DETERMINANTS OF PRODUCTIVITY AND POST-HARVEST LOSSES AMONG SMALLHOLDER MAIZE FARMERS IN KILOSA DISTRICT, MOROGORO REGION

NTIRANKIZA MISIBO

A DISSERTATION SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN AGRICULTURAL ECONOMICS OF SOKOINE UNIVERSITY OF AGRICULTURE. MOROGORO, TANZANIA.

2016

ABSTRACT

The Government of The United Republic of Tanzania has been taking different initiatives to increase maize yields and reduce post-harvest losses. Nevertheless, there has been persistent low maize productivity that is amounting to 1.2 T/Ha in contrast to the ideal maize productivity of about 6-7.5 T/Ha. The low maize produced is lost during different maize post-harvest operations and the losses are estimated to range between 5% and 40%. Due to these problems, maize demand is higher than supply. The present study which was conducted in Kilosa District aimed at assessing determinants of productivity and post-harvest losses among smallholder maize farmers. The specific objectives were to determine the technical efficiency of maize producers; to determine factors affecting technical efficiency; to identify the determinants of post-harvest losses and to examine the relationship between technical efficiency and post-harvest losses. The study employed cross sectional design from 166 respondents obtained through simple random sampling. To estimate the technical efficiency, input oriented Data Envelopment Analysis (DEA) was employed and Tobit regression model was used to determine factors affecting technical efficiency. Furthermore, semi log multiple regression function was used to identify the determinants of post-harvest losses in maize and simple correlation coefficient was used to examine relationship between technical efficiency and post-harvest losses in maize. The results show that on average maize productivity is about 523.85kg/acre and maize losses is about 19.55% per household. The findings further show that, on average, technical efficiency was estimated at 83.63%. Experience, numbers of years in school, land size for maize and extension services were found to be positively and significantly ($P < 0.01$) associated to technical efficiency. Gender was found to be positively and significantly ($P < 0.1$) associated with technical efficiency. Off-farm income was negatively and significantly ($P < 0.01$) related to technical efficiency. This study further found that years of education and experience were negatively and significantly ($P < 0.01$) associated with postharvest losses in maize. The household size was negatively and significantly ($P < 0.05$) associated with postharvest losses. Gender and maize yield per acre were positively and significantly ($P < 0.01$) associated with postharvest losses. Proportion of farm allocated to maize crop was positive significant ($P < 0.05$) associated to post-harvest losses. Moreover, the results show that, there is a moderate positive correlation between technical efficiency and post-harvest losses ($P < 0.01$). The study suggests that, the government, farmers and private organizations should invest in capacitating on knowledge and skills for the usage of different inputs; focus in women empowerment and capacity building on access to financial services.

DECLARATION

I, Ntirankiza Misibo, 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 it has neither been submitted nor being concurrently submitted at any other institution.

05/07/2016

Ntirankiza Misibo — **Date**

(MSc. Candidate)

The above declaration is confirmed by

05/07/2016

Dr. Damas Philip — **Date**

(Supervisor)

COPYRIGHT

ACKNOWLEDGEMENTS

First and foremost, I would like to present my sincerely thanks to the Almighty GOD who created and gave me unquestionable health up to this end, for his blessing and wisdom did not go unnoticed. He gave me strength to go on when I was about to give up and when things did not seem so promising.

Furthermore, my acknowledgements are extended to many people who supported me in one way or another in accomplishing this dissertation work. My heartfelt appreciation and gratitude goes to my supervisor Dr. Damas Philip for his extensive, mentoring and kindness guidance probably without his assistance the completion of this dissertation would have been impossible. Special thanks go to iAGRI Project which provided full sponsorship for this study.

I wish to express my indebtedness to my family members led by my lovely wife Salome C. Magimilo and my children Ponsiano F. Misibo, Priscilla F. Misibo, Patricia F. Misibo and the newly born twins Pravin F. Misibo and Praise F Misibo who missed fatherly care for a long time. Much thanks to my brother George K. Ntakimazi for his tireless encouragement and follow up.

I would also like to extend my acknowledgements to Kilosa farmers, extension officers and Kilosa DAICO office for their assistance during the survey stage. Special acknowledgements also go to MR. Milaho C. and Caroline O. A. for their unique help.

Lastly, I do appreciate all staff members in the Department of Agricultural Economics and Agribusiness of Sokoine University of Agriculture, my fellow postgraduate students for their encouragement, support and assistance during preparation of this dissertation. I thank them very much for their support and words of encouragement that they were always ready to give at no cost. It is my prayer that GOD blesses them abundantly for the rest of their lives.

DEDICATION

This work is dedicated to my Father, the late Misibo Mpfanye Kinywebhere and my mother the late Agness Matwalane Katoto who together laid the foundation of my Education. I also dedicate this work to my brothers and sisters who encouraged me and supported me during the entire study time.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ABBREVIATIONS AND SYMBOLS

AE_i	Input Oriented Allocative Efficiency
AE_o	Output Oriented Allocative Efficiency
ANOVA	Analysis of Variance
ASDP	Agricultural Sector Development Programme
ASDS	Agricultural Sector Development Strategy
ASR	Agricultural Sector Review
CBOs	Community Based Organisation (s)
CRS	Constant Return to Scale
DAICO	District Agriculture, Irrigation and Cooperatives
DEA	Data Envelopment Analysis
DEAP	Data Envelopment Analysis Programme
DMU	Decision Making Unit
DTMA	Drought Tolerant Maize for Africa
EE_i	Input Oriented Economic Efficiency
EE_o	Output Oriented Economic Efficiency
FAO	Food and Agriculture Organisation
FCS	Food Chain Supply
FGD	Focus Group Discussion
ha	Hectare
iAGRI	innovative Agricultural Research Initiative
LDC	Least Developed Countries
LSD	Least Square Difference
MAFCS	Ministry of Agriculture, Food Security and Cooperatives
MKURABITA	Mkakati wa Kurasimisha Biashara Tanzania
NGOs	Non-Government Organisation
NIRS	Non-Increasing Returns to Scale

NSGRT	National Strategy for Growth and Reduction of Poverty
OLS	Ordinary Least Square
PASS	Private Agricultural Sector Support
PER	Public Expenditure Review
PHL	Post-Harvest Losses
PRA	Participatory Rural Appraisal
SACCOS	Saving and Credit Cooperative Societies
SAGCOT	Southern Agricultural Growth Corridor of Tanzania
SFA	Stochastic Frontier Function
SNAL	Sokoine National Agricultural Library
SSA	Sub-Saharan Africa
TAFSIP	Tanzania Food Security Investment Plan
TDV	Tanzania Development Vision
TE_{CRS}	Technical Efficiency under Constant Returns to Scale
TE_i	Input Oriented Technical Efficiency
TE_o	Output Oriented Technical Efficiency
TE_{VRS}	Technical Efficiency under Variable Returns to Scale
TFP	Total Factor Productivity
URT	United Republic of Tanzania
USA	United States of America
VICOBA	Village Community Bank
VRS	Variable Returns to Scale
ZSGRP	Zanzibar Strategy for Growth and Reduction of Poverty

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background Information

Agricultural production in many African countries, including Sub-Saharan Africa in which Tanzania is situated depends on smallholder farmers. In Tanzania smallholder farmers are estimated to be about 80% (Jones *et al.*, 2011). Hodges *et al.* (2010) reported that, smallholder farmers in Tanzania are the most important producers of food as well as cash crops. Asea *et al.* (2014) describes smallholder farmers' characteristics as; small farm acreage (0.2-2 ha), low yields (1.0-1.8 t/ha), high production costs and low returns.

Maize is the most important staple food in Tanzania which serves a dual function as source of employment, income, feeds and food security for smallholder farmers in Tanzania (Bala *et al.*, 2010). Maize is grown at least in every continent in the World (Rashid, 2013). Maize is grown almost everywhere in Tanzania (Morice, 2014). PASS Trust (2013) reported that the area under maize production is estimated to range between 1.8 and 2.0 million ha (44%) compared to 3.3 million ha (56%) arable land with suitable climate for the production of maize in Tanzania. Hoff, (2012) reported an increase of maize production in the World by 50% capturing the trend of over ten years. In Sub-Saharan Africa, Nigeria is the largest producer harvesting 30% of maize followed by Tanzania (FAO, 2010). Maize is the leading cereal accounting for about 74% of the total cereal production in Tanzania (Osuna *et al.*, 2013; MAFSC, 2013). It was averaged to be 4.9 million tons of maize as a total production, 2011/12 season in Tanzania (PASS Trust, 2013). Though the production trend seems to increase, it is said that such increase is due to expansion and opening of new virgin land. For example, MAFSC, (2013) report show that the high increase in area under maize production compared to total production is an indication that production may have decreased.

In agriculture, two components/systems are looked up. The first one being food production where researchers/practitioners/policy makers and decision makers wish farmers/producers to increase yields and second, system is post-harvest handling; here they wish to handle food in such a way that food losses are minimal to maintain the produced food (Folayan, 2013). Productivity in this study refers to maize productivity and post-harvest losses refer to maize post-harvest losses. Productivity of the firm (Farmer) is defined as the ratio of the output(s) to that it produces to input(s) that it uses where the output in this case is maize and inputs are land, labour, seeds, fertilizer and agrochemicals (Coell, 1957; Damas, 2007).

Hodges *et al.* (2010) defined post-harvest losses as measurable quantitative and qualitative food losses in the post-harvest system. Losses of quantity (weight and volume) and quality (altered physical condition) can occur at any stage in the post-harvest system. Losses are often estimated as percentage of the amount remaining from the previous stage of the post-harvest operation.

Most of the maize produced in Tanzania is grown under rain-fed conditions. Technology used in maize production varies due to agro-ecology, culture and resource availability. Presentation by Damas, (2011) stresses that the technologies used are rudimentary (poor use of agrochemicals; poor seeds; poor spacing; poor use of fertilizers and inadequate control of pest and diseases) which inevitably, results into low productivity. Smallholder farmers in Tanzania face numerous challenges in producing maize. For example, they face consistently low maize productivity. MAFSC, (2013), Osun *et al.* (2013), FAOSTAT (2012) and PASS trust (2013) reported that Tanzania National maize yields are very low averaging 1.2 t/ha in contrast to the potential of 6 t/ha . Low yield is caused by a number of reasons, such as technical inefficiencies, unfavourable climatic conditions, pest and diseases and poor use of Agricultural inputs (DTM, 2010). These among other constraints present serious threats to the supply of maize. Deshmanya and Patil (2007) suggest that, maize production must increase at 3.0-3.5% annually to match increasing demand in Tanzania.

Tanzania has had several initiatives geared at enhancing agricultural productivity including on maize (Gabagambi, 2013; Morice, 2014). Different approaches/strategies/slogans have been practiced (Appendix 1); for instance, *Siasa ni Kilimo* (1972) (Politics is Agriculture) *kilimo cha kufa na kupona* (1974/75) (Agricultural for survival), *kilimo ni uti wa mgongo* (Agriculture is a back born) and Ujamaa villages, though had little or no impact on agriculture productivity improvement. Recently, post-harvest handling sensitisation has declined due to little or non-participation of non-governmental sector and international organization. This has caused policy makers, planners, practitioners and decision makers to reduce concentration on the issue of post-harvest losses with consequent high post-harvest losses (Hodges *et al.*, 2010; FAO, 2009).

Despite the low yield recorded by farmers, there are high maize post-harvest losses ranging from five percent to 40% (Jones *et al.*, 2011; Hell *et al.*, 2010; Chapoto and Jayne, 2010; Hodges *et al.*, 2010; World Bank, 2010; Folayan, 2013 and Morice, 2014). According to Jones *et al.* (2011) and FAOSTAT (2010), the most causative agents of high post-harvest losses are pests, rodents and spill out. Other losses occur due to less or careless (improper handling/inefficiencies) in post-harvest operations.

Together with low maize productivity as main staple food, and high maize post-harvest losses, Tanzania is facing another challenge of high population growth rate and an increasing of urbanization which have increased maize demand and subsequent maize shortage (FAO, 2009; Yusufu and Yong, 2011; MAFSC, 2013; December, 2010).

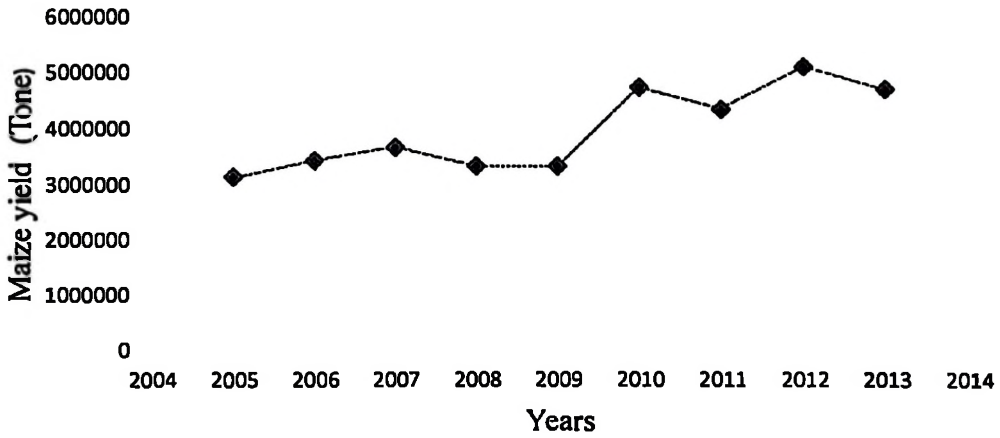

Figure 1: Trend of Maize Yield in Tanzania for Nine Years

Source: Computed from FAOSTAT data

Fig.1shows that maize yield slightly increased from 2005-2007 then bumper harvest was realized in 2008. Furthermore, 2009-2013 maize yields were declining. If compared to the population increase as evidenced by the census of 2012 however, Tanzania population which almost tripled the population in 1967 grows at the rate of 2.7% per annum. This growth rate ranks as one of the fastest in the World and translate to a net total of about 1.2 million people being added to the population annually. At this rate Tanzania's population will cause high demand for maize as a main staple food (Agwand and Amani, 2014; Nie *et al.*, 2016).

To improve maize production and productivity, farmers need to improve the efficiency with which they use the various inputs and decrease the post-harvest losses in maize. This can be achieved by increase in proper use of agricultural inputs, extension services, use of high yielding and early maturing maize seed varieties, disease resistant varieties and capacitating the means of access to credit to farmers by various agricultural stakeholders (Folayan, 2013; Kimatu, 2013; FAO, 2011). Therefore, this study aimed to raise attention on the need and means to increase maize productivity and identifying the determinant of post-harvest losses in maize which is consistent and supportive of the recent government's chain of initiatives. These initiatives includes, Tanzania Development Vision (TDV) 2025, Mini-Tiger Plan 2020, Agricultural Sector Development Programme (ASDP/ASDS), Tanzania's National Strategy for Growth and Reduction of Poverty and or Zanzibar Strategy for Growth and Reduction of Poverty (NSGRP I and II/ZSGRP) Or (MKUKUTA/MKUZA), the Poverty and Business Formalization Program for Tanzania well known in Kiswahili as MKURABITA, Agriculture first (KILIMO

KWANZA), Southern Agricultural Growth Corridor of Tanzania (SAGCOT), 5-year development plan, Tanzania Food Security Investment Plan (TAFSIP) and the current one Big Results Now model (Appendix 2).

1.2 Problem Statement and Justification

Maize Farmers in Tanzania specifically in Kilosa District experience many problems. The most important problems faced by Kilosa's District farmers are low maize productivity and high post-harvest losses (DTM, 2010; MAFSC, 2013; Osun *et al.*, 2013; FAOSTAT, 2012; PASS trust, 2013). Tanzania Government, together with international organizations are trying hard to initiate different agricultural intervention/approaches/strategies/slogans to enhance productivity, yet there have been persistent low maize yield and high variation in maize yields. Review by Kihupi (2012) and Agriculture Sector Review/ Public Expenditure Review (ASR/PER, 2010/2011) indicated that the existing land productivity of maize in Tanzania which is about 1.2 tons per hectare is nowhere near the productivity potential of 6-7.5 tons per hectare. Other studies which pointed out this persistent low maize productivity are DTM (2010); MAFSC (2013) and Osun *et al.* (2013). DTM (2010) stressed that, maize average yield declined to 1.1 t/ha in 2008-10. Furthermore, if compared with world average productivity of 4.3 t/ha and some other African countries like South Africa with 2.5 t/ha Tanzania is still behind (FAO, 2009). So efforts are needed to attain the maize potential production of 6-7.5 t/ha (Osun *et al.*, 2013; FAOSTAT, 2012; PASS trust, 2013).

Low maize yield on one hand is a big problem, but on another hand, the low maize yield obtained is lost due to inefficient post-harvest handling (MAFSC, 2013; Osun *et al.*, 2013). At one point in previous years, Non-Governmental Organisation (NGOs) and International Organization concerted their efforts and focused on post-harvest handling which led to policy makers, practitioners, decision makers to strengthen on different initiatives addressing post-harvest handling issues. This brought awareness on this topic which resulted into different skills and knowledge hence low post-harvest losses. The situation currently is bad as reported from different studies. Jones *et al.* (2011), Hell *et al.* (2010), Chapoto and Jayne, (2010), Hodges *et al.* (2010), World bank (2010), Folayan (2013), Morice, (2014) reports that, maize post-harvest losses ranges between 5% to 40%. Folayan, (2013) insisted that, increased food production is taking place in the developed countries in contrast to most of the post-harvest losses as occurring in the developing countries. Maize post-harvest losses is a great problem among the smallholder producers as pointed out by The World Bank, (2011), Feed the Future (2013), Lipinski *et al.* (2013), FAO, (2013), Mutambuki, (2012), Yakubu (2012) and Gustavasson *et al.* (2011), because the lost maize is evaluated as enough to feed 48 Billion people for 12 months and is valued at around of $4 Billion. Kimatu, (2013) evaluated this amount of maize to be equivalent to half annual grain imported to Africa. This amount of maize lost would otherwise be available for eating, selling and or bartering.

The increasing maize demand as staple food arises from different angles. According to December (2010); FAOSTAT (2012); MAFSC (2013); Folayan (2013); FAO (2009) and Hodges *et al.* (2010), there is a threat of rising population. World population predicted to reach 9.1 billion by 2050, with increasing trend towards urbanization. This is evidenced by the population and housing census for The United Republic of Tanzania, which reported the growth rate to be 2.7 (URT, 2012). It is projected that the world will require 70% more food for 9.1 Billion people. Moreover, the land availability will decline from 4.3 ha in 1961 to 1.5 ha per household in 2050. It is expected that this challenge will decrease annual growth rate of major cereals from 5% in 1980 to about 1% in 2050. Hodges *et al.* (2010) have pointed out that, all of these will occur in the Least Developed Countries (LDCs) where the bulk of agriculture depends on smallholder farmers who produce little or even no surplus for sale and lose a lot.

Also, DTMA (2010) shows that the national demand for maize used in food is estimated at 3.6 million tons and is growing at a rate of 2.5%. A study by Osun *et al.* (2013) shows that per capita utilization of maize is about 114kg of maize annually, contributing an estimated 61% of total dietary calories. Lyimo (2005) found that maize supply to match current demand must increase by 3.0-3.5%. It is stressed that, there is an open evidence for the maize demand to overwhelm supply even to non-scholars, as expressed by serious maize shortages in rain season (demarcated by end of November to April of every year) due to low production and inadequate post-harvest handling (Makalle, 2012; Lyimo *et al.*, 2014; Ranam, 2014; Chauvin *et al.*, 2012 and Macauley, 2015). Due to this increasing maize demand as justified in the previous paragraphs, there is a need to conduct a study titled 'Determinants of Productivity and Post-harvest Losses Among Maize Smallholder Farmers' that will come out with suggestion of increasing maize yield and reducing maize post-harvest losses among smallholder farmers.

1.3 Objective of the Study

1.3.1 Overall Objective

The overall objective of the present study was to assess the productivity and determine factors influencing post-harvest losses among smallholder maize farmers in Kilosa District.

1.3.2 Specific Objectives

i. To determine the technical efficiency of maize producers in Kilosa District
ii. To determine factors affecting technical efficiency among maize producers in Kilosa District
iii. To identify the determinants of maize post-harvest losses in Kilosa District
iv. To examine relationship between technical efficiency and post-harvest losses in Kilosa District

1.3.3 Hypotheses

i. Socio-economic and farm specific factors have no significant influence on the technical efficiency of smallholder maize farmers in Kilosa District
ii. Socio-economic factors have no significant influence on maize post-harvest losses in Kilosa District
iii. There is no linear relationship between technical efficiency and post-harvest losses among maize farmers in Kilosa District.

1.4 Organisation of the Study

This dissertation is organised in five chapters. Chapter one presents background information, an overview of the research problem and justification, objectives of the study and hypotheses; Chapter two presents literature review, whereas chapter three describes the methodology adopted. The findings and discussion are presented in describes the methodology adopted. The findings and discussion are presented in chapter four. Chapter five concludes the study and gives recommendations according to the findings.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Productivity and Technical Efficiency Analysis

The performance of a firm can be measured by its productivity or efficiency (Philip, 2007). Productivity and efficiency normally are used interchangeably by many scholars; however, they are not precisely the same things (Coelli *et al.*, 2005). The efficiency of the economic unit is a relative concept and it refers to a ratio of the observed total output to the potential aggregate output that can be obtained from the same level of factors of production (Folayan, 2013). Productivity is an absolute concept and it refers to a ratio of actual total output to that of total factors of production which is used to produce that output (Coelli *et al.*, 2005). Javed *et al.* (2009) argue that, efficiency is an important economic concept and is normally used to measure economic performance of a firm. Efficiency in production is explained as productive efficiency of a firm which mean it is successful in producing as much as possible from the given set of factors of production. Production efficiency is concerned with the relative performance of the process used in transforming factors of production into outputs.

