TC**	**Size (acre/T)**	**Unit cost**	**TC**	**Size (acre/T)**	**Unit cost**	**TC**
Land preparation									
Planting									
Weeding									
Fertilization									
Harvesting									
Transporting									
Other									
Total									

Other expenses in production operations (apart from labour charges)

33. What other expenses (apart from labour) did you incur in producing the following crops in the last season/{Cost for tractor services, harvest transport, equipment hire e.g. sprayers etc}

Season ⟶	2009/10								
Crop ⟶	Maize			Sorghum			Pigeon Peas		
Operation/Activity ↓	Amount	Unit cost	TC	Amount	Unit Cost	TC	Amount	Unit Cost	TC
Tractor services									
Equipment hire									
Transporting									
Other									
Total									

34. Did you Purchase fertilizers or any other agrochemicals during the last growing seasons? 1 = Yes 2 = No

35. If the answer for question 34 is 'Yes',then where did you buy those inputs?

1 = Input suppliers within the ward ( ) 2 = Input suppliers in Babati town ( )

3 = from farmer's associations ( ) 4 = From Suppliers in Arusha ( ) 5 = other

(specify) ( )

36. If the answer for question 35 is 'No', then what were the reason for not buying those inputs

1 = Not available ( ) 2 = Expensive ( ) 3 = Not necessary ( ) 4 = other

(specify) ( )

37. Indicate amounts and prices for the inputs used in various productions in the last seasons.

Season	2009/10								
Crop →	Maize			Sorghum			Pigeon Peas		
Operation/Activity ↓	Amount	Unit cost	TC	Amount	Unit Cost	TC	Amount	Unit Cost	TC
Fertilizer									
Seeds									
Herbicides									
Labor									
Land									

G. Investment

38. Indicate the number, acquisition price, year of acquisition and expected life span of the following items:

Item	Number	Year	Economic life	Acquisition cost	Total Cost
Hoe					
Machete					
Sprayer					
Bicycle					
Car					
Tractor					
Newland					
Others					
Total					

39. What method do you use to control weeds?

1= Chemical control (use of herbicides) ( ) 2 = Cultural control (Flooding, mulching) ( )

3 = Mechanical control (hoeing) ( )

40. What method do you use to enhance soil fertility?

1 = Use of organic fertilizers ( ) 2 = Use of inorganic fertilizers ( ) 3 = Use of both organic and inorganic fertilizers ( ) 4 = none ( )

41. Where is the farm for crop production located [ ] 1.Sloped area 2.Flat area
42. Which area of land provides more output? [ ] 1.Sloped area 2.Flat area

I. Access to Institutions

A) Credit Services

43. Do you have access to credit facilities? 1.Yes ( ), 2 = No ( )
44. If you have access to credit facilities, then what are the sources of credit?

1 = Bank ( ) 2 = VICOBA 3 = SACCO's ( ) 4 = Traders ( )

45. Have you applied for credit from any agency last year? 1 = Yes ( ), 2 = No ( )
46. In what form did you receive the credit? 1 = in kind ( ); 2 = Cash ( )
47. If in kind what inputs/services did you obtain?

Input Services ↓	2009/10		
	Amount	Crop	Total value
Land preparation			
Fertilizers			
Harvesting			
Transport			
Other			
Total			

48. If in Cash, what was the amount (in TZS) received in 2009/10? [ ]
49. What was the interest for the credit? [ ]
50. What was the repayment procedure for the credit? 1 = Cash ( ) 2 = In kind ( )

3 = both cash and in kind ( ) [ ]

51. What was the repayment period?

52. If you have not applied for credit, then provide reason (s) for not applying for credit.

1 = Not available (lack of credit facilities) ( ) 2 = High interest rates ( )

3 = I have enough own funds ( ) 4 = High risk (crop failure) ( )

5 = other

(specify)...

53. Has credit restriction affected your maize/sorghum/Pigeon peas production in any way/

1 = Yes 2 = No

54. If yes, How? 1 = Use less amount of inputs ( ) 2 = Restrict expansion of farm size ( ) 3 = others
(Specify)...

J. Extension Services

55. Do you have access to extension services?

1 = Yes ( ) 2 = No ( )

56. If yes, how many times the extension agent did visited you in the last growing season? [ ]

57. Have you participated in any farmer training workshop in recent years?

1= Yes ( ) 2 = No ( )

58. Have you received any extension material, such as leaflets, in the last growing seasons?

1 = Yes ( ) 2 = No ( )

59. Provide ranks for the influence of the following factors on crop production(Answer:1 = Very important, 2 = Important, 3 = Not sure, 4 = Not important)

Shortage of land( )	Low soil fertility( )	Shortage of hired labour ( )	Shortage of extension services ( )
Unreliable input supply ( )	Unreliable market ( )	Low output prices( )	High input Prices ( )
Difficulties in transporting crops( )	Damages caused by crop pests( )	Lack of capital to purchase inputs ( )	Other (Specify) ( )

THANK YOU VERY MUCH FOR YOUR COOPERATION