INFLUENCE OF UTILIZATION OF MODERN FARMING TECHNIQUES ON FOOD SECURITY IN THE DRY HIGHLANDS: A CASE OF RUGURU WARD IN MATHIRA WEST SUB COUNTY, NYERI COUNTY

BY

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DECLARATION

This research project report is my original work and has not been presented for a degree or other award in any other university.

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This research project report has been submitted for examination with my approval as university supervisor.

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DEDICATION

This research work is dedicated to my dear wife Jane, and daughters Tabitha and Anjela for their immense support and encouragement during this study.

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ABBREVIATIONS AND ACRONYMS

AEZ – Agro Ecological Zones

AGRA – Alliance for a Green Revolution in Africa

Agrovet – Agrochemical and veterinary store

ASALs – Arid and Semi-Arid Lands

ASARECA – Association for Strengthening Agricultural Research in Eastern and Central Africa

ASCU – Agriculture Sector Coordinating Unit

NCPB – National Cereals and Produce Board

CAADP – Comprehensive African Agriculture Development Programme

CDF – Constituency Development Fund

CGIAR – Consultative Group on International Agricultural Research

EAAPP – East African Agricultural Productivity Program

GHG – Greenhouse gases

GOK – Government of Kenya

IFPRI – International Food Policy Research Institute

IPCC – Inter Governmental Panel on Climate Change

KAPAP – Kenya Agricultural Productivity and Agribusiness Project

KALRO – Kenya Agricultural and Livestock Research Organization

GDP – Gross Domestic Product

G-8 – Group of 8 Nations

RCoE – Regional Centre of Excellence

SPSS – Statistical Package for Social Sciences

UN – United Nations

ABSTRACT

The agriculture sector is the backbone of Kenya's economy and a means of livelihood for most of the population. The achievement of national food security is a key objective of the agricultural sector. Food availability, according to the Kenya National Food and Nutritional policy (2011), has over time been understood in terms of cereals surplus and food security in terms of having enough maize. Food and Agriculture Organization (2000) referred maize as the staple food for Kenya, averaging 80% of the total cereals produced. The demand for maize is growing and is expected to double by 2050 (Rosegrant et al. 2007). This study examined the influence of utilizing modern farming techniques on maize yields as way of addressing food insecurity in Ruguru ward and in the dry highlands in general. The objectives of the study were to examine how the use of early maturing crop varieties influences maize yields in Ruguru ward, to establish the extent to which the use of fertilizer influences maize yields in Ruguru ward, to establish how water harvesting influences maize yields in Ruguru ward and to determine how training affects maize yields in Ruguru ward. The study used a descriptive survey design. A sample of 250 respondents, from 9,133 households, was considered. Questionnaires were used to collect data. Data analysis was done using Statistical Package for Social Sciences and Ms Excel. Descriptive statistic was done and data presented using frequency tables. In the first objective, the study showed that 53.9% of the respondents used early maturing maize varieties (2-3 months) with a fairly good yield of seven 90kg bags per acre. Though the average maize yields obtained from this study were lower than the optimal maize yields, the early maturing maize varieties gave 2 bags (29%) more than the moderate maturing maize varieties, and 3 bags (43%) more than the long maturing maize varieties. In the second objective, 93.9% of the respondents used manure, inorganic fertilizer or both for maize production. 47.4% of the respondents used inorganic fertilizer only obtaining an average of 6 bags per acre. 16.7% of the respondents used manure and fertilizer getting an average of 8 bags per acre. The respondents who used manure only obtained 3 bags (75%) more than those who used nothing, those respondents who used fertilizer only got 5 bags (83%) more than those who used nothing, and respondents who used a combination of manure and fertilizer obtained 7 bags (88%) more than those who used nothing. On water harvesting, 61.4% of the respondents used terraces and grass strips, which were not sufficient for their maize production as was evident from the observed lower actual maize yields (7 bags per acre) in relation the expected maximum yields (16 bags per acre) while using early maturing maize varieties. On training, 73.2% of the respondents had obtained trainings on maize production mainly from government extension staff. This led to improved use of production practices aimed at improving crop yields and food security at the household level. For instance 93.9% of the respondents used manure and or fertilizer and got 4-8 bags of maize acre compared to 1 bag for those who used no fertilizers. The resulting maize yield difference of between 75% and 87.5% is an indicator of informed farmers able to make fairly good production decisions. Thus technologies utilized by the respondents promote good yields in an area experiencing light and unevenly distributed rainfall for 66.7% respondents. From the study it is recommended that the government and stakeholders do the following: increase the supply of subsidized fertilizers, support water harvesting and community irrigation schemes, offer more training on maize agronomy and related aspects to the farmers. Individual farmers, in the dry highlands, encouraged to adopt modern farming techniques for improved food security.