In measuring the performance of the firm reference is made to the historical background at the beginning of theoretical development in measuring output as presented by the work of Debreu (1951) and Koopmans (1951). Further development was done by seminal work of Farrell (1957) basing on Debreu and Koopmans (1951) who defined a simple measure of the economic unit efficiency that could account for the multiple inputs and there after it was propounded by Charnes, Cooper and

Rhodes (1978). According to Coelli *et al.* (2005) Farrell suggested that, the efficiency of the economic unit consists of two things. The first one is technical efficiency which is explained as the ability of the economic unit to achieve maximum output from a set of given factors of production using the best technology; while the second one is allocative efficiency and is explained as the ability of the economic unit to use factors of production in optimal proportions that maximize producers profit or minimizes costs with the respective prices and production technology. The product of these two measures provides measure of total economic efficiency. Farrell (1957) used different terminologies apart from those used in recent literature. For example, price efficiency for the allocative efficiency and overall efficiency for the total economic efficiency. Kuwornu *et al.* (2013) defined production technology as the transformation of the vector of inputs into the vector of outputs.

Production frontier is the boundary that may be used to demarcate the relationship between the factors of production and the output. The production frontier represents the maximum output that can be achieved from each factor of production level. So it reflects the current state of technology in the industry (Aye and Mungata, 2010). So, economic units have to work on that frontier if they are to be technically efficient. Nevertheless this is not often the case due to random factors such as bad weather, animal destruction and economic unit specific factors which lead the farm to produce below the expected output frontier (Battese and Coelli, 1995). Technical efficiency measurements therefore, try to identify factors that are economic unit specific which do interrupt production along the frontier.

2.1.1 Input-Oriented Efficiency Measure

Farell (1957) assumed that two inputs x_1 and x_2 are used to produce single output y under the assumption of Constant Return to Scale (CRS). The constant return to scale assumption allows one to present the technology using the unit Isoquant. Farell (1957) discussed the extension of his method so as to accommodate more than two inputs, multiple outputs and non-constant return to scale.

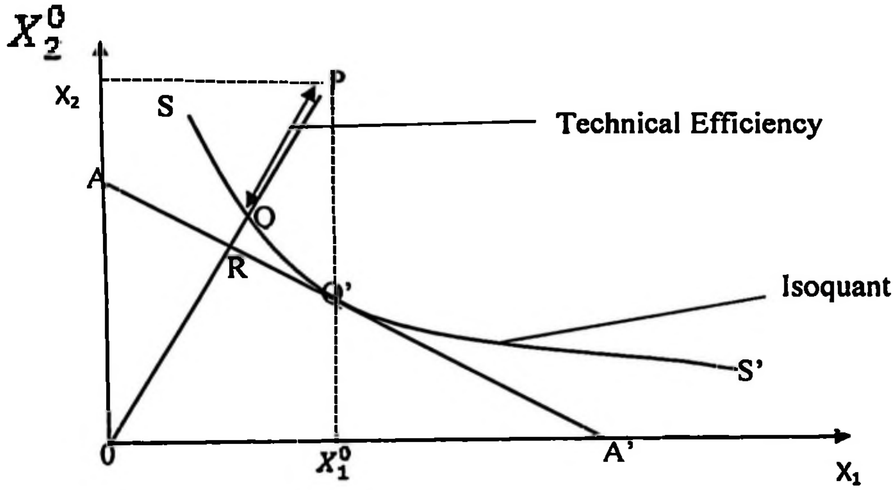

Figure 2: Input-Input Relationship

Source: Adopted from Coelli *et al.* (2005)

A firm is producing a given level of output using an input combination defined by point Q. At Q is the point at which there is attainment of least cost combination of inputs that produces output level SS, in other words where the marginal rate of technical substitution is equal to the input price ration P_2/P_1 (Takeuchi *et al.*, 2012). Suppose the firm uses quantities of inputs at point P to produce a unit output as shown in Fig. 2. The technical inefficiency of that firm could be presented by QP this is the amount by which all inputs could be proportionally be reduced without a reduction in output. In percentage term is represented as QP/OP. Technical Efficiency therefore is TE = OQ/OP which is equal to 1- QP/OP that will take a value between $0 \leq TE \leq 1$ and hence provides an indicator of degree of technical inefficiency of a firm. A value of 1 indicates the firm is fully technically efficient. If input price are given, allocative efficiency can be calculated. As shown in Fig 2. AA' represents an isocost line showing all possible quantities of two inputs, given their relative market prices, which would cost the same amount to the firm. The slope of isocost line represents the input price ratio. The allocative efficiency (AE) of the firm operating at P is AE_i = OR/OQ. Since RQ distance represent the reduction in production costs that would occur if production were to occur at the allocative and technically efficient point Q' instead of at the technically efficient but allocative inefficient point Q. The product of technical and allocative efficiency provides the overall economic efficiency TE_i x AE_i = OQ/OP x OR/OP = EE_i. The input-oriented technical efficiency measure, addresses the question by how much can input quantities be proportionally reduced without changing the output quantities produced?

2.1.2 Output- Oriented Measure

Alternative question to 'how much can input quantities be proportionally reduced without changing the output quantities produced?' How much can output quantities be proportionally expanded without altering the input quantities used?

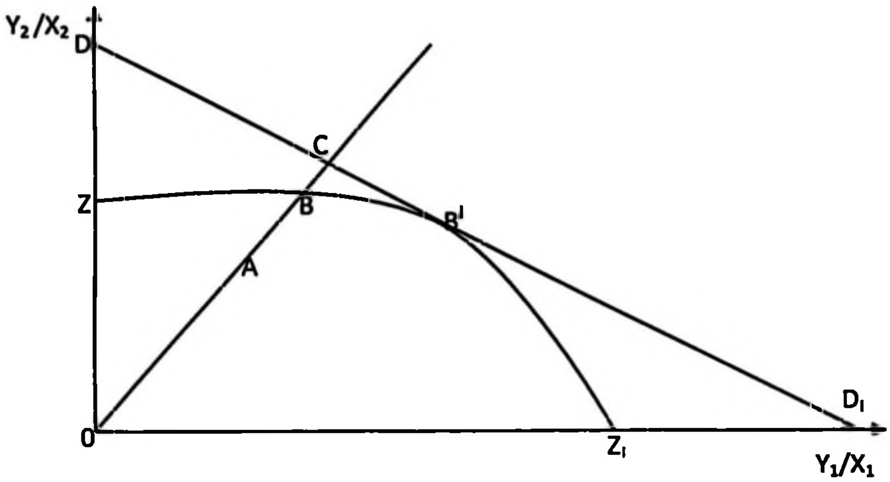

Figure 3: Output-output Relationship

Source: Adopted from Coelli *et al.* (2005)

The distance AB represents technical inefficiency, the amount by which outputs could be increased without requiring extra inputs. TE_o = OA/OB. If we have price information then we can draw the isorevenue line DD_I and define the allocative efficiency to AE_o = OB/OC which has a revenue increasing interpretation (similar to the cost reducing interpretation of allocative inefficiency in the input-oriented case). The overall economic efficiency becomes EE_O = OA/OC = OA/OB x OB/OC = TE_o x AE_o. A point to note is all of the efficiencies are measured along the ray from the origin to the observed production point. Advantage, Radial efficiency measures are unit invariant.

2.1.3 Efficiency Measures Approaches

Coelli *et al.* (2005) presented four main approaches that have been developed for measuring production efficiency. These approaches are; Least-squares econometric production models; Total Factor Productivity (TFP) indices; Data Envelopment

Analysis (DEA) and stochastic frontiers function. Two methods that are, Least-squares econometric production model and Total Factor Productivity provide measures of technical change and /or TFP. These methods assume that all economic units are technically efficient. The latter two methods applied to data on a sample economic unit (cross-sectional data) and provide measures of relative efficiency among those economic units. They do not assume that they are all technically efficient. The good thing is that DEA and SFA can be used to measure technical change and efficiency change, if panel data are available. In other way round, the first method and the last method involves the econometric estimation of parametric functions, in contrast the second and third approaches do not.

In this study DEA have been adopted. The decision to use DEA is mainly based on its ability to incorporate economic theory, observed institutional and economic reality. This technique suit agriculture because farmers and other stakeholders in the agriculture sector observe agriculture production in terms of units per unit area. For instance the amount of fertilizer in terms of kg/ha as well as agricultural produce in terms of kg or tonnes per ha (Philip, 2007). Furthermore, DEA is useful in computing the implication of changes in resource endowments, market conditions and new technologies in profit maximization or cost minimization. So, the present study uses DEA to determine how farmers in Kilosa respond to factors of production, institutional arrangement and economic realities in producing maize.

2.1.4 Data Envelopment Analysis (DEA)

DEA is a very powerful service management and benchmarking technique. The approach was introduced by Farrell (1957) thereafter propounded by Charnes, Cooper and Rhodes (1994) to evaluate non-profit and public sector organisations. DEA has since then proven to allocate ways to improve service not visible with other techniques. It is used in the estimation of production functions and many studies have used it for measuring technical efficiency in a range of economic units. DEA estimates the maximum ideal output for a given set of inputs, hence has been used in the estimation of efficiency (Philip, 2007). Focusing on economic units, it is impossible to determine what the engineered, optimum or absolute efficient output-to-input ratio, but we can however compare several economic unit output-to-input than another benchmarking. The difference in efficiency will be due to the technology or production process used, how well that process is managed, and /or the scale or size of the unit. DEA can be adapted to help improve service productivity. Linear programming is the underlying methodology that makes DEA particularly powerful compared with alternative productivity management tools.

The question that comes in is, why prefer DEA approach compared to the alternative approach of econometric? Firstly, DEA compares economic unit .considering all resources used and services provided and identifies the most efficient unit(s) or best practice unit(s) and the inefficient units in which real efficiency improvement are possible; secondly, DEA calculates the amount and type of cost and resource savings that can be achieved by making each inefficient unit as efficient as the most efficient or best practice units; thirdly, DEA estimates that amount of additional service an inefficient economic unit can provide without the need to use additional resources; lastly is management receives information about performance of economic units that can be used to help transfer, system and managerial expertise from better-managed, relatively efficient units to the inefficient ones.

Charles and Kumar, (2012) pointed out that, the popularity of DEA over an alternative approach of econometric method lie in its flexibility to incorporate the existence of multiple inputs and multiple outputs readily without any assumption on the functional forms. Given the set of inputs and outputs of different firms it can construct its own functional form and avoids the danger of misspecification of frontier technology compared to econometric method which assumes a functional form, like Cobb-Douglas or Translog relating to inputs and outputs. However, with its strength, DEA has the following limitations; being deterministic rather than statistical techniques; DEA produces results that are particularly sensitive to measurement errors; DEA only measure efficiency relative to best practice within the particular sample and so it is not meaningful to compare the scores between two different studies. Moreover, according to Färe and Primont (1995) and Coell *et al.* (2005) the estimated parameters of output distance functions normally violet the monotonicity, quasi convexity and convexity constraints implied by economic theory. This causes the estimated elasticity and shadow prices to have incorrect signs and leads to headstrong conclusion regarding the effects of factors of production and output changes on relative technical efficiency levels. This is the reasons DEA approach is used in estimating technical efficiency among maize smallholder farmers in Kilosa District.

In DEA, there are two scale assumptions normally employed: Constant returns to scale (CRS) and variable returns to scale (VRS). The first scale assumption reflects the concept that, output will change by the same proportion as inputs are changed. The second scale assumption comprises both increasing return to scale and decreasing return to scale. In this case of Variable return to scale the production technology may exhibit increasing, constant and/or decreasing return to scale (Coelli *et al.*, 2005).

2.1.4.1 Variable Return to Scale Model (VRS) and Scale Efficiency

The CRS assumption is suitable and can be used when all decision making unit (DMUs) are practicing at the optimal scale. Nevertheless, imperfect competition and various constraints like lack of credit may cause a DMU not to operate at the optimal scale. So if CRS model will be used while all DMUs are not operating to that optimal scale, the results obtained in measuring efficiency will be baffled by scale efficiency. Because of this problem Charnes and Coope suggested an extension of the CRS model to justify variable returns to scale estimations (Coelli *et al.*, 2005). The VRS model allows the computation of efficiency without the effects of the differences in execution levels among the DMUs. Due to the facts that, maize smallholder farmers in Kilosa District are likely not to operate at optimal scale, then this study uses VRS model to be more credible.

Fig 3 gives an illustration of the effects of scale assumptions on the measure of efficiency. From the figure, there are four data points (E, F, G and H) which are used to estimate the efficient frontier under both scale assumptions. To illustrate the difference, it is considered only fixed factor of production. With CRS the frontier is defined by point G, all other points fall below the frontier. In VRS the frontier is defined by points E, G and H, only point F is below the frontier.

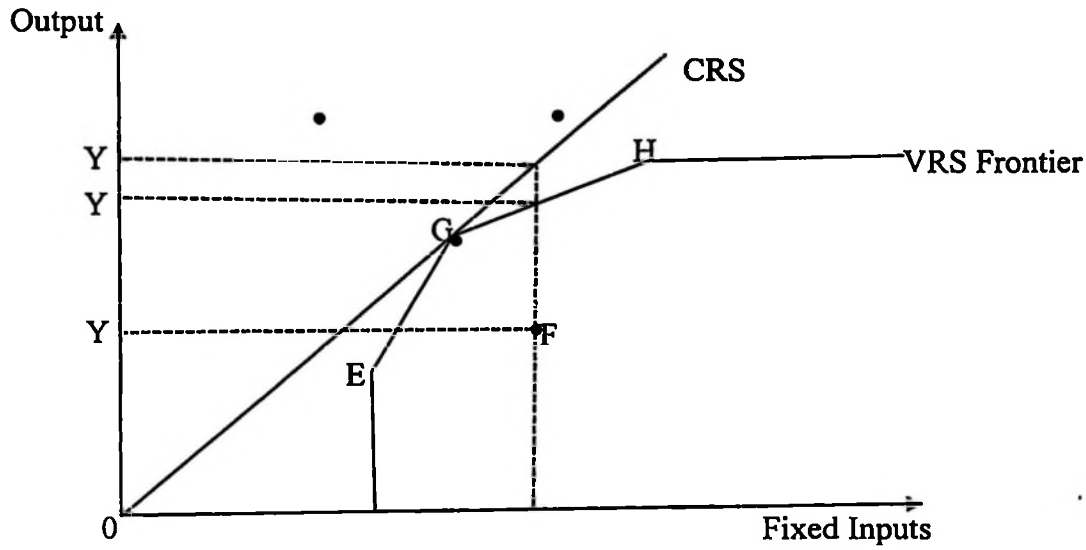

Figure 4: CRS and VRS Frontiers
Source: adopted from Philip (2007)

2.1.4.2 Computation of Scale Efficiency

According to Coell *et al.* (2005), technical efficiency scores resulted from using DEA has two components. One component is due to pure technical inefficiency and another component is due to scale inefficiency. Scale efficiency is computed by conducting both CRS and VRS models using the same set of data. If there is a difference between the two TE scores for a certain DMU, such a DMU has scale inefficiency. The scale inefficiency can be calculated by finding the differences between VRS TE and CRS TE scores absolutely.

2.1.4.3 The Mathematical Formulation of the DEA Model

Decision Making Unit (DMU) is always used to refer to economic units which are evaluated in terms of their respective abilities to make transformation of factors of production into outputs. The linear programming technique is used to find the set of coefficient (u's and v's) that will give the highest possible efficiency ratio of output to inputs for the DMU being evaluated. A study will have n DMUs, with each DMU applying varying amount of m factors of production to produce s different outputs. Where by:-

j= Number of economic units being compared in the DEA analysis

UE_j= Economic unit number j

θ= Efficiency rating of the economic unit being evaluated by DEA

y_{rj}= Amount of output r used by economic unit j

x_{ij}= Amount of input i used by economic unit j

i= Number of inputs used by the EUs

r= Number of outputs generated by the EUs

U_r= Coefficient or weight assigned by DEA to output r

V_i= Coefficient or weight assigned by DEA to input i

The data required to apply DEA are actual observed outputs produced Y_{rj} and the actual inputs used x_{ij} during one time period for each DMU in the set of DMUs being evaluated. Hence, x_{ij} is the observed amount of the i^{th} input used by the j^{th} DMU and y_{rj} is the amount of r^{rt} output produced by the jth DMU. The theoretical development of this approach is discussed in detail in Cooper, Seiford and Jones, (2000) and Zhu, (2003).

A DMU uses amount of x_{ij} of inputs i and produces y_{rj} of output r. Assumption is made that; $x_{ij} \geq 0$ and $Y_{rj} \geq 0$, using the ratio-form of DEA the function to be maximised can be presented as;

$$Max\ h_o(u,v) = \sum_r u_r y_{ro} / \sum_i v_i x_{io} \quad (1)$$

Whereby $u_r's$ and $v_r's$ are the coefficients or weight assigned by DEA to output r and input i while y_{ro} and x_{io} are the output and factors of production and values respectively of DMU_o, the DMU in equation. Without more additional constraints, equation 1 is unrestrained. A set of normalising constraints (one for each DMU) reflects the condition that, the virtual output to virtual input ratio of every DMU including $DMU_j = DMU_o$ must be less than or equal to one. This mathematical programming problem may thus be specified as;

$Max\ h_o(u, v) = \sum_r u_r y_{ro} / \sum_i v_i x_{io}$ Subject to,

$\sum_r u_r \frac{y_{ro}}{\sum_i v_i x_{io}} \leq 1$ for j = 1, 2,...................n (2)

$u_r, v_i \geq 0$ for all i and r

In input oriented DEA models the output is fixed. The objective of the firm is to minimize inputs while the outputs are fixed. U and V are weights that can be interpreted as normalised shadow prices.

The ratio form yield an infinite number of solutions. I.e. if (u*, v*) is optimal then (αu*, αv*) is also optimal for α > 0, nevertheless the transformation for linear fractional programming selects a representative solution (i.e. the solution (u, v) for which the denominator in the objective function in equation (2) i.e $\sum_{i=1} v_i x_{io} = 1$, and yields the equivalent linear programming problem in which the change of variables from (u, v) to (μ,v) can be formulated as follows;

$$Max\ Z = \sum_{r=1}^{s} u_r y_{ro}$$

Subject to

$$\sum_{r=1}^{s} u_r y_{ri} - \sum_{i=1}^{m} v_i x_{ij} \leq 0 \qquad (3)$$

$$\sum_{i=1}^{m} v_i x_{io} = 1$$

$$u_r, v_i \geq 0$$

To obtain the information provided in equation (2) one needs to employ the dual linear program to model equation (3)

$\Theta^*=\min \theta$

Subject to $\sum x_{ij\lambda_j} \leq \theta x_{io}$ i=1, 2 ....m;........... (a)

$\sum_{j=1}^{n} y_{rj} \lambda_j \geq y_{ro}$ r=1, 2 ....s; .... (b) (4)

$\lambda_j \geq 0$ j= 1, 2 ....n.............. (c)

The dual is seeking the efficiency rating, minimize θ subject to constraint (a) weighted sum of the inputs of the other DMUs is less than or equal to the inputs of the DMU being evaluated; (b) Weighted sum of the outputs of the other DMUs is greater than or equal to the DMU being evaluated. The weights are λ (lambda) values.

By the benefit of the dual theorem of linear programming we have Z*= Θ*, hence either problem may be used. We can set Θ = 1 and $\lambda_k^* = 1$with $\lambda_k^* = \lambda_o^*$ and all other $\lambda_j^* = 0$a solution of equation (4) always exists. On top of that, this solution implies θ* ≤ 1. The optimal solution θ*, yields can efficiency score for a particular DMU. The DMU, for which θ* < 1 are inefficient, while DMUs for which θ*=1are boundary points. Some boundary points may be weakly efficient. The performance of a "DMU is weakly efficient" if and only if both θ*=1and $s_i^{-*} \neq 0$and $s_r^{+*} \neq 0$ some i and r in same alternative optima, i.e. there are non-zero slacks. Equation (4) does not take into consideration the possibility of having non-zero slacks. The problem can be solved by invoking the following linear programming in which the slacks are taken to their maximal values.

$$Max \sum_{i=1}^{m} s_i^- + \sum_{r=1}^{s} s_r^+$$

Subject to

$\sum_{j=1}^{n} x_{ij}\,\lambda + s_i^- = \theta^* x_{io} i$=1, 2 ....m; (5)

j=1nyrj-sI+= yror =1, 2 ....s;

$\lambda_j, s_i^-, s_r^+ \geq 0 \forall_i, j, r$

Very important note is that the choices of s_i^-, and s_r^+do not affect the optimal solution which is determined from equation (4). Solving equation (5) is equivalent to solving the following problem in two steps.

$$Min\ \theta - \varepsilon(\sum_{i=1}^{m} s_i^- + \sum_{r=1}^{s} s_{r=1}^+)$$

Subject to

$\sum_{j=1}^{n} x_{ij}\,\lambda_j + s_i^- = \theta x_{io} i$= 1, 2 ....m; (6)

$\sum_{j=1}^{n} y_{rj} - s_i^- = y_{ro} r$= 1, 2......................s;

$\lambda_j, s_i^-, s_r^+ \geq 0 \forall_i, j, r r$=1, 2........................s;

Where the s_i^- ands_r^+ are slack variables used to convert the inequalities in equation (4) to equivalent equations

Here ε > 0 is non-Archimedean element defined to be smaller than any positive real number. This is equivalent to solving equation (4) in two stages, i.e. by first minimizing θ then fixing θ = θ*. Formally, this is equivalent to granting pre-emptive priority to the determination of θ* in equation (3). In this manner the fact that the non-Archimedean element is defined to be smaller than any positive real number is accommodated without having to specify the value of ε.

2.1.5 Factors Affecting Production Inefficiencies

In order to investigate the relationship between firm inefficiency and various socio-economic and firm specific factors, only two alternative approaches can be applied (Tavana *et al.*, 2012). The first approach used is to calculate correlation coefficient or to conduct other simple non-parametric analysis. The second approach is first to measure inefficiency then use Tobit regression model in which inefficiency is expressed as a function of socio-economic and firm specific factors (two steps Procedure). This approach was adapted to this study. Why Tobit regression model instead of Ordinary Least Square regression model? Javed *et al.* (2009) indicates that the inefficiency score from DEA are limited between 0 and 1, so the regressed variable in regression model does not have normal distribution. This implies that OLS regression model is not appropriate and estimation with OLS regression would lead to biased parameters estimates.

In this study Technical efficiency estimates were estimated by using DEA models. The method of Tavana *et al.* (2012); Javed *et al.* (2009, 2009), Nyariki (2011) and Philp (2007) was followed to calculate the inefficiency indices by subtracting the efficiency estimates from 1. The total technical efficiency has two components; pure technical efficiency which is related to management practices and scale efficiency which is related to the residuals (Nyariki, 2011). Only the pure technical inefficiency component was chosen as the independent variable in the analysis of factors explaining the technical inefficiency differential. Technical inefficiency scores were separately regressed on socio-economic and firm specific variables to identify sources of technical inefficiencies.

2.1.6 Review of Empirical Technical Efficiency Studies in Agriculture

Studies done on the production efficiency measurements are many. These studies have either based on input oriented or output oriented efficiency measures. These two approaches are similar on the assumption of Constant Return to Scale (CRS) and do differ on the Variable Constant to Scale (VRS) (Färe *et al.*, 1994). In addition to that, both non-parametric and parametric approaches as used by different scholars in different studies were reviewed. The analytical parametric approach is based on stochastic frontier analysis and non-parametric approach is based on Data Envelopment Analysis and productivity indices based on growth accounting and index theory principles. There are many studies in the literature on productivity and post-harvest losses among smallholders in agriculture. To this study these are notable most; Takeuchi *et al.* (2012); Isinika and Oleke (2011); Aye and Mungatana (2010, 2011); Kuwornu *et al.* (2013); Kawasaki and Fujimoto (2009) and Geta *et al.* (2013). Other studies are Elena *et al.* (2010); Padilla *et al.* (2009); Lagata *et al.* (2012); Kibirige (2008); Oyewo and Fabiyi (2008); Coeta *et al.* (2013); Tavana *et al.* (2012); Javed *et al.* (2009, 2010, 2012); Morinot *et al.* (2010); Kipkoech, (2012) and Nyanjong and Lagata (2012). Furthermore are Douglas (2008); Nyariki (2011); Ghaffari (2012); Boundeth *et al.* (2012); Sibiko, (2012) and Philip, (2007).

These studies were done within and outside the African continent. The notable countries where these studies were done are Pakistan, Iran, Philippine, India, Bangledesh, Vietnam and Srilanka outside the African continent, whereas within Africa countries are Ethiopia, Nigeria, Ghana, Kenya and Uganda.

Most studies have associated farmers' age, education, access to extension, access to credit, agro-ecological zones, land size, farmers' family size, gender and access to improved technologies such as fertilizers, agrochemicals, tractors and improved seed as a source of inefficiency (Geta *et al.*, 2013; Aye and Mungatana, 2010, 2011; Oyewo and Fabiyi , 2008; Coeta *et al.*, 2013; Tavana *et al.*, 2012; Javed *et al.*, 2009, 2010, 2012; Morinot *et al.*, 2010; Kipkoech, 2012 and Nyanjong and lagata, 2012). Study by Elena *et al.* (2010) argue that, most of the studies which concentrated in farm productivity and technical efficiency considered factors of production as land owned, land size under production, fertilizer, agrochemicals, seed variety, seed quantity in Kilogram (Kg), labour, machinery cost and animal traction services. Takeuchi *et al.* (2012), Isinika and Oleke (2011), Aye and Mungatana (2010) in their studies found that, access to extension, farmers' age and education, access to credit, family size, farmers' access to fertilizers, agrochemicals and improved seeds were positively associated to technical efficiency as contrasted to Kuwornu *at al.* (2013) who found that seed, fertilizer and family labour were negatively related to technical efficiency.

Although studies by Takeuchi *et al.* (2012) and Aye and Mungatana, (2010) found the relationship between land holdings size, and efficiency to be positive, a clear cut conclusion on the influence of this variable on efficiency has not been reached as discussed in Geta *et al.* (2013) work. Moreover, influence of the number of plots on efficiency has been reported by Kawasaki and Fujimoto, (2009) to be negative. This implies that, land fragmentation (as measured by number of plots) have negative impact on yield.

Most of the studies selected samples by multistage random sampling procedure; some of these includes Geta *et al.* (2013); Aye and Mungatana (2010); Javed *et al.* (2010) and Kibirige (2008) while Morinot *et al.* (2010), Kipkoech *et al.* (2012) and Tavana *et al.* (2012) selected their samples using simple random procedures. Mode of analysis was varying from one study to another, though most of them used stochastic frontiers, data envelopment analysis, to determine sources of inefficiency these includes, Msuya (2008), Isinika and Oleke (2011). The studies by Aye and Mungatana (2010) and Padilla et al. (2009) used four different models; parametric stochastic distance frontier; parametric stochastic production frontier and two non-parametric stochastic distance frontier. In contrast Javed *et al.* (2012) study used Data envelopment analysis on cotton-wheat farming system.

Studies by Takeuchi *et al.* (2012); Isinika and Oleke, (2011); Aye and Mungatana, (2010); Bala *et al.* (2010); Kolowelo, (2010); Folayan, (2013) to mention few they have used Cob-Douglass style approach while Musuya *et al*, (2008) and Kibaara, (2005) applied normalized translog production function in an estimation of the maize yield. The model used in finding the causal relationships between dependent variables and independent variables varied from multiple regression model to probit regression model.

2.2 Post-Harvest Losses (PHL)

Post-Harvest Losses (PHL) refers to food (Maize) lost along the supply chain from harvest until household consumption or other end uses (Aulakhet *et al.*, 2013). For the purpose of this study, it is focused on the segment of the supply chain which covers harvesting through household consumption. Food (Maize) losses in developing countries occur mostly during the field-to market stages with the smallest share of losses occurring at the consumer's level. Food moves along the Post-harvest activities namely: - harvesting; transportation; drying; bagging/loading and unloading; threshing and storage (Folayan, 2013). Moreover, as food travel along different stages, food losses occur at each stage along the chain and contribute to total PHL. PHL is divided into quantitative and qualitative losses. On one hand qualitative loss of food implies a reduction in the available quantity as results of infestation by pests at harvesting or storage level; physical loss during handling and reduction in quantity due to changes in temperature, moisture content or chemical composition. On another hand qualitative loss of food result in changes which lower its economic or nutritive value that ends at disposing or discarding the food.

Post-harvest losses are always estimated as percentage of residual from the previous level of post-harvest activities (Aulakh *et al.*, 2013). Approaches for estimating post-harvest losses focuses at giving a concept about quantitative losses that are occurring during post-harvest handling since, it is impossible and difficult to estimate some of the losses like time, manual labour, opportunity cost, illusion and hopes (Folayan, 2013).

2.2.1 Factors and Causes of Grain Losses

As explained in the previous paragraph, there are factors that cause food losses while travelling through different stages of the Food Chain Supply (FCS). These factors are in four main groups that are responsible for the post-harvest losses. These factors are; physical factors, biological factors, engineering and mechanical factors and socio-economic factors. The physical factors include temperature and moisture content of the stored grains. Temperature is responsible for the respiration of the live pests and pathogens that will damage grain and moisture contents determine easy or hardness of the pest and agent of disease to attack the stored grains. Biological factors include insects, mites, birds, rodents and other wild animals affecting the grains. Furthermore, microorganisms such as fungi and bacteria can contaminate and spoil grains. Engineering and mechanical factors are looked in the perspectives of efficiency of tools, machines and other equipment used in the post-harvest operations. Socio-economic factors are concerned mostly by financial status, farming system, demographic data, storage and marketing system (Folayan, 2013).

2.2.2 Review of Empirical Studies of Post-harvest Losses of Grains

Bala (1978), Singaravadiel (1992), Sexena *et al.* (2000), Singh *et al.* (2002) and Basappa *et al.* (2007), did estimates of quantitative losses of paddy, wheat and maize in Bangladesh at each operations level. The important operations levels were, threshing, drying, distribution and storage while the largest losses were found to be at storage stage.

Sampling techniques used in most of the studies range from multistage, purposive and simple random sampling. Multistage used mostly in drawing the villages and provinces where the researches were conducted. For example, Randala, (2010) and Begun *et al.* (2012) used simple random sampling method, Folayan, (2013), and Bassappa *et al.* (2007) used purposive, while Basavaraja *et al.* (2007), Begun *et al.*

(2012) and Bala *et al.* (2010) used multistage sampling techniques. Most of studies collected data using structured questionnaires tool to mention few of them are Deshmanya and Patil (2007); (Guisse, (2010); Folayan, (2013); Randala, (2010); Begum *et al.* (2012); Basavaraja *et al.* (2007); Bala *et al.* (2010) and Basappa *et al.* (2007). However, Randala (2010) used questionnaire and Participatory Rural Appraisal (PRA) to collect data.

Begun *et al.* (2012) and Basavaraja *et al.* (2007) used cross-sectional and time series design in contrast to the rest of the studies which used mostly cross section only. Analysis used by these studies ranges from tabular presentation, percentage, frequency distribution, averages and functional analysis. The most socio-economic important variables used by these studies were; age; sex; household size; educational background; and family labour.

Rugumamu (2009) did an assessment of post-harvest technologies and gender relations in maize loss reduction at Pangawe village in Eastern Tanzania. This study employed stakeholder participatory approaches, by conducting village meetings and Focus Group Discussion (FGD); interviews and field observation. Moreover this study used qualitative analysis and one way Analysis Of Variance (ANOVA). Mboya (2011) conducted research on the effects of storage methods on the quality of maize and household food security in Rungwe Disrict Tanzania. By employing matrix for scoring and ranking, this study found that quality of maize stored using roof and sack storage method were low due to the infections by ***Fusarium***, ***Aspergillus*** and ***Penicillium*** species which are associated with production of mycotoxins.

Mbure *et al.* (2012) assessed grain damage and weight loss on farm stored maize in highlands areas of Bungoma District in Kenya. They sampled six stores of farmers and conducted simulation trial every four weeks. 10 Kg sample were removed from each bag and 1 kg sample was taken from it for analysis. The data were analysed using both excel and stata graphic software. Factors mostly affecting stored maize were identified through Analysis Of Variance (ANOVA). Furthermore, multiple range test based on the Least Square Differences (LSD) was used to separate treatment means at each sampling period. The study found that farmers were continually losing a lot of stored grain to insects after harvesting due to delayed treatment, non-treatment, incorrect dosage and lack of retreatment especially from those storing for more than 6 months.

A study on determinants of post-harvest losses on maize in Akure North Local Government area of Ondo state, Nigeria done by Folayan (2013) found that, inadequate finance, insect pest attack, high cost of transportation and price instability were important variables in post-harvest losses of maize. Folayan (2013) used simple random sampling techniques, and through 100 respondents collected data using the tool of structured questionnaire supplemented with interview schedule checklists. This study analysed data by employing descriptive statistics such as frequency distribution, percentages and regression analysis. The ordinary least square method of regression analysis was used with functional forms of semi log and double log to estimates the relationship between the dependent variables and the set of explanatory variables.

Sitoe (2009) conducted on-farm trial for identifying pests that occur on maize traditional stores and assed the losses caused by pests and defining an alternative strategy for controlling. On his findings 47% of dry matter losses were attributed to insects in on farm stores. Data on this study were collected from 96 farmers through semi-structured interviews. The study used method of counting and weighing methods.

The study by Guisse (2010) titled 'post-harvest losses of rice from harvesting to milling' found that, post-harvest losses were due to poor management of post-harvest systems; belated traditional manual methods of harvesting too late; methods of collecting; attack by rodents; termites and shattering of grain. Furthermore, the study pinpointed that, spilled over, broken grain, eaten by chicken, inefficiencies retrieval, poor operator skills, deterioration and infestation by pests as route, of post-harvest losses.

Most of the studies have focused only on storage stage of the supply chain, ignoring the other important steps which also are contributing to PHLs. The studies focus has mainly been on large grain borer damage. The current study however, focuses on identifying the determinant of post-harvest losses among smallholder farmers in Kilosa Distric associated with socio-economic factors that contribute to total PHLs.

2.3 Theoretical Framework

The economic theory followed by the current study is Neoclassical Economic Theory. Neoclassical economics is a theory that focuses on how the perception of efficacy or usefulness of products affects market forces: supply and demand. Neoclassical economics is attributed with integrating the original classical cost of production theory with utility in a bid to explain commodity and factor prices and the allocation of resources using marginal analysis. It describes the technical relationship between inputs and output in physical terms, and general form it holds that production of a specific commodity depends on certain specific inputs. The theory categorizes three important efficiency measures *i.e.* technical efficiency, allocative efficiency and economic efficiency (Mlote *et al.*, 2013). Therefore the current study adopted this theory in determining technical efficiency of maize production in Kilosa District.

CHAPTER THREE

3.0 RESEARCH METHODOLOGY

3.1 Description of the Study Area

Survey of this study was conducted in Kilosa District. Kilosa district is one of the seven districts in Morogoro Region. The district is located in East Central Tanzania at an average distance of 300 Km west of Dar es Salaam and it is bounded by latitude 5'55" and 7'53" south and Longitude 36'30" and 37'30" East (NBS, 2003). Kilosa district borders Mvomero districts to the East, Kilombero district and Iringa Region to the South. To the North it borders Gairo district while to the West it borders Gairo and Mpwapwa Districts. The District covers a total area of 12,393 square kilometres which is equivalent to 17% of the area of Morogoro Region.

3.1.1 Demographic Data

According to URT, (2012) the District has 438 178 people being the most populated District in Morogoro region with 218,378 males and 219 797 females. There are 102 447 households; population growth is 2.6%; population density is 34 persons per square Km; Average family size 4.6 and Sex Ratio of 99:100.

3.1.2 Climate and Topography

Kilosa district is characterised by semi humid climate, receiving an average annual rainfall of 800 mm distributed in eight months (October-May). Kilosa district cropping patterns is an agro-ecological zone that fall into bimodal rainfall regime. The bimodal rainfall regime has short rain season (vuli) which rains from October-December and long rain season (masika) which rains from March-May. The vuli rains provide a minor cropping season with planting around November and harvesting in late January/February, while the masika rains provide the main cropping season in the bimodal areas with planting in late February/March and harvesting in July/August. Temperature ranges from 18°c in hills to as high as 30°c in the low lands. Kilosa district has several rivers, but the major ones being the Wami and the Ruaha. The soils are poorly drained, black cracking clays in the central parts, and subject to seasonal flooding. In the peripheral western part, sediment fans are of black fertile soils, making them suitable for a range of crops, such as maize, cotton and sisal (Kajembe *et al.*, 2013).

3.1.3 Main Economic Activities

The main economic activities in Kilosa district is agriculture, practicing crop production and livestock keeping (Magehema *et al.*, 2014). Over 80% of people in Kilosa district depend on agriculture (Kajembe *et al.*, 2013) and with its varied conditions, ranging from a plateau characterized by seasonally flooded plains, to mountainous areas with altitudes conditions for farming (Kajembe *et al.*, 2013; Magehema *et al.*, 2014 and Kahimba *et al.*, 2015). A variety of crops is grown in the district including maize, rice, millet, cassava, beans, bananas and cowpeas. Besides food crops, the main cash crops are sisal, cotton, sesame, cashew nuts, coconuts, sugar cane and sunflower. Some of the food crops are also used as cash crops. The district has 536,590 hectors suitable for agriculture in cultivation of cash and food crops. Approximately 93% of land used for farming is under subsistence crop production, while 7% is used for cash crop production (Kajembe *et al.*, 2013; Magehema *et al.*, 2014 and Kahimba *et al.*, 2015).

Table 1: Crop Production (Tons) in Kilosa District 2008-2010

	Years		
Crop	**2008**	**2009**	**2010**
Maize (*Zea mays*)	128 801	209 087	249 748
Paddy (*Oryza sativa*)	42 465	61 273	111 960
Millet (*Pennisetum glaucum*)	3820	6675	5700
Cassava (*Manihot esculenta*)		91 567	132 160
Beans (*Phaseolus vulgaris*)	8998	16 491	14 460
Banana (*Musa*)	18 500	6210	29 000
Cowpea (*Vigna unguiculata*)	924	1427	1830
Total production	**203 508**	**392 730**	**544 858**

Source: Magehema *et al.* (2014)

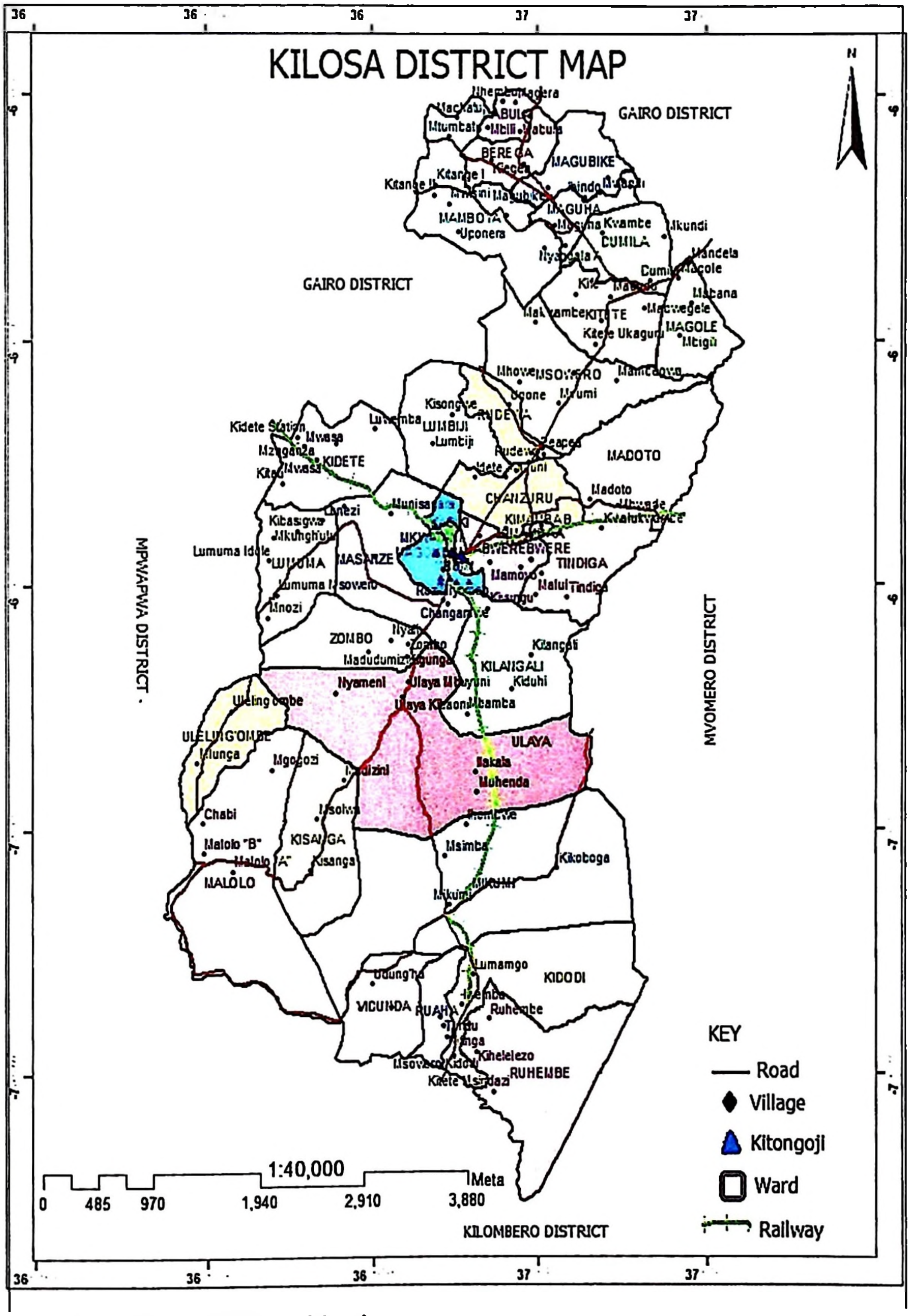

Figure 5: A Map of Kilosa District

Source: District Executive Director's Office-Kilosa District (2013)

3.2 Conceptual Frame Work

This section presents a brief description of the conceptual framework that was used as a guide to data gathering during the research. The general objective of the current study is to assess the productivity and determine factors associated with post-harvest losses among smallholder maize farmers in Kilosa District. Variables used to measure technical efficiency and determinants of post-harvest losses are influenced by farmers endowments of the factors of production mainly land, labour and capital which together play a central role in any production process and post-harvest handling processes.