CHAPTER ONE

INTRODUCTION

1.1 Background to the study

Weather is the condition of the atmosphere for a particular place over a short period of time. Climate on the other hand refers to the weather pattern of a place over a long period time, 30 years or more. The atmospheric characteristics of weather include humidity, air temperature and pressure, wind, clouds and precipitation. Weather variations affect a wide range of economic activities. For instance, weather changes can affect levels of production and production costs. Severe weather can also damage or destroy property. Crop yields are strongly affected by changes in technological inputs such as fertilizers, pesticides, irrigation, plant bleeding and management practices (Kevin Trenberth et.al,2000).The semi-arid and arid areas are characterized by severe lack of available water to the extent of hindering or preventing the growth and development of plant and animal life. The leading hazards affecting the Arid and Semi-Arid Lands (ASALs) are mainly natural and include among others drought and floods (Moyaga et al, 2013). Incidences of drought and floods often lead to food insecurity and conflicts in the ASALs, which calls for short term relief services and in a few instances some long term mitigation measures.

The wet highlands in Kenya have fertile soils and a high annual rainfall (up to 3000mm). These conditions support various food crops, cash crops and livestock farming. Though these areas also experience challenges emanating from climatic changes, they remain food secure most of the time. The dry highlands experience transitional weather conditions in between the wet highlands and the ASALs. During periods of adverse weather changes, the

dry highlands are prone to be food insecure. This situation calls for understanding and use of appropriate mitigation measures.

Ruguru ward is one of the wards in Mathira Sub County, Nyeri County.Nyeri County is one of the 47 counties in Kenya and has eight Sub Counties namely Nyeri South, Mukurweini, Tetu, Mathira East, Mathira West, Nyeri Central, Kieni East and Kieni West.Nyeri County lies in the Central Highlands, in between the western slopes of Mount Kenya and the eastern base of the Aberdare Ranges.The western part of the county is flat, whereas further southwards, the topography is characterized by steep ridges and valleys, with a few hills such as Karima, Nyeri and Tumutumu. These hills affect the pattern of rainfall, thus influencing the mode of agricultural production in some localized areas. The county experiences equatorial rainfall due to its location within the highland equatorial zone of Kenya. The long rains occur from March to May while the short rains come in October to December. Nyeri County is agriculturally productive due to its location in the fertile central highlands. Much of the agricultural products are from small holder farms, which produce both food and cash crops especially in the higher potential areas of Mathira, Tetu and Othaya while in the marginal areas of Kieni plateau, subsistence and drought resistant crops with a mixture of horticulture, wheat farming and livestock rearing are predominant.

Mathira West borders Kieni East Sub County to the west, Mathira East Sub County to the east, Mukurweini Sub County to the south and Mt. Kenya forest to the north. It measures 165.6 square kilometres with a population of 60,394 (National population and housing census, 2009). The main physical features of Mathira West Sub County are Mount Kenya to the north and Tumutumu hill in the south.The major rivers found in the Sub County are Rui Ruiru and Sagana. Mathira West Sub County experiences equatorial rainfall, as it falls within the highland equatorial zone of Kenya. The annual rainfall in the Sub County varies

from1, 200 to 1,600mm during the long rains and 500mm to 1,500mm during the short rains season. Mathira West Sub County falls within two main Agro Ecological Zones, Upper Midland 2&3 (UM2, UM3). UM 2 is the main coffee zone whereas UM 3 is the marginal coffee zone. The following are the main crops grown in Mathira West Sub County: coffee, maize, beans, bananas, Irish potatoes, cabbages, kales, and macadamia. The main livestock kept in Mathira West include dairy cattle, beef cattle, dairy goats, sheep and poultry.