Apart from farmer's resource endowment as mentioned in the previous paragraph, there are also some institutional factors which are likely to influence maize production. These are extension services, credit services and market access. Others are policy factors that encompass political and economic trends. Fig. 6 describes how various factors are inter-related to affect maize production and post-harvest operation in Kilosa District.

The policy factor is featured by the existence of political and economic trends in the nation which can affect farming system and indirectly determine the maize output and reduction of the post-harvest losses. Within the farming system there are various sets of factors that determine maize productivity and post production losses reduction.

Agricultural inputs such as seeds, fertilisers, plot size, and agrochemicals are the key inputs for the maize production process to take place. Availability and distribution of these inputs may be affected by the policy factors which in turn determine the extent of maize production as well as post-harvest losses reduction. It is hypothesized that, the more inputs are used in a farm, the more the yield of maize per unit area of land although increase in use of agricultural inputs like fertilizers in production may results into negative effects on yield of maize provided that such farm has reached diminishing return to scale with respect to inputs.

Institutional and Socio-economic characteristics of the farmers are another factor which influence maize productivity and post-harvest operation. For the production operation and post-harvest operation to be effective, the way in which available resources are mixed is crucial. Institutional factors affects production and post-harvest handling processes in different manner. It is again hypothesized that, being close to the market, group membership, credit access, and extension access affect positively production and post-harvest operations efficiency while the opposite affect negatively. A group membership solves the problem with market imperfections. It is hypothesized that farmers in organized groups are able to access credit easily and able to stand with same voice *i.e.* collective bargaining power in input and output markets. Credit access helps farmers in mitigating the problem of cash with which they are able to access inputs and capital for the off farm projects and extension services are assumed to help farmers in bridging the gap of information and acquiring new agricultural technologies.

Socio-economic factors include age of the farmer, gender of the farmer, farmer's occupation, off farm activities, education of the farmer, farmer experience, farm size and ownership of assets. It is assumed that age has a positive effect on the production efficiency since; older farmers have a lot of experience in farming compared to young farmers. Female farmers are faced with a lot of challenges compared to male farmers due to taboos, traditions and customs. Female farmers have limited access to information and resources. Farm occupation affects maize production efficiency as being employee and doing business affect maize production efficiency positively through improved capital for farming. Educated farmers are expected to be more efficient if they will be committed on farm since they are able to adopt improved technology compared to those with less education. However education may affect negatively if farmers with high education will engage in other income generating activities apart from farming due to paying less attention to their farms. Farmer experience is expected to influence maize production efficiency positively since farmers with experience might have met with farming challenges and past mistakes they previously committed in their farming activities. So they can take rational decisions compared to less experienced farmers. Farm size affects positively production efficiency since those with large farms enjoy the economies of size. Lastly, ownership of assets influence positively the efficiency of production; owning bicycle and motorcycle facilitates farmers to move easily to the market and transportation of both inputs and outputs. For a farmer to possess televisions and radios will facilitate him/her in accessing agricultural information easily and mobile phones will facilitate farmers to communicate and exchange agricultural information quickly.

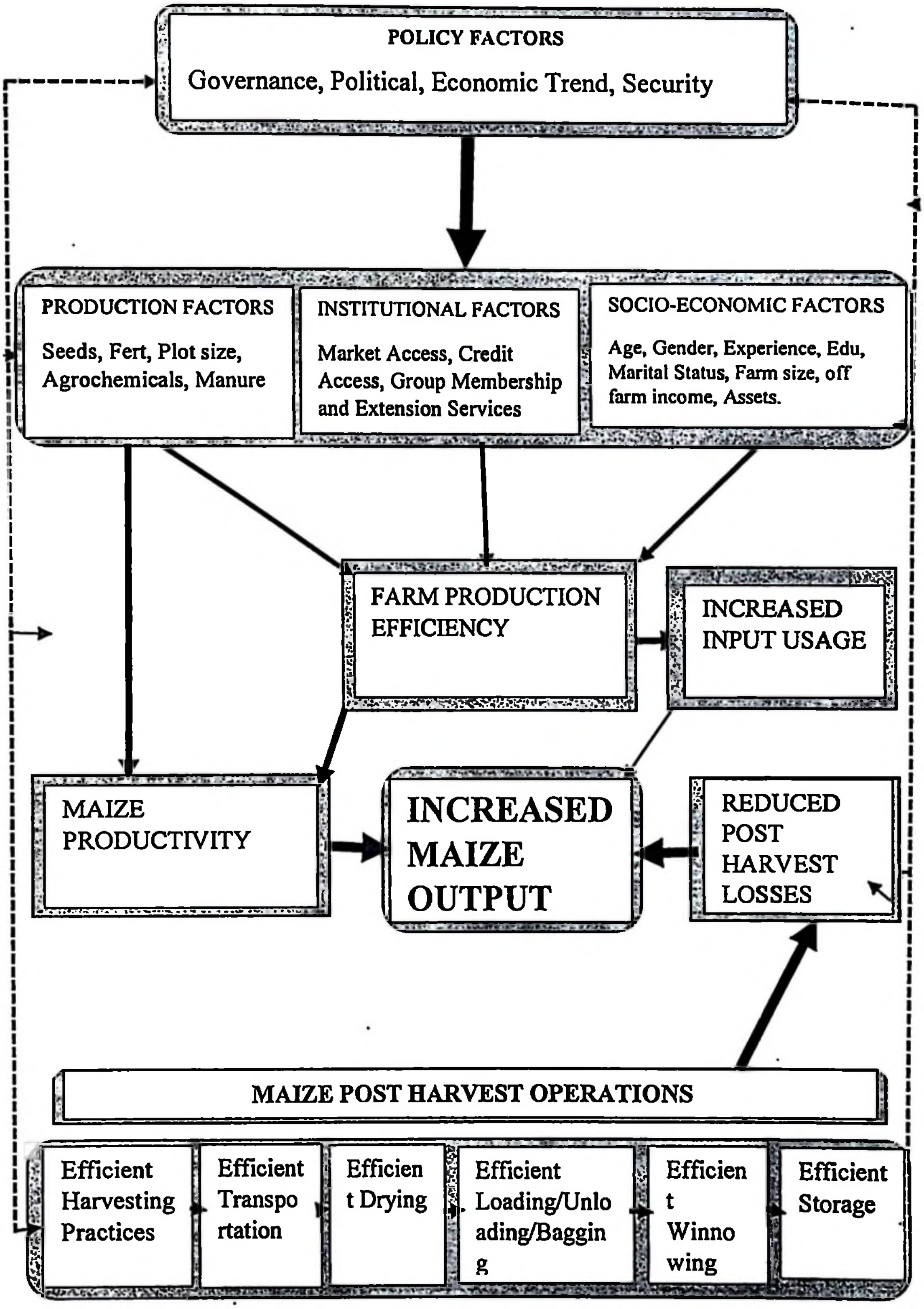

Figure 6: The Conceptual Frame Work of Factors that Influence Production and Post- harvest Operation Efficiency

Source: Adopted and Modified from New Institutional Economics Theory

3.3 Data Required and Their Sources

Both quantitative and qualitative primary data were collected from maize growers sampled households in Kilosa District. Data were collected from three divisions of Masanze, Kimamba and Magole, in which six wards and six villages were involved. These villages and their respective wards were Madudu from Kitete ward, Rudewa Pea Pea from Rudewa ward, Mji Mwema from Kimamba A ward, Malangali from Tindiga ward, Mvumi A from Msowero ward and Kibao from Mabwerebwere ward. The key variables for which primary and secondary data were collected are; yield of maize, socio-economic variables, labour, fertilizer (Nitrogen, Phosphorous and Potassium), seeds, and percentage of harvesting and post-harvest losses. Secondary data were collected from various sources like Kilosa District Council reports, Sokoine National Agriculture Library (SNAL) in Morogoro (SNAL).

3.4 Survey Design

This study adopted cross-sectional design. In this design, data are collected at a single point in time without repetition from research population (Babbie, 1990). According to Kothari, (2008) this design is simple and use less time. It allows researcher to compare many different variables at the same time. It offers a snapshot of single moment in time.

3.4.1 Sampling

The study was undertaken in Kilosa District and two stage sampling design was employed for the collection of maize production data. Firstly, three divisions were purposively chosen out of seven divisions from which two wards each were also selected purposively due to their importance as the major maize growing areas as per District Agriculture, Irrigation and Cooperatives Officer (DAICO). Secondly, simple random sampling design was employed to select six villages, of which one village was drawn from each ward, making a total of six villages. Furthermore, maize farmers sample size was calculated from Cochran, (1963:75) equation, $n = Z^2pq/e^2$. Where by n = sample size; Z^2 = Abscissa of the normal curve that cuts off an area α at the tail (s); P = is the estimated proportion of an attribute that is present in the population; 1-α = the desired confidence level; e = is the desired level of precision and q = 1-p. For social science research, 5% level of precision is recommended. However, if there is resource limitation more than 5% level of precision can be used (Naing *et al.*, 2006). Therefore the current study suggested Z = 1.96, p = 0.5, e = 7.6% and q = 0.5 with an assumption of homogeneous population. The study came up with the sample size of 166 maize growers in Kilosa.

Table 2: Sampling of Divisions, Wards, Villages and Farmers

Divisions	Wards	Villages	Households
MASANZE	Tindiga	Malangali	27
	Mabwerebwere	Kibao	28
MAGOLE	Kitete	Madudu	27
	Msowero	Mvumi A	28
KIMAMBA	Rudewa	Rudewa Pea Pea	28
	Kimamba A	Mji Mpya	28
Total			**166**

3.4.2 Data Collection Methods and Implementation

3.4.2.1 Primary Data

A structured questionnaire was developed based on assessing the determinants of productivity and post-harvest losses among smallholder maize farmers in Kilosa district. The questionnaire was designed to capture data from sampled maize farmers in the areas. Questionnaire contained both close-ended and open-ended questions on farm household characteristics, maize production data, labour and other input data, maize post-harvest losses, income of the household, micro credit and extension services and data on rain fall. The Researcher administered questionnaire to farmers by means of interviews with the help of two enumerators. On administration of questionnaire, the researcher together with enumerators managed to visit the farmer's household home.

Prior to actual survey, the questionnaire were piloted under field conditions to counter check if they answered the stated objectives. A total of 15 questionnaires were administered during the pilot exercise and this exercise was done in Mlali Mvomero district where, farmers perform same economic activities as those of Kilosa district. After the pilot exercise some of the questions were found to be irrelevant and others were not clear. Adjustments were made to unclear questions and irrelevant questions were omitted and others were modified.

3.4.2.2 Secondary Data

Secondary data included in various reports on maize growing records and references (documentary sources) from Kilosa District, Sokoine National Agricultural Library (SNAL), Ministry of Agriculture, Food Security and Cooperatives (MAFSC), research reports, journals and other sources were also used. Most of the data used were that of maize production, maize post-harvest losses and uses of agrochemicals, fertilizers, improved seeds and agronomic practice on maize crop.

3.5 Analytical Framework

The first objective has been addressed estimating Technical efficiency using DEA model which is based on the mathematic programming techniques. To achieve objective number two, technical inefficiencies indices were calculated by subtracting technical efficiency from 1, then use Tobit regression model in which technical inefficiencies calculated is expressed as a function of socio-economic and farm specific factors (two step procedures). The third objective was achieved by estimating post-harvest losses through summation of post-harvest losses from each stage/level of maize supply chain, then apply regression model in which post-harvest losses is expressed as a function of socio-economic characteristics. Lastly, the fourth objective was achieved through correlation of post-harvest losses estimated in objective three against technical efficiency estimated in objective one.

Charnes *et al.* (1978) proposed that a researcher should choose orientation from input-oriented DEA model or output-oriented DEA model according to which quantities (either inputs or output) a manager has more control over. In the input-oriented the DEA model, defines the frontier by seeking the maximum possible proportional reduction in inputs usage with output level held constant. However, in the output-oriented DEA model defines frontier by seeking the maximum possible proportional expansion in output with the same input level (Lissitsa *et al.*, 2005). Since farmers in Kilosa have more control over inputs than outputs, therefore input-oriented DEA model was used in the current study.

3.5.1 DEA Model for the Estimation of Total Technical Efficiency

Maize output (Y) was the output variable used to estimate Technical Efficiency and inputs used for this study were, Size of land (x_1), Labour (x_2) and seed (x_3). The input oriented constant returns to scale DEA model was used for the calculation of the Total Technical efficiency as described hereby below;

$Min\ \theta, \lambda\theta,$

Subject to

$-y_i + Y\lambda \geq 0$

$\theta x_i - X\lambda \geq 0$

$\lambda \geq 0$

Whereby, Y represents matrix for N farms, θ is a Total Technical Efficiency of i^{th} farm and X is input matrix for N farms, while y_i represents total farm income of the i^{th} in Tanzania shillings, x_i represent input factors of x_1, x_2 and x_3 and λ is Nx1 constants. The linear programming problem must be solved N times, one for each farm in the sample. A value of θ is then attained for each of the farms.

3.5.2 DEA Model for Estimation of Pure Technical Efficiency

According to Coell *et al.* (2005) input-oriented DEA model under the assumption of Variable Return to Scale was used to estimate Pure Technical Efficiency can be described as follows,

$Min\ \theta, \lambda\theta,$

Subject to

$-y_i + Y\lambda \geq 0$

$\theta x_i - X\lambda \geq 0$

$N1'\lambda = 1$

$\lambda \geq 0$

Whereby, θ represents the Pure Technical Efficiency of i^{th} farms and $N1'\lambda$ represents a convexity constraint which ensures that an inefficient farm is only benchmarked against farms of the similar size.

3.5.3 Estimation of the Scale Efficiency

Scale Efficiency was commutated by dividing Technical Efficiency under constant return to scale (TE_{CRS}) by the Pure Technical Efficiency under the Variable Return to scale (TE_{VRS}).

$SE = TE_{CRS}/TE_{VRS}$

SE = 1 indicates scale efficiency or constant return to scale (CRS) or SE < 1 indicate scale inefficiency. Scale inefficiency arises due to the presence of either increasing return to scale or decreasing return to scale. This was estimated by running another DEA model under Non-Increasing Return to Scale (NIRS).

$Min\ \theta, \lambda\theta,$

Subject to:

$-y_i + Y\lambda \geq 0$

$\theta x_i - X\lambda \geq 0$

$N1'\lambda \leq 1$

$\lambda \geq 0$

3.5.4 Factors Affecting/Influencing pure Technical Efficiency

Pure Technical Inefficiencies were estimated by using a regression model in which inefficiency was expressed as a function of socio-economic and farm specific factors. According to Javed *et al.* (2009) this approach is known as 'two-step procedure'

The method adopted by Javed *et al.* (2009) was followed where-by technical inefficiency indices are obtained by subtracting the technical estimates from 1. The technical inefficiency scores were regressed on gender of the household, marital status, household size, experience of the household, education of the household, off-farm income, microcredit and extension services. These factors either directly or indirectly influences the quality of management of the farm's operations hence have impact on the level of technical inefficiencies of the farm. Expected signs regarding the relationship between dependent and explanatory variables are explained in Table 2

Table 3: Description of effects of Socio-economic and Farm Specific Factors on Technical Inefficiency

Socio-economic and farm specific factors	Descriptions`	Expected signs
Gender	Dummy (1 for male, 0 for female)	-
Marital status	Married	-
Household size	Number of family members in the household	-
Experience in farming	Years in farming maize	-
Education	Number of years attended in formal school	+ or -
Off-farm income	Tzs earned out of farming	+ or -
Access to credit	Microfinance to the household earned	-
Access to extension	Access to extension services	+ or -

In order to determine the effect of these socio-economic and farm specific factors on inefficiency estimates Tobit regression model was determined as:

$$E_i = E_i^* = \beta_0 + \beta_1 Z_{1i} + \beta_2 Z_{2i} + \beta_3 Z_{3i} + \beta_4 Z_{4i} + \beta_5 Z_{5i} + \beta_6 Z_{6i} + \beta_7 Z_{7i} + \beta_8 Z_{8i} + \beta_9 Z_{9i} + \varepsilon_i$$

If $E^* > 0$ E = 0, and If $E_i^* \leq 0$

Where by:-

$\beta's$ = are unknown parameters to be estimated ; ε_i = is the error term; i= i^{th} farm in kilosa maize farmers sample; E_i =inefficiency measure representing technical inefficiency of the i^{th} farm; E_i^* =is the latent variable; Z_{1i}= Dummy variable of the gender, being 1 for male and 0 female; Z_{2i} =Dummy variable of the marital status, being 1 for single 0 otherwise, 1 married 0 otherwise, 1 Divorced 0 otherwise; Z Z_{3i} =Household size (number of people in a household); Z_{4i} = experience of the household head in number of years in growing maize; Z_{5i} = Education of the household head (number of years in school); Z_{6i} = Dummy variable of credit access being 1 for those who access and 0 otherwise; Z_{7i} = Off-farm income in Tz Shilling; Z_{8i} = Dummy variable for the access to extension services being 1 for those farmers who access and 0 for the farmers who do not access and lastly was Z_{9i} = farm size of the Household (acre).

3.5.5 Estimation of Maize Post-harvest Losses per Household

Estimation of maize post-harvest losses computed from the post-harvest losses data obtained from the households during operations of harvesting, transportation, bagging/loading, threshing, drying and storage. The total post-harvest losses were estimated as a sum of all these losses.

Total PHL = Sum of PHL at each stage of the maize supply chain.

$$Total\ PHL = \sum S i = \sum f\ (X_j)$$

Where by:-

S_i = Maize Losses in each critical stage of FSC

X_j = Factors affecting maize losses at each step

i = Critical stages from harvesting to consumption of maize

Functional analysis was carried out to examine the factors affecting post-harvest losses at farm level in maize as used by Begun *et al.*, (2012) in Northen regions of Bangladesh. The following semi log multiple linear regression function was specified in the current study.

$$Log\ Y = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \beta_3 X_{3i} + \beta_4 X_{4i} + \beta_5 X_{5i} + \beta_6 X_{6i} + \beta_7 X_{7i} + \beta_8 X_{8i} + \beta_5 X_{9i} + \varepsilon_i$$

Where by:-

Log Y= Natural logarithm of post-harvest losses;

$\beta's$ =Unknown parameters to be estimated

ε_i = Error term

i= i^{th} farm in Kilosa maize farmers sample

X_{1i}= Dummy variable of the gender, being 1 for male headed household and 0 female headed household

X_{2i} =Household size (number of people in a household)

X_{3i} = Experience of the household head in number of years in growing maize

X_{4i} = Education of the household head in a number of years in school

X_{5i} = Dummy variable of credit access being 1 for those who access and 0 otherwise

X_{6i} = Off-farm income in Tz Shilling

X_{7i} = Dummy variable for the access to extension services being 1 for those farmers who access and 0 for the farmers who do not access and lastly was

X_{8i} = Farm size of the household in acres

X_{9i} = Maize yield per acre

Expected signs between dependent and explanatory variables were explained in Table 3.

Table 4: Description of Effects of Socio-economic and Farm Specific Factors on Post-harvest Losses

Socio-economic and farm specific factors	Descriptions	Expected signs
Gender	Dummy (1 for male, 0 for female)	-
Household size	Number of family members in the household	-
Experience in farming	Years in farming maize	+ or -
Education	Number of years attended in formal school	+ or -
Access to credit	Microfinance to the household earned	-
Off-farm income	Tzs earned out of farming	-
Access to extension	Access to extension services in number of visit	-
Farm size	Proportion of land grown with maize in acres	+
Maize yield	Maize yield in kg	+

3.5.6 Linear Relationship Between Post-harvest Losses and Technical Efficiencies

The current study related the post-harvest losses to technical efficiency scores to find out whether post-harvest losses decreases as efficiency increases. In order to achieve this, post-harvest losses were correlated to technical efficiency scores. Simple correlation coefficient is a measure of the degree/strength and direction of linear association/relationship between two variables. The simple correlation coefficient is free of the effects of scale of measurements. It varies from -1 to +1 which indicates perfect linear association.

Correlation

$$r = \frac{\sum xy - \frac{\sum x \sum y}{n}}{\left(\sum x^2 - \frac{(\sum x)^2}{n}\right)\left(\sum y^2 - \frac{(\sum y)^2}{n}\right)}$$

Where by:-

r = Correlation

x = Estimated post-harvest losses

y = Technical efficiency

$r = 0$ No association between maize post-harvest losses and technical efficiency

$r > 0$ Positive correlation

$r < 0$ Negative correlation

$|r| > 0.8$ Very strong correlation

$|r| > 0.4$ -0.8 Moderate correlation

$|r| < 0.4$ Weak correlation

In order to test the hypotheses that $\rho = 0$ *i.e.* there is no linear relationship between technical efficiency and post-harvest losses this is because a t-test was used. r has a t distribution with n-2 degree of freedom and the test statistics was given by

$$t = r\sqrt{n-2/1-r^2}$$

Where-by n is maize grower sample size, and r is the simple correlation coefficient.

Where by:-

r = Correlation

x = Estimated post-harvest losses

y = Technical efficiency

r = 0 No association between maize post-harvest losses and technical efficiency

r > 0 Positive correlation

r < 0 Negative correlation

$|r| > 0.8$ Very strong correlation

$|r| > 0.4$ -0.8 Moderate correlation

$|r| < 0.4$ Weak correlation

In order to test the hypotheses that $\rho = 0$ *i.e.* there is no linear relationship between technical efficiency and post-harvest losses this is because a t-test was used. r has a t distribution with n-2 degree of freedom and the test statistics was given by

$$t = r\sqrt{n-2/1-r^2}$$

Where-by n is maize grower sample size, and r is the simple correlation coefficient.

CHAPTER FOUR

4.0 RESULTS AND DICUSSION

4.1 Descriptive Results

4.1.1 Gender of the Household Head

As tabulated in Table 5, the results show that about 71% of sample maize farmers' households were male headed maize farmers with female headed household comprising about 29%. This has an implication on productivity and post-harvest losses of maize in the study areas. Due to traditions, norms and customs, females are deprived of production resources and information compared to males. Female also are less confident in decision making concerning technology use (Kasanki, 2015), so large proportion of male headed households sound good in maize productivity and maize post-harvest losses reduction. The results are consistent with Kansaki (2015) and SDC (2015a, b and c).

Table 5: Distribution of Respondents by Gender of the Household Head

Gender	Number of farmers	Percent
Male	115	71.0
Female	47	29.0
Total	**162**	**100.0**

4.1.2 Marital Status of the Household Head

The results on the marital status of the household head as indicated in Table 6 show that most (71%) of the household head in Kilosa district were married which is above the national average of 57% (URT, 2014). The results further show that, widowed household heads in Kilosa district accounts for about 11.7% of the maize farmers which is also above the national average of 2% according to the National Census (URT, 2014) and divorced household heads in Kilosa district accounts for about 8%

of the maize farmers. This is twice as much to that of National average of 4.3% (URT, 2014). The high percentage of the married household head implies that, community in Kilosa District is stable which is good for the production activities.

Table 6: Marital Status of the Household Head

Marital status	Number of farmers	Percent
Single	15	9.3
Married	115	71.0
Divorced	13	8.0
Widow	19	11.7
Total	**162**	**100.0**

4.1.3 Household Size

The results on household size as indicated in Table 7 show that, 80.2% of the interviewed household comprises members ranging between 2 and 7. Households that comprise members less than 2 members constitute 6.8% of the total number of the households. It could be further noted that households with family sizes ranging from 8 to 13 accounts for 11.8% of the total households interviewed. The smallest portion (1.2 %) of the total household interviewed comprises more than 13 household members. The largest household size in the sampled households was 15 members while smallest household size contained only a single member. The average household size among the sampled maize grower household is 5 members. This is very close to the national average household size of 4.7 members (URT, 2012).

Table 7: Distribution of Respondents by Household Size

Family size	Number of farmers	Percent
below 2	11	6.8
2-4	48	29.6
5-7	82	50.6
8-10	16	9.9
11-13	3	1.9
above 13	2	1.2
Total	162	100.0

4.1.4 Education of the Head of the Household

The current study also assessed education of the producers of the maize by using number of years attended in school. Education plat form focus on the need to develop knowledge and skills that support decision making and activity management during production process. Therefore, it is believed that household head with many years of formal education will lead to better management of agronomic practices hence high productivity and low post-harvest losses. The results of this assessment as presented in Table 8 show that about 80.2% of the households' head reported to have attained some form of formal education. This is little above the national literacy level which is 71.53% (URT, 2012). Similar results were reported by Philip, (2007) who found the literacy level to be 80% in Morogoro region. Furthermore, the Table shows that 74% of those who reported to have attained formal education completed more than seven years of schooling. The results therefore, imply that Kilosa district community has farmers who can be trained easily since most of them attained the basic education.

Table 8: Distribution of Respondents by Level of Education

No of years in school	Number of farmers	Percent
0	32	19.8
1	1	0.6
2	2	1.2
3	1	0.6
4	6	3.7
6	1	0.6
7	110	67.9
9	1	0.6
11	7	4.3
15	1	0.6
Total	**162**	**100.0**
Mean		5.61
Std. Deviation		3.15
Minimum		0.00
Maximum		15.00

4.1.5 Experience in Maize Production

The number of years of maize cultivation achieved by household head is used as proxy for managerial input. Older farmers are more experienced, therefore are more efficient than younger farmers who are less experienced in managing and allocating productive resources. The present study assessed experience of maize farmers in the study area and the results in Table 9 show that, the maximum numbers of experience in years of growing maize were 60 years and minimum number of experience in years of growing maize were 2 years. The average years in growing maize however, was 22.27 and standard deviation of 13.973. Furthermore, results show that 30.9% of the respondents had an experience of growing maize between 2-10 years, while 69.1% of the respondents had grown maize for more than 11 years. This implies that most of the farmers in Kilosa district are experienced farmers who can make right decision in managing and allocating productive resources.

Table 9: Distribution of Respondents by Number of Years in Maize Cultivation

Years in Growing Maize	Number of respondents	Percent
2-10	50	30.9
11-20	37	22.8
21-30	31	19.1
31-40	29	17.9
41-50	13	8.0
51-60	2	1.2
Total	162	100.0
Mean		22.27
Std. Deviation		13.97
Minimum		2
Maximum		60

4.1.6 Land Tenure and Land Size Among Maize Farmers

The present study assessed the land tenure and size of the land in relation to maize production. Firstly from Table 10 the study found that, 47.5% of the sampled responded acquired land for production through hiring, 29.6% of the respondents obtained land through inheritance, and only 5.6% obtained the land through buying. Moreover, the results show that, the remaining percent of the respondents, 9.9% and 7.4% acquired land through village authority and accessing free land respectively. Secondly from Table 10 the results show that, the share of land located for the maize production between 1 and 3 acres accounted for about 77.2% of the sampled respondents, below an acre comprises 2.5% of the household sampled, while 11.1% of the household famers allocated between 3.1 to 4 acres. The households which allocated land for maize cultivation above 4 acres accounted 11.7% of the respondents.

Table 10 show that, total land owned by household ranging between an acre to 5 acres accounted 71.6% of the respondents. Moreover, the Table shows that 1.2% of the respondents allocated total land below an acre and 24.2% of the respondents allocated total land between 6 to 15 acres.. The interviewees who owned total land above 15 acres accounted for 3.1% only.

Table 10 further shows that, the largest portion of land cultivated with maize only in the study area were 16 acres per household in contrast to the largest total land owned by an individual household which were 50 acres. The minimum land cultivated for maize only in the study area was 0.5 acres per household. The average land grown for only maize found in the study area is 2.7 acres compared to average total land owned of 5 acres. The results shows that, Kilosa has scarce land for crop production, and farmers in Kilosa are typical smallholders and intensity in the land use is generally high. The land is fragmented a lot and limits farmers to enjoy economies of scale. These results confirmed the works of many empirical studies on agricultural production in the developing countries that, smallholder farmers operate small farm size scattered in smallholdings as represented by the study of Oduol *et al.* (2012) and Osun *et al.* (2013).

Table 10: Land Tenure and Size of the Land to Household

Access to land	Number of farmers	Percent
Inherited	48	29.6
Bought	9	5.6
Given by village authority	16	9.9
Accessed the free land	12	7.4
Hired	77	47.5
Total	**162**	**100.0**
Maize land Size	**Number of farmers**	**Percent**
Below 1 acre	4	2.5
1-1.5 acre	33	20.4
1.6-2 acre	57	35.2
2.1-2.5 acres	8	4.9
2.6-3 acres	23	14.2
3.1-.3.5 acres	2	1.2
3.6-4 acres	16	9.9
Above 4	19	11.7
Total	**162**	**100.0**
Mean	2.71	
Std. Deviation	1.91	
Minimum	0.50	
Maximum	16.00	
Total Land	**Number of farmers**	**Percentage**
Below 1 acre	2	1.2
1-5 Acres	116	71.6
6-10 Acres	34	21.0
11-15 Acres	5	3.1
Above 15 Acres	5	3.1
Total	**162**	**100**
Mean	5.03	
Std. Deviation	5.05	
Minimum	0.50	
Maximum	50.00	

4.1.7 Availability of Credit Services in the Study Area

The study went further to explore whether sampled maize farmers had any access to credit. Results on Table 11 show that, majority of the respondents (85.8%) reported to have no any access to credit and only 14.2% of the respondents reported to secure credit. Credit access has an impact to maize productivity and post-harvest operations. It is expected that, if a farmer is able to secure credit, will be able to purchase inputs, hire labour, hire and /or purchase equipments and initiate off farm activities. The influence of credit access on productivity is in line to the study conducted by Aye and Mungatana, (2010) on Technical efficiency of maize farmers in the northern province of Laos Nigeria.

Table 11: Distribution of Respondents by Credit Access

Response	Number of farmers	Percent
yes	23	14.2
No	139	85.8
Total	**162**	**100.0**

4.1.8 Availability of Extension Services in the Study Area

On the assessment of the extension services in Kilosa district, respondents were asked whether they had access to extension services for the issues related to maize production activities. Also the interviewees were asked whether they had attended any farmers' training and/or received any extension materials such as leaf-lets. Moreover, they were asked if they had any farmers group where they normally act together. The results of analysis of these questions are presented in Fig 7. Results show that about 58% of the respondents reported to have an access to extension services. This implies that Kilosa district has enough networks of extension services. The Figure further shows that, 38.5% of the respondents had attended farmers' training on various issues related to maize production activities. The same figure shows that, only 27.8% of the respondents reported to have received various extension materials. The relatively low proportion of farmers who had attended farmers' training and/or received extension materials could be attributed to the fact that most of the farmers (about 60.5%) do not belong to any farmers groups. These results are the same as those reported by Geta *et al.* (2013) who conducted a study on Productivity and efficiency analysis of smallholder maize producers in Southern Ethiopia and found that, most of farmers had an excess to extension service with positive impact on maize productivity.

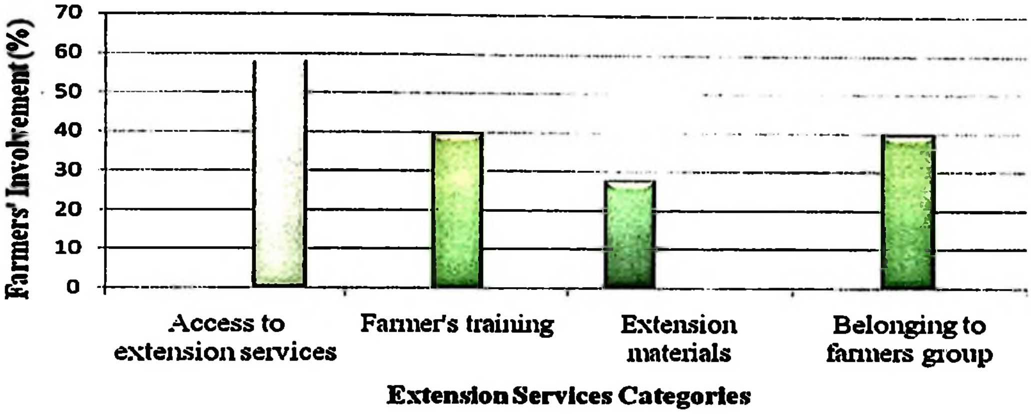

Figure 7: Farmers' Access to Various Types of Extension Services

4.1.9 Use of Fertilizer and Agrochemicals in the Study Area

As shown in the Table 12, Kilosa farmers do not apply fertilizer and agrochemicals in their crops. The results show that 93.2% of the respondents disagreed to use fertilizers and agrochemicals. Only 6.8% of the respondents were found to be using fertilizers which most of them were offered as a trial. The fertilizers were offered by the Business Sisal Chinese Company located in Rudewa Pea Pea. Reasons of not using fertilizers and agrochemicals varied from village to village.

Table 12: Reasons of not Using Fertilizers and Agrochemicals

	Village name						
Reasons not to use fertilizers	**Madudu**	**Mji Mpya**	**Malangali**	**Rudewa Pea Pea**	**Kibao**	**Mvumi A**	**Total**
Too expensive	2	6	8	13	10	12	51
Not available	0	0	1	1	0	2	4
Not necessary because soil is still fertile	20	22	10	5	7	6	70
Fear of its effect on soil	2	0	0	0	1	2	5
Ignorance	2	0	6	3	6	3	20
Not applicable	1	0	2	6	2	1	12
Total	27	28	27	28	26	26	162

Responses	**Number of farmers**	**Percent**
Yes	11	6.8
No	151	93.2
Total	**162**	**100.0**

The table show that 43.21% of the respondents said that they are not using fertilizers because their land is still fertile, 31.48% said that fertilizers are too expensive and 12.35% of the respondents admitted that is because of ignorance. Furthermore, the results show that, 2.47% of the respondents said the fertilizers were not available. Few respondents (3.09%) said that they feared the fertilizers effect on soil and 7.41 % of the respondents did not respond to the question. Similar results of low use of fertilizers are reported by Aye *et al.* (2010) who studied Technical Efficiency of Traditional and Hybrid Maize Farmers in Nigeria.

4.1.10 Use of Maize Seeds

From results on Table 13, this study found that 69.8% of the sampled maize producers are still using traditional maize varieties, whereas only 19.8% of the sampled maize producers are using improved varieties and the rest of the respondents reported to be using both traditional and improved varieties. On the other hand regarding the quantity of seeds used, Table 12 shows that 48.1% of the respondents used the agronomic proposed quantity of between 7-9 kg/Acre, 17.3% of the respondents used seed quantity between 3-6 kg per acre and 1.9% of the sampled maize farmers used below 3 kg per acre. Furthermore, about 12.3% of the respondents used 10-13 kg per acre while 15.4% and 4.9% of the sampled farmers used 13-19 and above 19 kg per acre respectively. The maximum seed quantity used in the study area were 23 kg per acre and minimum seed quantity used were 2 kg per acre, the average seed quantity used in the study area were 9.66 kg per acre.

Table 13: Maize seeds Used

Maize variety	Number of farmers	Percent
Improved varieties	32	19.8
Traditional varieties	113	69.8
Both Improved and Traditional varieties	17	10.5
Total	162	100.0
Amount of maize seeds (kg/Acre)	**Number of farmers**	**Percent**
Below 3	3	1.9
3-6	28	17.3
7-9	78	48.1
10-13	20	12.3
13-19	25	15.4
Above	8	4.9
Total	162	100.0
Mean	9.6 6	
Std. Deviation	4.56	
Minimum	2.0	
Maximum	23.00	

4.1.11 Use of labour in the study area

A result on Table 14 show that, man day per acre used for land preparation activity was 10.5 on average. For the activity of seeding an acre required 2.5 man days while weeding activity accomplished with an average of 12.3 man days per acre. The results further shows that agrochemical application activity demanded 1.1 man days per acre and harvesting activity required 3.4 man days per acre.

Table 14: Labour used per Acre in Man days

Farming activities	Average man days/acre
Land preparation	10.5
Seeding	2.5
Weeding	12.3
Agrochemical application	1.1
Harvesting	3.4
Total	29.8

4.1.12 Off-Farm Income of the Respondents

The results on Table 15 show that, sampled maize producers in Kilosa had varied off farm income ranging from a maximum of Tzs 4.5 million to the minimum of Tzs 0. Average off farm incomes from different activities was Tzs 540 847.2 and standard deviation of Tzs 751 751.8818. As shown in Table 14, 32.1% of the sampled maize farmers in Kilosa were found to have off farm incomes below Tzs 50 000. Furthermore, the results show that, 26.5% of the respondents had off farm income above Tzs 631 000, 11.7% of the respondents found to have off farm income between Tzs 50 000 and Tzs 100 000, and the rest of the percent of the respondents were between Tzs 101 000 Tzs and Tzs 630 000. This implies that, most of the maize farmers in Kilosa District acquire off-farm income which increases the income base of the farm household thus helping them to overcome credit that used to finance farm operations. These results are similar to those of Aye and Mungatan, (2010) who studied Technical Efficiency of Traditional and Hybrid Maize farmers in Nigeria and Sibinko, (2012) who carried study on Determinants of Common Bean Productivity and Efficiency in Earsten Uganda who found that off-farm income had positive effect on bean productivity.

Table 15: Distribution of Off-farm Income Among Respondents

Income Category (Tzs)	Frequency	Percent
below 50 000	52	32.1
50 000-100 000	19	11.7
101 000-160 000	13	8.0
161 000-220 000	5	3.1
221 000-270 000	3	1.9
281 000-330 000	6	3.7
340 000-390 000	3	1.9
401 000-450 000	8	4.9
461 000-510 000	3	1.9
521 000-570 000	4	2.5
581 000-630 000	3	1.9
Above 631 000	43	26.5
Total	**162**	**100.0**
Mean	54 0847.22	
Std. Deviation	751 751.88	
Minimum	0	
Maximum	4 500 000	

4.1.13. Household Maize Yield

The maize yield in kg from sampled maize farmers were computed by using own survey data. The results on Figure 8 show that, 46 household harvested between 200 to 400 kg per acre and 44 households harvested between 401 to 600 kg per acre. The smallest portion of household (4 households) harvested between 1001 and 1200kg per acre while 4 households harvested above 1201 kg per acre. The average yield of maize per acre in the sampled maize farmers in Kilosa District was 523.85 kg per acre. Low productivity could be attributed to the input use efficiency. The average yield of 523.85 kg/acre from the current study is contrasted from the result of average maize yield (2 268 kg/acre) by Takeuch *et al.* (2012) who conducted a study of Analysis on technical efficiency of maize farmers in the northern provinces of Laos who found low productivity as contributed by technical inefficiency of input.

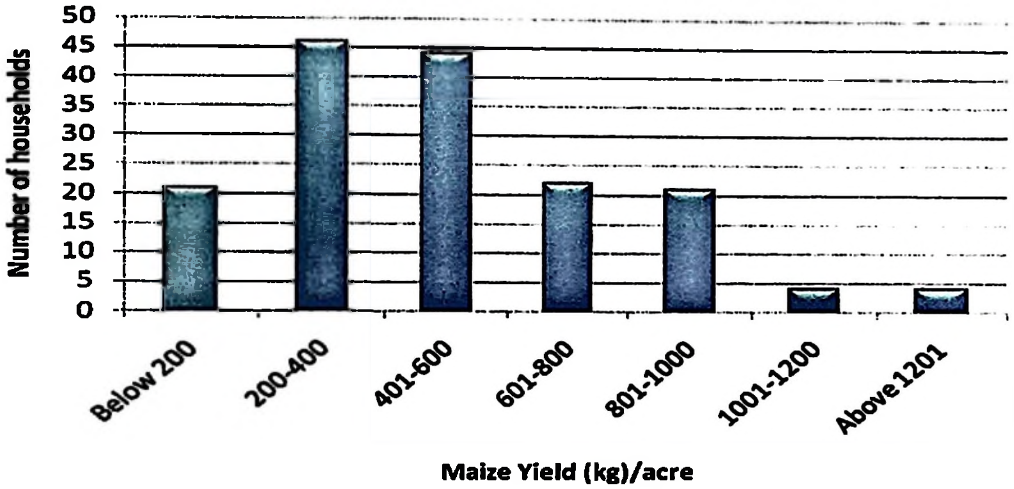

Figure 8: Distribution of the Maize Yield (kg) per acre

4.1.14 The Production Costs for Maize Under Various Farm Operations

The production costs for maize for various farm operation were computed from own survey data. The results on Table 16 present the average production cost of each farm operation involved in producing maize in Kilosa district. The results show that, on average cost of all operation per household was Tzs 177 845.3 which is required to produce an average of maize output of 523.85 kg per acre.

Table 16: Average Cost of the Farm Operations per Acre

Farm operation	Unit	Average cost of the Operation
Land preparation	Tzs/acre	24 042
Seeding/Planting	Tzs/acre	4 665.7
Weeding	Tzs/acre	15 834
Agrochemical application	Tzs/acre	12 052
Maize harvesting	Tzs/acre	9 112.4
Transportation	Tzs/Tone	10 971
Maize threshing	Tzs/Tone	8 186.2
Fertilizer	Tzs/Bag	69 502
Improved seeds	Tzs/kg	2 890
Hired land	Tzs/acre	20 590
Total cost for per acre	Tzs	177 5.3

4.2 Empirical Results of the DEA and Tobit Regression Models

4.2.1 Technical Efficiency Scores Obtained with DEA Model

The technical efficiency of the maize production in Kilosa district was obtained by using DEA models. The results are presented in Table 16 which shows that, the average technical efficiency was found to be about 0.84 under VRS. The results imply that, if the average farmers operated at the same technical efficiency as the most efficient farms in the sampled household, they could reduce on average; their inputs use by about 16% and still produce the same level of maize output. Under CRS approach however, the results show that the average technical efficiency was found to be about 0.57 implying that if the average farmers operated at the same technical efficiency as the most efficient farms in the sampled household, they could reduce on average their inputs use by about 43% and still produce the same level of maize output.