Ruguru ward has an area of 114.2 Kilometres square and a population of 31,712 (National population and housing census, 2009).This ward comprises of five locations and seventeen sub locations. The main AEZ in Ruguru ward is UM3, the marginal coffee zone. Most parts of Ruguru fall under the dry highlands, experiencing sub-humid and unreliable weather conditions. Maize is the staple food crop in Ruguru ward. Thus any failure in maize production signifies the onset of food insecurity in the ward.

1.2 Statement of the problem

The dry highlands have transitional weather conditions between the normally wet highlands and semi-arid areas. The wet highlands usually experience cool and wet weather conditions leading to good performance of the various agriculture oriented activities, and are mainly food secure areas. On the other hand the semi-arid areas frequently experience food shortages as a result of adverse weather conditions. These areas are characterized by severe lack of water and high temperatures. The dry highlands, which are found in most parts of Ruguru ward, are becoming food insecure as a result of unpredictable rainfall patterns. In the dry highlands frequent low crop yields result to insufficient food supplies in most households. This may lead to hunger, malnutrition or even death in extreme cases. The main food crop in Ruguru ward is maize. This implies that low maize yield is a signal towards food insecurity in this area. Thus by examining the utilization of modern farming techniques

on maize production in Ruguru ward, this study will identify areas of intervention that will reduce the adverse effects associated with food insecurity in the dry highlands.

1.3 Purpose of the study

The purpose of this study was to establish the influence of the utilization of modern farming techniques on food security in Ruguru ward, a dry highland area.

1.4 Objectives

This study was guided by the following objectives:

i. To examine how the use of early maturing crop varieties influences maize yields in Ruguru ward
ii. To establish the extent to which the use of fertilizer influences maize yields in Ruguru ward
iii. To establish how water harvesting influences maize yields in Ruguru ward
iv. To determine how training affects maize yields in Ruguru ward

1.5 Research questions

This study sought to answer the following research questions:

i. To what extent does the use of early maturing varieties affect maize yields in Ruguru ward?
ii. To what extent does the use of fertilizer affect the maize yield in Ruguru ward?
iii. How does water harvesting influence maize yields in Ruguru ward?
iv. How does training of farmers affect maize yields in Ruguru ward?

1.6 Signifance of the study

The findings from this study will indicate how the use of modern farming techniques affects crop yields, and in particular maize in the dry highlands. From the identified influence of

modern farming techniques on maize yields, the policy makers and other stakeholders will be able to adopt or support the most appropriate mitigation measures against food insecurity in the dry highlands. The findings of this study will also stimulate further research in this area.

1.7 Scope of the study

The scope of this study included establishing the influence of using modern farming techniques on the yields of the most common food crop in Ruguru ward i.e. maize. The farming techniques included the use of early maturing crop varieties, the use of fertilizers, and water harvesting. The influence of training in terms of information and knowledge acquisition was also examined.

1.8 Limitation of the study

The period of data collection exercise was characterized by intermittent rainfall which posed considerable challenges in accessing the various respondents. Food security is a sensitive issue in this area, hence this study elicited high expectations from the respondents. This was addressed by having written requests and approvals from the concerned persons.

1.9 Assumptions of the study

The study assumed that the information given through interviews and questionnaires was correct and reliable.

1.10 Definitions of key terms and concepts used in the study

Climate: The average weather pattern in a place over many years. It is the average condition of weather at a particular place over a period of many years as exhibited in absolute extremes, means, of temperature, wind velocity, precipitation, and other weather elements.