The results on Table 17 further show that 47.5% of the sampled maize farmers under VRS, approach in contrast with the results presented under CRS approach, only 16.7% of the respondents were full technically efficient in utilizing their scarce resources. The results further show that 8% of the respondents under VRS approach compared to 43.8% of the respondents under CRS approach operated at the level of technical efficiency of below 0.5. On one hand, it was found that 44.5% of the respondents under VRS approach operated at the level of technical efficiency between 0.50 and 0.90 while on the other, 39.5% of the respondents operated at the similar level of technical efficiency under the CRS approach.

For the inefficient farms, the causes of inefficiency may either be inappropriate scale or misallocation of resources. Inappropriate scale suggests that the farm is not taking advantage of economies of scale. While misallocation of resources refers to inefficiency in input combinations because mean scale efficiency of the sampled maize growing farms is relatively high (0.67), it can be deduced that inefficiencies are mainly due to improper use of inputs. These results are consistent with those of Javed *et al.*, (2009) who carried out An Efficiency Analysis of Punjab's Cotton-Wheat system in India who found average technical efficiency of 0.839 under VRS.

Table 17: Distributions of Technical Efficiency Scores Obtained with DEA model

Efficiency level	DEA TE SCORES					
	CRS TE		VRS TE		SE	
	No of farmers	Percent	No of farmers	Percent	No of farmers	Percent
Less than 0.40	60	37.0	5	3.1	35	21.6
0.40-0.50	11	6.8	8	4.9	10	6.2
0.50-0.60	15	9.3	15	9.3	18	11.1
0.60-0.70	13	8.0	14	8.6	8	4.9
0.70-0.80	16	9.9	24	14.8	20	12.3
0.80-0.90	13	8.0	9	5.6	16	9.9
0.90-1.00	7	4.3	10	6.2	25	15.4
1.00	27	16.7	77	47.5	30	18.5
Mean		0.57		0.84		0.67
Std. Deviation		0.31		0.20		0.30
Minimum		0.00		0.22		0.00
Maximum		1.00		1.00		1.00

4.2.2 Inputs Slacks and Number of Farms Using Excess Inputs

Mean inputs slacks and excess input use percentages are shown in Table 18. A slack indicates excess use of an input. A farm can reduce its expenditure on an input by the amount of slacks without reducing its maize output. As indicated in Table 18, the greatest slacks were in labour use and seed use which are represented as 19.9% and 10.3% respectively. Numbers of farms using input in excess were as follows; 21

farms land size excess, 48 farms used labour in excess and 30 farms used seeds in excess. This implies that, these farmers can reduce costs without affecting maize output. The results on current study are in line with those of Tavana *et al.* (2012) on efficiency measurements in Fuzzy additive data envelopment analysis in United States of America (USA) who found greatest slacks to be in labour and fertilizer use.

Table 18: Inputs Slacks and Number of Farms using Excess Inputs

Inputs	No of Farms	Mean Slack	Mean Input Uses	Excess Inputs use (%)
Land size	21	0.13	2.71	4.83
Labour (Man days)	48	17.59	88.17	19.95
Seeds	30	1.13	10.97	10.34

4.2.3 Causes of Inefficiencies

Socio-economic and farm specific characteristics are likely to influence the level of technical efficiency. The present study attempted to investigate the sources of inefficiency of the maize growing households in Kilosa district. In order to achieve this, VRS_TE estimates were regressed on socio-economic and farm specific variables respectively using a Tobit regression model. The results are presented in Table 19. The findings show that, gender is positively and significantly associated with technical efficiency implying that, being a male affect the technical efficiency positively compared to female.

The results as presented in Table 18 show that farmer who is single is negatively and significantly associated with technical efficiency of farm and is implying that, to be single lead in decrease of technical efficiency.

Furthermore, the results show that the most important determinants of technical efficiency are access to extension services. Extension services variable was meant to capture the effect of access of extension services on technical efficiency. It is expected that farmers with extension services are positive. The result of this study show that extension services is positively and significantly associated with technical efficiency of farm, implying that farms with contact to extension services have less inefficiency in compared to farms with no contact to extension services.

Moreover, Off-farm income in this study was found to be negatively and significantly related to technical efficiency whereby those farms with off-farm income are able to access inputs and information that are of important to maize production. Experience, number of years in school and average land size planted maize are all positively and significantly related to technical efficiency implying that, as a maize farmer gain more years in growing maize, learn more new ways, and is able to face farming challenges and making sound decisions. In addition farmers with more years in school are able to learn new ways, able to innovate, easily access information on credit, technology and agronomic practices in contrast to their counterparts. Likewise land size was found to be more technically efficiency due to its small sizes, being able to be managed compared to larger ones.

These results are similar to the results of Oyewo and Fabiyi, (2008) Oyo State; Aye and Mungatana, (2010) in Nigeria; Tsukuda *et al.* (2010) in Tanzania, Tekeuchi *et al.* (2012) in Northern provinces of Laos and Geta *et al.* (2013) who did productivity and efficiency analysis of smallholders maize producers in Southern Ethiopia and found that access to extension services, off farm income, experience and access to credit were positively and significantly associated to technical efficiency.

Table 19: Results of Tobit Model for Technical Efficiency Score

VRS_TE	Coef	Std. Err.	t	P>t
Cons	0.2849	0.1063	2.68	0.008*
Dummy gender	0.0658	0.0380	1.73	0.08***
Dummy Single	-0.1729	0.0888	-1.95	0.053**
Dummy Married	-0.1195	0.0792	-1.51	0.133
Dummy Divorced	-0.141	0.0623	-2.27	0.025**
Dummy Extension	0.2170	0.0759	2.86	0.005*
Off-Farm Income	-1.38	5.08	-2.72	0.007*
Household size	-0.007	0.0085	-0.78	0.436
Experience (Years)	0.0307	0.0070	4.38	0.000*
No of Years in School	0.0216	0.0060	3.58	0.000*
Av Land size (Maize)	0.0288	0.0102	2.83	0.005*

*, ** and *** indicate the level of significance at 1, 5, and 10 percent respectively.

Tobit regression
F (10, 152) = 40.03
Prob > F = 0.0000
Log pseudo likelihood = -176.873,
Pseudo R2 = 0.712
Obs. summary: 0 left-censored observations
161 uncensored observations
1 right-censored observation at VRS_TE >= 9.79

4.3 Estimation of Post-harvest Losses in Maize at Farm Level

The estimated post-harvest losses per kilogram of maize are presented in Table 20. The results in this Table show that, total average loss is about 148.86 kg per household. The various stages involved in this loss were, harvesting; bagging/loading; transportation; drying, threshing and storage. Storage stage causes maximum losses of about 180 kg and an average of 88.9 kg. The loss in this stage tends to be rather high in Kilosa district due to fact that the most of households store their maize at the houses ceiling board and in bags at the crashing machine centre and at home in the seating rooms. The important causes of storage losses were less skills on post-harvest management; damage by rodents, pests and dampness.

The results of Basappa *et al.* (2007) in Karnataka India reported the similar findings that the most important stage in post-harvest losses was storage in which rodents and pests were mentioned to be the cause of these post-harvest losses.

The next important stage of maize post-harvest losses to that of storage stage was harvesting stage. The post-harvest losses in this stage were estimated to an average of 46.68 kg with maximum of 90 kg. This loss was due to negligent and left over of maize cobs and grain in the farm by the family and hired labour. The left over maize was due to wrongly thrown maize cobs on mini heap, negligence of small sized cobs and spill over when collecting and recollecting in the farm. Further results show that, on average the transportation stage cause a loss of an average of 4.56 kg. This loss was mainly due to the fact that most of the maize growers transporting their maize produce by motorcycles, bicycles and head through unmaintained feeder roads.

Moreover the results show that the losses under threshing and drying stages were on average 4.2 kg and 3.43 kg respectively. On one hand, losses under threshing level was mainly due to many farmers threshing their maize produce by employing small children who are careless. Furthermore, few farmers used tractor mounted machines to thresh their maize produce and the losses during threshing were in terms of broken grains, scattering and be socked onto soil sands. On the other hand, losses under drying was mainly due to the fact that most of the farmers dry their maize produce by spreading grain and/or cobs down on tarpaulins hessian cloth for a long time in such a way that maize losses occurs due to rodents, birds, children, termites and spill overs. Further results show that maize loss under the bagging/loading stage was found to be 1.09 kg. These results are consistent to the results of Begun *et al.* (2012) in Bangladesh and Basavaraja *et al.*, (2007) in India who found that bagging/loading stage were associated with little losses in comparison with the rest of stages.

Table 20: Estimated Post-harvest Losses at Different Stages in the Maize

Post-harvest Operation	Amount of maize loss (kg)			Percentage Loss (%)		
	Min	Max	Average	Min	Max	Average
Harvesting	0	90	46.68	0	12	6.03
Bagging/Loading	0	12	1.09	0	3	0.69
Transportation	0	16	4.56	0	4	0.35
Drying	0	8	3.43	0	2.2	1.48
Threshing	0	9	4.2	0	9	2.30
Storage	0	180	88.9	0	14	8.7
Total	0	315	148.86	0	44.2	19.55

4.4 Determinants of Post-harvest Losses at Farm Level

The current study determined the influence of various socio-economic and farm specific features on post-harvest losses on maize. In order to identify the determinants of post-harvest losses on maize, multiple regression analysis with semi log model was fitted and estimates are presented in Table 21. The results show that, the nine explanatory variables included in the regression model explained nearly 57% variation in the total post-harvest losses on maize. The F-ratio was significant at 1% indicating thereby the good fit of the model.

The results further show that, the regression coefficients of all the variables except household size, experience of the household head and education level were positively associated with the total post-harvest losses. The variables of household size, experience of the household head and years in education were negatively associated with the total post-harvest losses.

Further results show that, gender of the household head was negatively and significantly associated with the total post-harvest losses indicating that, household headed by female had lower post-harvest losses compared to household headed by male. This might be attributed to the fact that, female are engaged with farm activities more in spite of being deprived of access to agricultural inputs.

The household size showed to be negatively significantly related to the total post-harvest losses implying that as the size of the household increases post-harvest losses decreases because of enough labour to perform post-harvest activities. The results further show that, experience and level of education of the household head were negatively and significantly associated with the total post-harvest losses at the farm level. These results mean that, as number of years in growing maize and education increase post-harvest losses decreases due to adoption of improved scientific methods in post-harvest operations such as iron metal silo and use of special bags (PICS).

Proportion of land under maize production and total maize output variables were positively and significantly associated with the total maize post-harvest losses. This implies that, as proportion of land under maize production increases, maize yield increas too likewise post-harvest losses increas too. This might be attributed to the fact that management of large area and large produce requires hiring of labour that is in most cases neglect some of the produce.

The rest of variables *i.e.* accesses to credit, off-farm income and access to extension services were insignificant. These results to some extend are similar to those of

Bassapa *et al.* (2007) in India, Bugun *at el.* (2012) in Bangladesh, Bale *et al.*, (2010) in Bangladesh and Folayan, (2013) in Nigeria. These studies in addition to the variable used in the current study, associated post-harvest losses with adverse weather condition, inadequate labour, inadequate transport, source of information, inadequate storage and frequency of sales which have never used to the current study.

Table 21: Determinants of Post-harvest Losses on Maize at Farm Level

Explanatory Variables	Semi Log Coefficients
Constant	3.275*
Gender	-0.210*
Household size	-0.0235**
Experience	-0.071*
Years in Education	-0.245*
Access to credit	0.094
Off-farm income	0.070
Access to extension services	0.028
Farm size	0.205**
Maize yield per acre	0.223*

*, ** and *** indicate the level of significance at 1, 5, and 10 percent respectively.
$R^2 = 0.57$
Adjusted $R^2 = 0.49$ F = 18.73*

4.5 Opinion of the Farmers Regarding Causes of Post-harvest Losses

The results on opinion on the probable causes of post-harvest losses are presented in Table 22. The most important causes of post-harvest losses which was reported by 27.78% of the respondents were; poor storage facilities, followed by poor harvesting method that accounted for 17.90% of the interviewee respondents. Inadequate knowledge on post-harvest losses was reported by 16.67% of the respondents.

Table 22: Opinion Regarding Causes of Post-harvest Losses of Maize Crop

Causes of post-harvest losses	Number of households	percent
Poor harvesting method	29	17.90
Poor storage facilities	45	27.78
Less knowledge on post-harvest losses	27	16.67
Lack of and/or high cost on storage pesticides	14	8.64
Poor feeder roads	19	11.73
Less supervision	18	11.11
Poor handling of equipment	10	6.17
Total	162	100

The results show further that, 8.64% of the respondents pointed out lack of and/or high cost of storage pesticides as one of causes of post-harvest losses on maize. Other causes of the post-harvest losses were poor feeder roads accounted for 11.73% of the respondents; inadequate supervision which comprised 11.11% of the responses and poor handling equipment which was pointed out by 6.17% of the respondents. On the other hand, sampled maize farmers gave opinions/suggestions on how to reduce post-harvest losses are presented in Fig 9. The opinions/suggestions had five things that can be undertaken to reduce post-harvest losses on maize. The most important strategy which can be adopted to reduce post-harvest losses on maize was training which was suggested by 58 households. The next important strategy put forward by maize growers was facilitation on rodents and pests which was suggested by 47 households. The results further show that, 20, 18 and 19 households proposed strategies like high quality maize variety, improved harvesting equipment and maintenance of the feeder roads respectively.

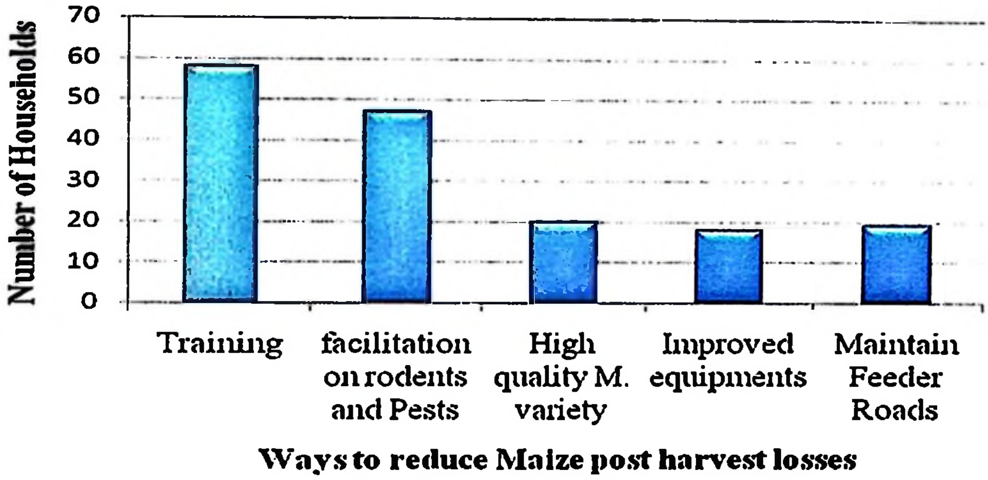

Figure 9: Suggestions of Farmers on the Way to Reduce Maize Post-harvest Losses

4.6 Linear relationship between post-harvest Losses and Technical Efficiency

The current study examined relationship between post-harvest losses and technical efficiency. In order to achieve this, simple correlation coefficient measure was carried out. The results on simple correlation are represented in Table 23 and Fig 10. These results show that, there is positive moderately strong correlation between post-harvest losses and technical efficiency ($r = 0.445$, $p < 0.000$). This implies that, farms with high technical efficiency are associated with high post-harvest losses and farms with technical inefficiency are moderately associated with less post-harvest losses in maize. These results deviate from the result of Bale *et al.* (2010) in Bangladesh who found moderately negative correlation between post-harvest losses and technical efficiency. However, a paired t-test was run on sample of 162 maize farmers to determine whether there were statistically significant mean difference between technical efficiency and post-harvest losses. The results in Table 22 show that there is positively relationship between technical efficiency and maize post-harvest losses ($t = 16.94$, $p < 0.000$).

Table 23: T-test of Technical Efficiency and Maize Post-harvest Losses

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Total_Post_losses	1.92	162	144.08	11.32
	technical efficiency	0.46	162	0.25958	0.02

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	Total_Post_losses & techical efficiency	162	0.445	0.000

Paired Samples Test

		Paired Differences							
					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	df	Sig. (2-tailed)
Pair 1	Total_Post_losses - technical efficiency	1.92	144.19	11.33	169.61	214.36	16.94	161	0.000

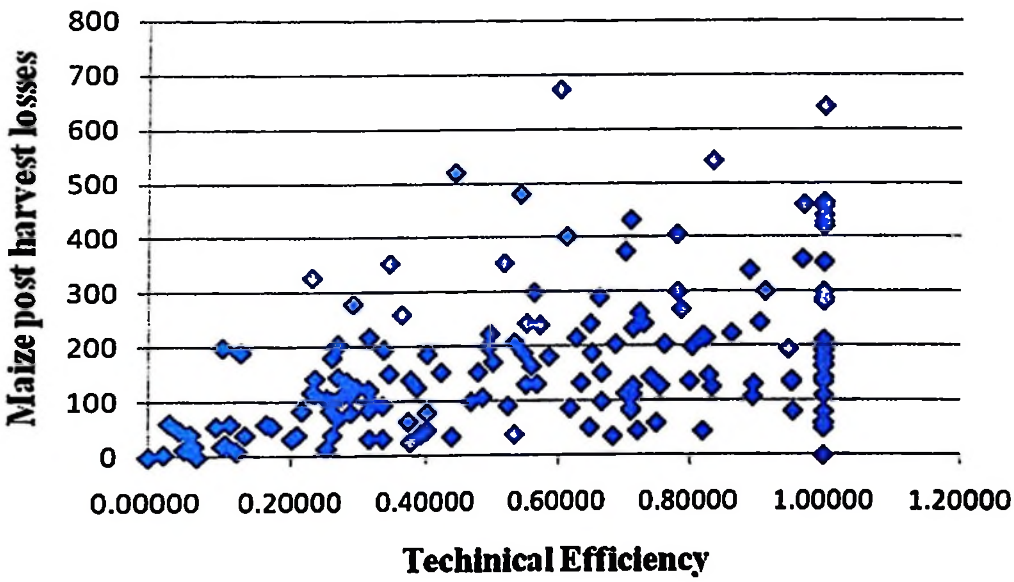

Figure 10: Linear relationship between Maize post-harvest losses and technical efficiency

CHAPTER FIVE

4.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

The Government of The United Republic of Tanzania has been taking different initiatives to increase maize yields and reduce post-harvest losses. Nevertheless, there has been persistent low maize yield that amounts to 1.2T/Ha in contrast to the ideal maize yield of about 6-7.5T/Ha. In addition to that, the low maize produced is lost during different maize post-harvest operations and the losses are estimated to range between 5% and 40%.

This present study was conducted in Kilosa district aspiring at assessing the determinants of productivity and post-harvest losses among smallholder maize farmers. The first specific objective of the study was to estimate productivity of maize farms in Kilosa district. To address this objective the study hypothesised that maize smallholder farmers are technically efficient and have no room for technical efficiency growth. On testing this hypothesis the study generated technical efficiency estimates by employing input oriented Data Envelopment Analysis (DEA) approach using DEAP computer software using cross sectional data collected from 166 maize farmers in the District. The findings of the current study have shown that, on average technical efficiency is estimated at 83.63% resulting in a maize yield of 523.85kg/acre. Therefore there is a 16.37% scope of reducing inputs while maintaining the same production level.

DEA results on slacks showed that the greatest excess was observed in labour, 19.94% and seeds of about 10.34%. All these excesses adversely affect technical efficiency of maize farming and could be reduced to a great extent while maintaining the same level of production.

The results also show that, experience, number of years in school, land size for maize, extension services, and gender are positively and significantly associated to technical efficiency. Off farm income and marital status in the categories of single and divorced were negatively and significantly related to technical efficiency. Household size and marital status in the category of married variables however, were insignificant.

This study further found that, maize farmers in Kilosa district are not using fertilizers, agrochemicals and mechanization. Reasons as to why farmers are not using fertilizers, 43.2% of the respondent's deliberation was, that soil is still fertile, and 32.7% of the respondents, responded that fertilizer was/is too expensive.

Furthermore, the study found that, the total average losses in maize was about 148.86 kg per household (19.55%). The important stages found to be leading in maize losses are storage (average losses of 8.7%) and harvesting stages (average losses 6.03%). The most notorious causes of maize loss in storage stage were rodents and pests while harvesting losses was due to mishandling, careless, and inappropriate harvesting equipment.

Moreover, the current study found that, nine explanatory variables included in the regression model explained 57% variation in total post-harvest losses on maize. The F-ratio was significant at 1% indicating the good fit of the function. It was further found that, all variables except household size, experience of the household head and years in education were positively associated to the total post-harvest losses. The most important causes of post-harvest losses in maize reported by 27.78% of the respondents to be poor storage facilities; poor harvesting methods by 17.90% of the respondents and inadequate knowledge on post-harvest management by 16.67% of the respondents. The sampled maize farmers suggested most important two strategies that will help to reduce post-harvest losses in maize. These are training on post-harvest management as suggested by 58 respondents and facilitation on how to control rodents and pests as suggested by 47 respondents. The current study also found that, there is positive association between technical efficiency and post-harvest losses meaning that, farms with high technical efficiency are associated with high post-harvest losses and farms with technical inefficiency are moderately associated with less post-harvest losses in maize.