Climate change: A persistent change in values of climate variables such absolute extremes, means and variances of temperature, wind velocity, precipitation, and other weather elements.

Crop failure: A failure to yield sufficient food to maintain a community or to provide surplus for sale. Instances of crop failure imply very low or no yields per unit area of a crop, resulting from adverse weather conditions. Crop failure leads to food insecurity.

Drought: This is an extended period when a region receives a deficiency in its water supply. This occurs when a region receives consistently below average precipitation.

Food security: The situation whereby all people have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life. Households are food secure when they have year-round access to the amount and variety of safe foods their members need to lead active and healthy lives. At the household level, food security refers to the ability of the household to secure, either from its own production or through purchases, adequate food for meeting the dietary needs of all members of the household.

Global warming: The increase in the average temperatures of the earth's atmosphere brought about by the increased emission of greenhouse gases (water vapour, carbon dioxide,

methane, nitrous acid and chlorofluorocarbons). This increase of global temperatures is sufficient to cause climate change.

Greenhouse effect: When sunlight reaches earth's surface some is absorbed and warms the earth and most of the rest is radiated back to the atmosphere at a longer wavelength than the sun light. Some of these longer wavelengths are absorbed by greenhouse gases in the atmosphere before they are lost to space. The absorption of this long wave radiant energy warms the atmosphere. These greenhouse gases act like a mirror and reflect back to the earth some of the heat energy which would otherwise be lost to space. The reflecting back of heat energy by the atmosphere is called the "greenhouse effect".

Government policy: The general principle by which a government is guided in its management of public affairs. A policy is aimed at guiding decisions towards the achievement of rational outcomes.

Group of eight nations (G-8): Eight industrialized countries of the world (Canada, France, Germany, Italy, Japan, Russia, United Kingdom, United States of America).

Mitigation measures: These are strategies meant to lessen or offset the impacts of expected negative occurrence. Mitigation measures against adverse weather conditions include water harvesting and conservation, agro-forestry, irrigation, drought tolerant crops, etc.

Regional Centre of Excellence: A leading agricultural technology program with established research, dissemination and training capacity that distinguishes it as a leader in the region and beyond.

Water harvesting: This refers to capturing of rains where it falls or capturing the runoff in order to use it during the dry season. Water harvesting can be done through capturing runoff

from rooftops, capturing runoff from local catchments, capturing seasonal flood waters from local streams and conserving water through water shed management.

Weather: This is the state of the atmosphere with respect to heat or cold, wetness or dryness, calm or cloudiness. On the earth the common weather phenomena include rain, wind, cloud, snow and dust storms.

Weather changes: This refers to observed variations in precipitation, temperature, storms, and droughts. Adverse weather changes include destruction or reduction of crop yields, damage to property, and loss of life, disruption of services like transportation, telecommunications, energy and water supply.

1.11 Organization of the study

This study is organized into five chapters. Chapter one is the introduction to the study. It comprises of background information, statement of the problem, research objectives, significance of the study, scope of the study, limitation of the study, assumptions of the study, and definition of key terms used in the study. Chapter two entails review of related literature. Literature review is organized in themes related food security at various levels and the influence of utilization of modern farming techniques on food security. The third chapter is on research methodology and explains the research design used in the study, target population, the sample selection and sample procedures, data collection methods, instruments validity and reliability and methods of data analysis. Chapter four presents a discussion of the research findings based on the objectives of the study. Chapter five is a summary of the major findings, conclusions, recommendations, suggestions for further research and contribution to knowledge based on the objectives of the study.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter provides the existing theoretical and empirical literature that is relevant to the study. This includes global warming and food security, world food security, Food security status in Kenya, Food security status in Nyeri, modern farming techniques and food security. The farming techniques considered in line with the study objectives includes early maturing crop varieties, use of fertilizer, water harvesting and their influence on food security. This chapter also includes the theoretical framework and the conceptual framework.