5.2 Recommendation

Based on the key findings, the present study recommends the following;

Firstly, the Government, farmers and private sectors have to invest in giving knowledge on appropriate usage of different inputs that will assist increase in crops productivity like fertilizers, agrochemicals, animal traction, mechanization and other equipment used in post-harvest handling.

Secondly, in order to increase agricultural yields, farmers should be supported by all agricultural stakeholders to access both informal and formal education, since education play a great role in productivity and post-harvest handling especially in decision making. Thirdly, government and private sectors should help to sensitize the farmers on the issue of post-harvest losses awareness in line with proposing different ways on handling produce at each stage of the post-harvest operation in oerder to minimize losses. Moreover, the government through The Ministry of Agriculture, Livestock and Fisheries have to increase internal yearly budget which will focus on post-harvest losses in general.

Fourthly, the Government, farmers and private sectors should strongly help in women empowerment so as to assure that the female headed household have an equal access to resources, information and training. This will help female to be confident when supervising or managing their family on the issue of crops productivity and post-harvest handling.

Besides, the Government should allocate more funds to strengthening the extensions services, research, agricultural inputs and e-agricultural communication that can be available to farmers.

Lastly, the Government should strengthen and give priority on maize crop due to its importance by involving different international organisation on maize post-harvest operation.

5.3 Areas for Furthers Studies

The present study focused on productivity and determinants of post-harvest losses among smallholder maize farmers in Kilosa district. However, the current study would like to recommend further studies to be done on allocative and economic efficiency of all farming systems in Tanzania instead of maize only. In addition, researchers are invited to conduct studies focussing on issues related to policy options that will give a true picture of agricultural systems in Tanzania and estimation of the post-harvest losses by controlled experiments in all farming systems of Tanzania. This is important because of the paucity of data on post-harvest losses in the country. Most of the data on this subject are quite old which makes it difficult for researchers to believe that will provide a good picture regarding the status of post-harvest losses in the country. Given the large amount of resources required to conduct a comprehensive study on post-harvest losses then, the relevant Government Departments should take lead to ensure that such a study is conducted.

REFERENCES

Abebe, H. Gabriel and Bekele, H. (2006). Farmers' Post-Harvest Grain Management Choices under Liquidity Constraints and Impending Risks: implications for achieving food security objectives in Ethiopia

Africa, S. and Report, W. D. (2010). Contribution of agricultural growth to reduction of poverty, *hunger and malnutrition*, 28–35.

Aigner, D. K., Lovell, C.K. and Schmidt, P. (1977). Formulation and estimation of stochastic frontier production function models. *Journal of Econometrics.* 6, 21-37.

Asea, G., Julius, S., Zubeda, M., Lydia, K., and Moses, O. 2014. "Quality Protein Maize Production and Post-harvest Handling Handbook for East and Central Africa." (May): 1–50.

Aye, G. C. and Mungatana, E. D. (2010). Technical efficiency of traditional and hybrid maize farmers in Nigeria : Comparison of alternative approaches, *5*(21), 2909–2917.

Aulakh, J., Regmi, A., Fulton, J. and Alexander. C. (2013). *Estimating Post-Harvest Food Losses*: Developing a Consistent Global Estimation Framework Selected Poster prepared for presentation at the Agricultural & Applied Economics Association's 2013 AAEA & CAES Joint Annual Meeting, Washington, DC, August 4-6, 2013

Babbie, E. (1990). *Survey research method*, wardswort publishing company, Belmont Calfonia, 366pp.

Bala, B. K. (1978). Post-harvest losses of paddy in Bangladesh. AMA. 9(4), 54-56. Tokyo,Japan.

Banker, R. D., Charnes, A., and Cooper, W. W. (1984). Some Models for Estimating Technical Efficiency and Scale Inefficiencies in Data Envelopment Analysis. Management Science, 30, 1078-1092.

Basappa, G., Deshmanya, J. B. and Patil, B. L. (2007). Post-harvest losses of maize crop in Karnataka – An economic analysis. *Agricultural Science*. 20(1), 69-71.

Basavaraja, H., S. B. Mahajanashetti, and N. C. Udagatti. (2007). "Economic Analysis of Post-Harvest Losses in Food Grains in India: A Case Study of Karnataka." *Agricultural Economics Research Review* 20(1).

Battese, G. E., Coelli, T. J. (1988). Prediction of farm level technical efficiencies with a generalized frontierproduction function and panel data. *Journal of Econometrics*, 38: 387–399.

Battese, G. E. and Tim, J. C. (1995). A Model for Technical Efficiency Effects in a Stochastic Frontier Production Function for Panel Data. *Empirical Economics* 20 (2):325-32.

Boundeth, S., Nanseki, T., and Takeuchi, S. (2012). Analysis on technical efficiency of maize farmers in the northern province of Laos, 7(49), 6579–6587. doi:10.5897/AJAR12.1814

Chapoto, A. and Jayne, T. S. (2010). Maize Price Instability in Eastern and Southern Africa: The Impact of Trade Barriers and Market Interventions. *Prepared for the COMESA policy seminaron "Variation in staple food prices: Causes, consequence, and policy options", MaputoMozambique, 25-26 January 2010, under the Comesa_MSU_IFPRI African AgriculturalMarkets Project (AAMP).*

Charnes, A., Cooper, W. W and Rhodes, E. (1978). Measuring the Efficiency of Decision Making Units. European Journal of Operational Research, 2, 429-444.

Coelli, T. J. (1994). *A Guide to Frontier 4.2: A Computer Programme for Stochastic Frontier Production and Cost Function Estimation.* Department of Econometrics, University of England. Arimidale.NSW 2351, Australia (1994).

Coelli, T. (1996). A guide to DEAP Version 2.1: *A Data Envelopment Analysis (Computer) Program,* "CEPA Working Paper 96/08, University of New England, Coelli, T., Rao, D. S. P., and Battese, G. E. (1998). An Introduction to Efficiency and Productivity Analysis, Kluwer Academic Publishers, Boston.

Coelli, T. J., Prasada, D. S. and George, E. B. (1998). *An introduction to efficiency and productivity analysis*. Boston: Kluwer Academic Publishers.

Coeta, M. L, Khana M., Wang W., Hudiburg W. T., and Delucia H. E. (2013). *TheEconomic Cost of Including the Indirect Land use Factor in Low Carbon Fuel policy: Efficiency and Distributional Implication* .Selected paper prepared for presentation at the 2013 Agricultural and Applied Economics Association Annual Meeting, Boston, Massachusette, 31 July-2 August, 2013. 23 PP.

Crops, H. and Luzi-kihupi, A. (2012). A Review of Crop Improvement Research in Tanzania With Specific Focus on Final Report August 2012, (August).

Damas, P. (2011). Scaling up Agriculture: Challenges and opportunities for modernizing agriculture in Tanzania

Deshmanya, J. B. and Patil, B. L. (2007). Post- Harvest Losses of Maize Crop in Karnataka - An Economic Analysis, *20*(1), 50–52.

Douglas, K. (2008). Analysis of the Impact of the Agricultural Productivity Enhancement Program in Technical and Allocative Efficiencies of Maize

Farmers in Masindi- Uganda. A Thesis Submitted to the School of Graduate studies in Partial Fulfillment of the Requirements for the Award of Master of Science in Agricultural and Applied Economics of Makerere Univesity Kampala 62 pp.

Draper, N. R. (1957) and Smith, H. (1966): *Applied Regression Analysis.* John Wiley and Sons, New York

DTMA. (2010). Country Strategies 2012–16. DTMA strategy for Tanzania. The East and Southern

Elena, P., Mirela, P., Viorel, O. C., and Marius, P. (2010). *Productivity and profitability of maize and sorghum crops in natural conditions from south area,* 214–219.

Esmat, Mst, Ara Begum, Mohammad Ismail, and Hossain Evaggelos. (2012). "Economic Analysis of Post-Harvest Losses in Food Grains for Strengthening Food Security in Northern Regions of Bangladesh." (July): 56–65.

Fabiyi, Y L. (2008). "Productivity of Maize Farmers ' in Surulere Local Government Area of Oyo State Produced by IJAERD Press - Nigeria , 2008." 1(2): 25–34.

Fare, Rolf and Lovell, C. A. K. (1978). Measuring the Technical Efficiency. *Journal of Economic Theory* 19 (1), 150–162.

Farrell, M. J. (1957). The Measurement of Productive Efficiency. *Journal of the Royal Statistical Society Series A* 120 (3):253-90.

Food Agricultural Organisation. (2011). *The role of women in agriculture*, (11).

Food Agricultural Organization, (2009). How to Feed the World in 2050. Rome: FAO.Availablefrom:http://www.fao.org/fileadmin/templates/wsfs/docs/expert_paper/How_to_Feed_the_World_in_2050.pdf (verified 23 November, 2014).

Food and Agriculture Organization, (2009). Food Balance Sheet Data. Available at: http://faostat3.fao.org/home/index.html. Accessed August 18, 2013.

Food and Agriculture Organization, (2010). *The State of Food Insecurity in the World. Addressing Food Insecurity in Protracte Crises.* FAO, Rome

Food and Agriculture organization, (2011). Situation a\Analysis: improving Food Safety in the Maize value chain in Kenya. Report prepared for FAO by Prof. Erastus Kang'ethe College of Agriculture and Veterinary Science, University of Nairobi, September 2011

Food and Agriculture Organization, (2013). Losses in the Field; an Opportunity Ripe for Harvesting

Fried, H., Lovell, C. A. K., and Schmidt, S. E. (1994). The Measurement of Productive Efficiency: Techniques and Applications. *London: Oxford University Press.*

Gabagambi, D. M. (2013). Pro-small Scale Agriculture Investment; Will the Current Investment Plans Enable Farmers Graduate from the Poverty Trape;" *Presentation at Media event"uneveiling of CROW Ambassadors, National Museum; Dar-Es-Salaam*, Friday 14th, June 2013.

Gabriel, A. H. (2006). Farmers' Post-Harvest Grain Management Choices under Liquidity Constraints and Impending Risks: Implications for Achieving Food Security Objectives in Ethiopia.

Geta, E., Bogale, A., Kassa, B., and Elias, E. (2013). Productivity and Efficiency Analysis of Smallholder Maize Producers in Southern Ethiopia. *Journal of economics.* 41(1), 67–75.

Green, W. H. (1993). Limdep Version 8.0: Econometric Modelling Guide. Econometric Software, Inc,Plainview, New York, p. 201.

Greene, W. H. (2003). *Econometrics Analysis*. Fifth ed. Upper Saddle River, New Jersey: Prentice Hall.

Gueye, E.F. (2004). The role of family poultry in poverty alleviation, food security and the promotion of gender equality in rural Africa. *Senegal Institute of Agricultural Research*, 29(2): 129-136

Gustavsson, J., Cederberg, C., Sonesson, U., Van Otterdijk, R and Meybeck,A. (2011). "Global Food Losses and Food Waste: Extent Causes and Prevention." United Nations, Food and Agriculture Organization. Rome, Italy.

Hatami-marbini, A. (2012). "Efficiency Measurement in Fuzzy Additive Data Envelopment Analysis Madjid Tavana Ali Emrouznejad Saber Saati." *Journal of Inteligent and Fuzzy Systems*.10(1), 1-9

Hell, K., Ognakossan, K. E., Tonou, A.K., Lamboni, Y., Adabe, K.E and Coulibaly, O. (2010). Maize Stored Pests Control by PICS-Bags: Technological and Economic Evaluation. Presentation at the 5th World Cowpea Conference, Saly, Senegal, 27 September – 1 October2010.

Henckes, C. (1992). Dividing the Harvest; an Approach to Integrated Pest Management in Family Stores in Africa, Northern Tanzania.

Hoff, R. K. and Kray, O. C. (2012), Brazil Grain Annual Report. 2012/2013 Forecast: Significant Increase in Corn, Production, Rice and Wheat Recovery. GAIN (Global Agriculture Information Network). Grain Report number BR0803. [http://gain.fas.usda.gov/Recent GAIN Publications/Grain and Feed Annual_Brasilia_Brazil_2-14-2012.pdf], (Accessed October 2014).

Isaac, O. (2011). Technical Efficiency of Maize Production in Oyo state. *Journal of economics and International Finance.* 3(4), 211–216.

Javed, M., Ishaq, A., S. A., Hassan, S., and Ali, A. (2009). An Efficiency Analysis of Punjab's Cotton-Wheat System, *2*(Winter), *Journal of Agricultural Research* 22(4), 97–124.

Javed, M. I., Adil, S. A., and Ali, A. (2009). Rice-Wheat System in Punjab , Pakistan using DEA Technique. *Journal of Agricultural Research. 48*(2), 227–238.

Jondrow , S. C. A., Knox Lovell, Ivan S. (1982). On the Estimation of Technical Inefficiency in the Stochastic Frontier Production Function Model. *Journal of Econometrics* 19 (2-3):233-38.

Jones, M., Alexander, C., and Lowenberg-deboer, J. (2011). An Initial Investigation of the Potential for Hermetic Purdue Improved Crop Storage (PICS) Bags to Improve Incomes for Maize Producers in Sub-saharan Africa by

Department of Agricultural Economics Purdue University. *Working paper* 11-3, September, 2011.

Kaliba, A. R. M., Verkuijl, H. and Mwangi, W. (2000). Factors Affecting Adoption of Improved Maize Seeds and use of Inorganic Fertilizer for Maize Production in the Intermediate and Low Land Zones of Tanzania. *Agricultural and Applied Economics Journal* 32:35–37.

Kalirajan, K. P., Obwona, M. B. (1994). A Measurement of Firm- and Input-Specific Technical and Allocative efficiencies. *Applied Economics*, 26: 393–398.

Kansaki, J. K. (2015). Assessement of Post harvest Losses of Maize in the Sissala East and West District of the Upper West Region of Ghana. Dissertation for Award of Msc Degree at Kwame Nkrumah Univesristy of Science and Technology, Kumasi, Ghana. 95pp.

Kinyau, M., Ley, G. J., Hella, J. P., Tenge, A. J., Opio, F and Rwomshana, I. (2013), Economic Analysis of Rice Legume Rotation Systems in Morogoro. Tanzania .*Journal of Sustainable Development.* 6(7), 113-122.

Kirway, T.N., Ulotu, H.A., Lyimo, S.D., Lema, N.M., Mduruma, Z.O., Semgalawe, Z.M., Akulumuka, V., Mushi, C.S., Rutaihwa, C.E. and Nyaki A.S. (2000). The Role of Technology in Poverty Alleviation: Farm Household Financial Profitability of Maize/beans Intercropping Technological

Packages. A Case Study of Northern Tanzania. *African Journal of Agricultural Research* 9(7), 643-657.

Kolawole, O. (2010). Efficiencies of Aquaculture farms in Southwestern , NIGERIA, *43*(3), 171–177.

Krasachat, W. (2003). Technical Efficiencies of Rice Farms in Thailand: A Nonparametric Approach, Proceedings Hawaii International Conference on Business. 18-21 June 2003, Honolulu. 14 PP

Kuwornu, J. K. M., Amoah, E and Seini, W. (2013). Technical Efficiency Analysis of Maize Farmers in the Eastern Region of Ghana. *Journal of Social and Development Sciencies* *4*(2), 84–99.

Lagat B., Michael B., Kibiego J. K and Bebe o. (2012). Comparative Analysis of Technical Efficiency of Milk Production System in Uasin Gishu County of Kenya. *Internationa journal of business, economics and management* 2 (6): 157-168

Lyatuu, E. T. (2016). Does the Improvement of Productivity of Maize and Rice Reduce Poverty? Comparison Case Study for Tanzania and Togo. *Journal of Economics and Sustainable Development*, *7*(2), 25–35.

Lyimo, S., Mduruma, Z. and Groote, H. D. (2014). The Use of Improved Maize

Varieties in Tanzania. *African Journal of Agricultural Research .9*(7), 643–657.

Lymo, N. G. (2005). Improving Farmers' Access to and Management of Disease Resistant Cultivars in the Southern Highlands of Tanzania. Crop Protection Program R 8220 (ZA 0535).

Luzi-Kihupi. A, Kashenge-Killenga. S and Bonsi C, (2012). A Review of Crop Improvement Research in Tanzania with Specific Focus on Maize, Rice, and Horticultural Crops

Majumdar, S. (2010). Post-harvest Loss and Technical Efficiency of Rice , Wheat and Maize Production System : Assessment and Measures for Strengthening Food Security, final report. Bangledesh Agricultural University Printer, Bangledesh. 198 PP.

Majumdar, S., Bala, B. K., Arshad, F. M., and Haque, M. A. (2016). Food Security through Increasing Technical Efficiency and Reducing Postharvest Losses of Rice Production Systems in Bangladesh. *Springer Science and Business Dortrecht and International Society for Plant Pathology*, 8, 361–374.

Maleko, A. G. (2013). *Annual research workshop Price Transmission and Integration of Maize Domestic Market : A Case Study of Tanzania.* Presented at the Joint 3rd African Association of Agricultural Economists

(AAAE) and 48th Agricultural Economists Association of South Africa (AEASA) Conference, Cap Town, South Africa, 19-23, September, 2013

Mboya, R. (2011). A Study of the Effects of Storage Method on the Qulity of Maize and Household Food Security in Rungwe District Tanzania. Thesis Submitted in Fullfilment of the Requirements fo the Degree of Doctor of Philosophy in Food Security . School of Agricultural Sciences and Agribusiness, University of Kwazulu-Natal.

Meeusen, W. and Van den Broeck, J. (1977). Efficiency Estimation from Cobb-Douglas production functions with composed error. *Journal of Econometric 19, 233-238*

Msuya, E. E., Hisano, S. Nariu, T. (2008). Explaining Productivity Variation Among Smallholder Maize Farmers in Tanzania. http://mpra.ub.uni-muenchen.de/14626/ accessed 10.03.2009.

Mutambuki, K., and Ngatia, C. M. (2012). Assessment of Grain Damage and Weight Loss on Farm Stored Maize in Highlands Areas of Bungoma District, Kenya. *Journal for Sustainable Developement 2*, 349–361.

Nadolnyak, D. A.,Valentina, M., Hartarska and Stanley, M. (2004). Estimating Peanut Production Efficiency and Assessing Farm-level Impacts of the

2002 Farm act. *Paper presented at the 2004 AAEA meetings, in Denver, Colorodo.*

Nag, S.K., Nahatkar, S.B. and Sharma, H.O. (2000). Post-harvest Losses of Chickpea as Perceived by the Producers of Sehore District of Madhya Pradesh, Agricultural Marketing. *India Journal of Agricultural Economics*, 61(1) 12-16.

Nyariki, D. M. (2011). Farm size , Modern Technology Adoption , and Efficiency of Small Holdings in Developing countries : Evidence from Kenya. *Journal of Economics and Sustainable Development, 6 (2): 154-160*

Olayemi, J. K (1998). *Element of Econometrics CARD*. University of Ibadan, Ibadan

Oleke, J. M.1 and Isinika, A. C. (2011). Assessing the Technical Efficiency of Commercial Egg Production in Tanzania for improved livelihoods, *Journal of Developemnt and Agricultural Economics*, *3*(8). 343–352.

Osun, A. I. (2013). Determinants of Post Harvest Losses of Maize in Akure North Local Government Area of Ondo State, Nigeria. *Journal of Sustainable Society, 2(1), 12-19*

Padilla-fernandez, M. D., Nuthall, P. L., and Zealand, N. (2009). Technical Efficiency in the Production of Sugar cane in Central Negros Area , philippines : An Application of Data Envelopment Analysis. *Journal of*

International Society for Southeast Asian Agricultural Science 15(1), 77–90.

Personal, M., Archive, R., and Lagat, J. (2012). Analysis of Efficiency in Sugarcane Production; the Case of Men and Women Headed Housholds in SONY Sugar out grower zone. Rongo and Trans-Mara District, Kenya. *MPRA Paper*, 22 August, 2012. 47 PP.

Ramatoulaye, G. (2010). Post-harvest Losses of Rice from Harvesting to Milling. A Case study in Besease and Nobewam in the EjisuJuabeng District in Ashant Region of Ghana. A Thesis Submitted to the Board of postgraduate studies Kwame Nkruma University of Science and Technology, Kumasi, Ghana in Partial Fullfilment of the Requirements for the Master of Science Degree.

Rembold, F., Hodges, R., Bernard, M., Knipschild, H. and Léo, O. (2011).*The African Postharvest Losses Information System Joint Research Centre Scientific and Technical Reports.* Luxembourg Printer, Europian Union. 73 PP.

Ranum, P. and Peliel, J. P. (2014). Global Maize Production , Utilization , and Consumption. *Annals of the New Academy of Science, 1312.* 105–112.

Rode, S. (2012). *Advanced Macroeconomics.* Penguin Random House, New York

United States Of America, 250 pp

Rosentrater, K. A., and Suleiman, P. (2015). Current Maize Production , Postharvest Losses and the Risk of Mycotoxins Contamination in Tanzania. *Confrence Proceedings and Presentation at Digital Repository in Iowa State Universirty.* July (26-29,2015)

Rugumamu, A. (2009). Assessment of Post-harvest Technologies and Gender Relations in Maize Loss Reduction in Pangawe Village Eastern Tanzania. *Tanzania Journal of Science* Vol 35. 5-10.

Services, E., and Osun, A. I. (2013). Determinants of Post-harvest Losses of Maize in Akure North Local Government Area of Ondo State , Nigeria, *2*(1), 12–19.

Saxena, H. K., Ajitha, K. R. and Singh, K. R. (2000). Assessment of Post-harvest Storage Losses in Wheat: Case Study in East Uttar Pradesh. Indian J. of Agri. Marketing. 16, 54.

Sharif, N. R. and Atul, A. D. (1996). An Empirical Study of the Patterns and Sources of Technical Inefficiency in Traditional and HYV Rice Cultivation in Bangladesh. *Journal of Development Studies* 32 (4):612-29.

Singpurwalla, D. (2013). *A Handbook of Statistics. An Overview of Statistical Methods.* Harper Collins Publishers, New York, United States Of America, 79 pp

Skoko, H. (2015). *Simplified Principles of Microeconomics.* Hachette Book Group, New York, United States Of America, 93 pp

Singh, D. S., Kumar, N., Gupta and Gupta, B. K. (2002). A Study of Post-harvest Loss of Wheat and its Management in Kanpur District of Uttar Pradesh. Indian J. of Agri.Marketing. 16, 53.

Swiss Agency for Development and Cooperation. (2015). *Gender Analysis of Maize Post-Harvest Management in Zambia: A Case Study of Chipata and Katete Districts.Swiss Office, South Africa, 72pp.*

Swiss Agency for Development and Cooperation. (2015). *Gender Analysis of Maize Post-Harvest Management in Zimbabwe: A Case Study of Shamva District.Swiss Office, South Africa,66pp.*

Wilson, R. T., and Lewis, J. (2015). *The Maize Value Chain in Tanzania. A report from the Southern Highlands Food Systems Programme.60 pp.*

World Bank, (2010). Missing Food: The Case of Postharvest Grain Losses in Sub Saharan Africa. Washington, DC: The World Bank.

World Bank. (2011). Post-harvest Management – Fights hunger with FAO, India Grains, March 2002, 4(3): 20-22.

Tsukuda, Y., and Tatsuyoshi M. (2010). "An Alternative Method for Predicting Technical Inefficiency in Stochastic Frontier Models An Alternative

Skoko, H. (2015). *Simplified Principles of Microeconomics*. Hachette Book Group, New York, United States Of America, 93 pp

Singh, D. S., Kumar, N., Gupta and Gupta, B. K. (2002). A Study of Post-harvest Loss of Wheat and its Management in Kanpur District of Uttar Pradesh. Indian J. of Agri.Marketing. 16, 53.

Swiss Agency for Development and Cooperation. (2015). *Gender Analysis of Maize Post-Harvest Management in Zambia: A Case Study of Chipata and Katete Districts.Swiss Office, South Africa, 72pp.*

Swiss Agency for Development and Cooperation. (2015). *Gender Analysis of Maize Post-Harvest Management in Zimbabwe: A Case Study of Shamva District.Swiss Office, South Africa,66pp.*

Wilson, R. T., and Lewis, J. (2015). *The Maize Value Chain in Tanzania. A report from the Southern Highlands Food Systems Programme.60 pp.*

World Bank, (2010). Missing Food: The Case of Postharvest Grain Losses in Sub Saharan Africa. Washington, DC: The World Bank.

World Bank. (2011). Post-harvest Management – Fights hunger with FAO, India Grains, March 2002, 4(3): 20-22.

Tsukuda, Y., and Tatsuyoshi M. (2010). "An Alternative Method for Predicting Technical Inefficiency in Stochastic Frontier Models An Alternative

Method for Predicting Technical Inefficiency in Stochastic Frontier Models." (September 2013): 37–41

Tzouvelekas, V., Christos, J. P. and Christos, F. (2001). Technical Efficiency of Alternative Farming Systems: The Case of Greek Organic and Conventional Olive-growing Farms. *Food Policy* 26 (6):549-69.

United Republic of Tanzania, (2013). Agricultural Basic Data 2005/2006-2009/2010.http://www.kilimo.go.tz/agricultural/statistics/Basic/Chapter 4.pdf.pdf (accessed 05 November, 2014). Analysis (Computer) Program. CEPA Working Paper 96/08, Department of Econometrics, University of New England, Armidale.

United Republic of Tanzania, (2013). *Population and Housing census*. Government Printing Office., Dar Es Salaam. 44PP.

United Republic of Tanzania, (1998b). *Expanded agricultural Survey, Vol.II*, Government Printing Office., Dar Es Salaam. 354 PP.

Wadud, A. (2003). Technical, Allocative, and Economic Efficiency of Farms in Bangladesh: A Stochastic Frontier and DEA Approach. *The Journal of Developing Areas* 37 (1):109-26.

WPP. (2008). World Population Prospects: The 2008 Revision. UN Department of Economic and Social Affairs, Population Division.

[http://www.un.org/esa/population/publications/wpp2008/wpp2008_high lights5] Visited on 15 May, 2015.

Yakubu, A. (2012). Reducing losses to maize stored on farms in East Africa using hermetic storage. A Dissertation Submitted to Graduate Faculty in Partial Fulfillment of Requrements for the Degree of Doctor of Philosophy

APPENDICES

Appendix 1: Questionnaire

PRODUCTIVITY AND DETERMINANTS OF POST-HARVEST LOSSES OF MAIZE AMONG SMALLHOLDER FARMERS IN KILOSA DISTRICT

1.0 Introductory statement (to be read to the respondent):

I am Mr. Misibo Ntirankiza, a Masters's student at Sokoine University of Agriculture (SUA). I am undertaking research titled "***Productivity and Determinants of harvesting and Post-harvest Losses of Maize among Smallholder Farmers in Kilosa District***" as a partial fulfilment for award of MSc in Agricultural Economics and this interview is part of this research. Your household was selected for this survey according to the sampling procedure from the Maize farmers living in the Kilosa District. I will be asking questions about socio-economics, maize production, rice production, Legumes production and maize post-harvest losses. Furthermore I will be asking questions on input prices and prices of maize, rice and Legumes. If you agree to participate in this research, the information you provide will be used for research purpose only. Your answers will not affect any benefits or subsidies you receive now or in the future. Your responses to these questions will be anonymous and remain strictly confidential. Your name will not appear in any data that is made publicly available. Do you agree to provide information for this study? You may disagree from responding and if there are questions that you would prefer not to answer then I respect your right not to answer them

Do you agree? 0=Yes, 1=No

A. Farm Household characteristics

(To be answered by Household head or most knowledgeable household member)

Date of interview/____/___/ Month/___/___/ Year /___/____/____/____/

1. Name of the household head ______________________
2. Village name ________________Ward name __________Division name ______________Name of the respondent _________________________
3. Name of the Enumerator ________________________________

4. Gender of the household head (Circle one) 1= Male, 2=Female
5. Marital status (circle one) 1=Single, 2=Married,3=Divorced,4=Widow
6. Household size ___________________________
7. Household composition.

Age category(age)	Sex		Total
	Male	Female	
Below 10 years			
10-17			
18-50			
50-65			
Above 65			

8. Years in maize production. ___________________________
9. Type of Education; (Circle one) 1. Informal education, 2. Formal Education
10. If Formal education indicate no. of years in school _______________

B. Maize Production Information

11. Did you grow maize in the farming season 2012/2013? (Circle one) (0=Yes, 1=No)
12. If the answer is yes, in Question (10) above, what was the size of the farm you used to grow maize in season 2012/2013? _______________acres.
13. Is the land used in crop production owned by you? (0=Yes, 1= No)
14. What is the average size of land (in acres) that has been used for crop production activities in general?___________________________
15. How did you access the land you use in crop production? (Multiple Circle allowed) 1. Inherited, 2. Bought, 3. Given by village authority, 4. Accessed the free land 5. Hired
16. Did you buy the land you use in crop production? (0= yes, 1= No)
17. If the answer is yes in question (15) above, how much was/is the price per acre? _______
18. If you hired the land used in crop production, what mode of payment did you pay in the last seasons? (circle one) 1= In form of cash, 2=In form of produce

19. Indicate the amount you paid according to the mode of payment, if any.______________Cash____________________________Produce.

20. If the answer is yes in question (10) above, which type of maize varieties did you use? (Tick one) 1. Improved varieties, 2. Traditional varieties, 3. Both improved and Traditional varieties

21. What was the total maize yield in the last season from the size of the land you grow the maize? ____________________________________

22. Did you sell the surplus maize of the household in these two years? (0= Yes, 1. No)

23. If the answer is yes to question (21), how much and at what price? ______________Kg ______________________________Tsh

C. Labour and other input Information

24. What was/is the average labour requirement (man-days per acre) for the following farm operations.

Farm operation	Persons	Days
Farm preparation		
Seeding/planting		
Weeding		
Fert. Application		
Herb Application		
Pest. application		
Harvesting		
Transportation		
Threshing		
Bagging		
Total		

25. Did you hire labour for the farm operation during maize growing? (0= Yes, 1. No)

26. If yes in question (24) above indicate the cost associated per each operation hired for the two last years.

Operation	Year 2013			
	No. Of person	Days	Size of farm	CostTsh
Farm preparation				
Seeding/planting				
Weeding				
Fert. Application				
Herb Application				
Pest. application				
Harvesting				
Transportation				
Threshing				
Bagging				
Total				

27. Did you apply fertilizer on maize farm(s) last season? (0=Yes, 1=No)
28. If the answer is no in question (26) above what was the main reason (s)?
    1. Too expensive, 2. Not available, 3. Not necessary because soil is still fertile, 4. Fear of its effect on soil, 5. Others (specify) ______________________
29. If the answer is yes, in question (26) what kind of fertilizer did you apply? 1=Inorganic, 2=Organic, 3. Both Inorganic and Organic
30. If the fertilizer used was Inorganic, what type of inorganic fertilizer? (You can make multiple circle) 1. TSP, 2. CAN 3. UREA, 4. SA, 5. Minjingu Lock Phosphate, 6. N.P.K., 7. Others (specify), ______________________
31. How did you access the fertilizer you have mentioned in question (28) above? 1. Buying, 2. Given, 3. Others (specify) ______________________
32. If you bought, how much did it cost per one bag of fertilizer? ______________________
33. What quantity of fertilizer did you apply for only maize farms in all application times?______________________
34. Who is main supplier of inorganic fertilizer you bought in question (31) above? 1. Supplier from the ward, 2. Supplier from the District, 3. Supplier from Morogoro Municipal, 4. Others (Specify) ______________________

Inputs		Amount/acre	Unit price	Total cost in Tsh
Seed	Improved			
	Traditional			
Labour				
Tractor/power tiller				

Fertilizer	Manure			
	Urea			
	TSP			
	SA			
	Minjingu			
	CAN			
	N.P.K			
	Others (Specify)			
Pesticides				
Animal traction				
Herbicides				
labour				
land				
Others (Specify)				
Total				

35. Were the fertilizer (s) bought, had subsidise? (0= Yes, 1= No)
36. If the answer is yes in question (34) above, by how much the fertilizer was/is subsidised?______

37. If the fertilizer used in question (28 were Organic fertilizer, what amount did you use? _______

38. Where did you get this organic fertilizer? 1. My own livestock, 2. To my neighbour (free), 3. My own manufacturing, 4. Buy from neighbour or other business entity, 5. Others (Specify) ____

39. If the organic fertilizer (s) were bought, what were the cost associated in last years?____________________Kg____________________Tsh

40. Did you apply any pesticides and /or herbicides in the maize production? (0= yes, 1= No) If the answer is yes in question (49) above, how many times? 1. Once, 2. Twice, 3. Thrice, 4. Many times.

41. Please indicate the type, amount and cost associated with an application of these pesticides and /or herbicides in last years ?

Type	Amount	Cost Tsh.
1		
2		
3		

42. Indicate amount and cost associated to the various input as used in the maize production in the last years

D. Maize Harvest and post-harvest losses

43. Do you experience post-harvest losses? 0= Yes, 1= No

44. Do you experience post-harvest losses? 0= Yes, 1= No

45. What causes Harvesting and Post-harvest losses of maize according to your perception?____

____

____

46. At what stage do you experience the highest harvesting and post-harvest losses? (Circle One) 1. Harvesting,2. Threshing, 3. Transportation, 4. Winnowing5. Bagging, 6. Storing

47. In what variety/do you experience the highest post-harvest losses? (Tick One) 1. Improved variety, 2. Traditional Variety

48. What total quantity of maize do you lose during the post-harvest activities?

____

49. What is your perception of post-harvest losses of maize in general? 1. Normal 2. Too much

50. What harvesting method do you use? 1. Bare hand moving cobscover, 2. Harvester machine Method, 3. Uproot the whole maize stock in hips, 3 others specify ___________

51. What threshing method do you use? 1. Bit in the bag, 2. Bit on the 'kichanja', 2. Bit them down the floor, 4. Use threshing machine, 5. Use finger for each maize cob

52. How do you dry your Maize? 1. down the soil floor, 2. Down the concrete floor 3. Hanging on the tree, 4.Spread on the roof

53. Do you store your maize before threshing? 0= Yes 1=No

54. What do you think can be done to reduce post-harvest losses of maize from harvesting to consumption? ___________________________

55. Fill the following tables to each of the post-harvest operation accordingly

a). Harvesting

Mode of harvesting (Tick one)		Amount harvested	Amount lost	Percentage loss
Manual	machinery			

b). Bagging/loading

Mode of loading (Tick one)		Amount loaded	Amount lost	Percentage loss
Manual	machinery			

c). Transportation

Mode of transporting (Tick one)			Amount transported	Distance	Amount lost	Percentage loss
On Heads	Animal Traction	Track				

d). Drying

Type of drying (Tick one)			Amount before drying	Amount lost	Percentage loss
drying on ground	drying on roofs	Drying on "Kichanja"			

e). Threshing

Mode of threshing (Tick one)			Amount before threshing	Amount lost	Percentage loss
Manual (by hand)	Manual(by Beating)	Machinery			

f). Storing

Mode of Store (Tick one)			Amount before storing	Amount lost	Percentage loss
Bags	ceiling	Structure aside			

E Income of the household

56. What is the major food crops and cash crops did you grow in the last years?

Crop	**Year 2013**		
Food Crop	**Acreage**	**Yield (Kg)**	**Price**
1			
2			
3			
4			
Cash Crop			
1			
2			
3			
4			

57. Indicate other economic activities for the household, and its earning in the last years, apart from crop farming activities

Source of income	Amount in 2013 Year
Formal Employment	
Brewing (local)	
Carpentry	
Charcoal/Firewood	
Small business	
Bricking making	
Masonry	
lumbering	
Others (specify)	
Total	

F. Micro credit and extension services

58. Do you have access to credit facilities? (Circle one)0=Yes, 1= No
59. If the answer is yes in question (57) above, please fill the information in below table.
60. Indicate credit amount, interest rate and repayment period in the table below.

Source of credit	Type of credit		Amount	Rate	Repayment period
	Formal	informal			
1.					
2.					

61. Do you pay in produce form also?(0=Yes, 1= No)
62. If the answer is yes in question 61 above, how much?

____

63. Do you think, credit is important in maize production? (0= Yes, 1=No)
64. If the answer is yes in question (63) above, how? 1. Use less amount of inputs if no credit, 2. Fail to expand farms in less or no credit, 3. Others (Specify) ______________
65. Do you access the extension services? (0= Yes, 1= No)
66. If yes, specify which type of service do you get, Frequency and if any payment do you make for it. 1= very often, 2= Often, 3= rarely 4. No access

Type of Extension Services	YES or NO	Frequency	Cost if any
DES			
NGO			

67. Have you ever participated in any farmers training workshop in the last two years? (0= Yes, 1= No)
68. Are there any farmer groups, where you can exchange farming experience? (0= Yes, 1= No)
69. Do you receive any extension materials such as Farming calendar, leaflets, Journals and Others? (0= Yes, 1=No)
70. Do you think Extension Service is important in improving maize productivity? (0=Yes, 1= No)
71. If yes In Question (68) above, how? 1. I miss light expertise, 2. I miss research information, 3. Others (Specify) ___________
72. Have you ever to NaneNane exhibition? (0=Yes, 1=No)___________________________
73. If yes, do you think the NaneNane Exhibit helps in Improving Crop productivity? (1=certainly, 2= Never)

G. Rainfall information

74. What was the rainfall received this year (2013) compared to normal in the past? 1. Much above normal, 2. Somewhat above normal, 3. Around average/normal, 4. Somewhat below normal, 5. Much below normal
75. How was the rain started this year (2013)? 1. Normal, 2. Little bit late, 2. Much too late, 3. Little bit early, 4. Much too early.
76. How the rain was ended this year (2013)? 1. Normal, 2. Little bit late, 2. Much too late, 3. Little bit early, 4. Much too early.

THANK YOU!

Appendix 2: Major investments in the agricultural sector (mainland Tanzania only)

Activity	Donors	Timeframe	Cost ($m)
Agricultural Sector Development Programme (ASDP)	URT, WB, JICA, Ireland, AfDB, IFAD	2006-2013	c200 pa
Accelerated Food Security Project (AFSP)	WB	2008-10	160
Feed the Future	USAID	2011-2015	300
Tanzania Bread-Basket Transformation Project	URT, AGRA	2010-2015	173
Southern Agriculture Growth Corridor for Tanzania (SAGCOT)	URT, private sector, WB, other DPs	2011-2031	3,400
Marketing Infrastructure, Value Addition and Rural Finance Support Programme (MIVARF)	URT, IFAD, AfDB, AGRA	2011-2018	150
Southern Highlands Food Systems Programme (SHFSP)	FAO	2011-2012	5.3
Rural Micro, Small and Medium Enterprise Support Programme (MUVI)	IFAD	2007-2013	25
National Rice Development Strategy (NARDS)	JICA	2009-2018	NA
Rural Livelihoods Development Programme (RLDP)	SDC	2005-2011	21

Source: Adapted from URT 2011:

Appendix 3: Trend of agricultural subsidies (2003/04-2010/11)

FY	Public spending
2003/04	TSh2.0 billion – 39 387 t of fertilizer
2004/05	TSh7.2 billion in subsidizing 81 766t of fertilizer
2005/06	TSh7.5 billion in subsidizing 63 000t of fertilizer
2006/07	TSh 21.0 billion in subsidizing 89 941t of fertilizer; and 814t of modern seeds
2007/08	TSh19.5 billion in subsidizing 82 005t of fertilizer and 1 071t of modern seeds
2008/09	TSh71.5 billion in subsidizing 155 000 t of fertilizer and 6 000t of modern seeds
2009/10	TSh- 102.8 billion in subsidizing 150 000t of fertilizer comprised of 75 000t of Urea, and 75 000t of CAN - a total of 1 500 000 farmers from 20 regions of Tanzania Mainland have benefited. The fund was also used to subsidize 15,150t of corn and rice seeds; 147.969t of pesticides to cashew farmers; 15 375t of cotton seeds and 4 653 900 packets of cotton pesticides for 576 710 farmers. A total of 289.8t of sorghum seeds and 85.4t of sunflower seeds were distributed to 121 011 farmers in Singida, Dodoma, Mara, and Shinyanga region.
2010/11	TSh146.0 billion have been set aside for subsidizing 200 000t of fertilizer and 20 000 t of corn and rice seeds.

Source: Ministry of Agriculture Food Security and Cooperatives

Appendix 4: Post-harvest operations and other characteristics

Response	Number of farmers	Percent
Yes	159	98.1
No	3	1.9
Total	**162**	**100.0**
High loss level	**Number of farmers**	**Percent**
Harvesting	49	30.2
Threshing	14	8.6
Transportation	1	.6
winnowing	8	4.9
Storing	87	53.7
Not applicable	3	1.9
Total	**162**	**100.0**
Harvesting method	**Number of farmers**	**Percent**
Bare hand moving cobs cover	158	97.5
No answer	4	2.5
Total	**162**	**100.0**
Transport means	**Number of farmers**	**Percent**
On heads	15	9.3
Animal Traction	2	1.2
Track	50	30.9
Bicycle	74	45.7
motorcycle	16	9.9
Do not Know	5	3.1
Total	**162**	**100.0**
Drying Maize	**Number of farmers**	**Percent**
Down the soil floor	20	12.3
Down on the trubai	117	72.2
Down on the concrete floor	1	.6
Hanging on the tree	1	.6
Spread on the roof	1	.6
On the Kichanja	2	1.2
No Answer	5	3.1
Not applicable	15	9.3
Total	**162**	**100.0**
Threshing/Shelling	**Number of farmers**	**Percent**
Bit in the bag	65	40.1
Bit on the Kichanja	17	10.5
Use threshing machine	38	23.5
Use fingers for ache maize cob	39	24.1
No answer	3	1.9
Total	**162**	**100.0**
Type of storage	**Number of farmers**	**Percent**
In Bags	159	98.1
Modern method	0	0
Kihenge	3	1.9
Total	**162**	**100**

Source: Own Computation