2.2 Global warming and food security

Global warming refers to change in climate that can be identified by changes in the mean and/or variability of its properties and that persists for extended periods typically decades or longer (IPCC, 2007). Global warming is brought about by the increased emissions of greenhouse gases (GHG), which includes water vapour, carbon dioxide, methane, nitrous oxide and chlorofluorocarbons. The atmospheric levels of carbon dioxide have risen by about 30 percent over the past 200 years which is likely to warm the earth's atmosphere (Lindzen, 2001). The potential hazards and outrage for human race and ecosystem led to the establishment of United Nations Intergovernmental Panel on Climate Change (IPCC) in 1988. The United Nations Framework Convention on Climate change (UNFCCC) and Kyoto Protocol (KP) were initiated internationally to deal with global warming. The convention and the protocol provide a framework for exchange, negotiations and institution building on matters relating to climate change. All parties of the convention (countries that have ratified, accepted, approved it) are required to focus their respective national actions

relating to provisions for sustainably managing carbon sinks (with sinks referring to forests and other ecosystems that remove more GHG from the atmosphere than they can emit),preparation to adapt to climate change, plans for climate change research, observation of global climate change system and data exchange, and plans to promote education, training and public awareness relating to climate change(GOK,2009). The efforts of UNFCCC and KP will only be successful if communities and individuals adjust to limit emissions and promote adoption (UNEP, 2006).

The consequences of global warming as stated by IPCC, 2010 includes severe water problem, flood and drought, decline in food availability, rise in sea levels, and progression in desertification. Global climate change models show that in the next century, Kenya will experience intense rains during the wet seasons, severe floods, severe droughts, and rise in overall temperatures, reduced crop yields and diversity and a negative impact on livestock (UNICEF, 2006). The effects of global warming on agriculture will vary widely from region to region and from place to place. This will result from changes in local and regional temperatures, precipitation, soil moisture, sunshine, cloudiness and extreme storms. Other important variables will include the species and varieties being farmed, soil properties, pests and diseases, and air quality.

According to the UN's World Meteorological Organization (WMO), which monitors global weather, the first six weeks of 2014 had an unusual number of extremes of heat, cold and rain – not in just a few regions as might be expected in any winter, but right the way around the world at the same time with costly disruptions to transport, power systems, and food production. Increasing atmospheric concentrations of greenhouse gases are projected to lead to regional and global changes in temperature, precipitation, and other climatic variables resulting in global changes in soil moistures, and increase in global mean sea level and

increasing the frequency and intensity of more severe extreme events such as extreme of temperature, precipitation floods, droughts, cyclones, and so on in some places (IPCC, 2007)

Africa is one of the most vulnerable continents to climate change. This situation is worsened by its poor state of economic development and low adaptive capacity. Over the last few years, the weather patterns have been changing and becoming more unpredictable. According to the Consultative Group on International Agricultural Research (CGIAR), it is not just droughts that are causing continuous food insecurity in Africa but rather, it is the minor climate shifts that have profound effects on farmers. The changing, unpredictable and erratic rainfall seasons have affected farmers' ability to plan their farming. Areas that used to receive adequate rainfall now receive insufficient rainfall, reducing the area of land that can support agriculture. Agricultural production will be affected by the severity and pace of climate change. If change is gradual, there will be time to adjust. However even a minor change could spark significant changes in the frequency of climate extremes, including heat waves, floods, and droughts. Rapid climate change could jeopardize agriculture, forestry, and biodiversity worldwide.

In Malawi, the adverse effects of climate change and variability are skewed disproportionately towards agriculture. Malawian subsistence farmers suffer from climate related stressors in different ways, through droughts, dry spells, floods, erratic and unreliable rainfalls (Chinsinga, 2012). In Kenya erratic weather patterns characterized by devastating floods and cycles of droughts have been more frequent with increasing intensity. Economic losses due to this environmental vulnerability have been estimated to cost up to 40% of the national GDP (UNEP,Kenya Country Programme).The highlands and moist transitional zones of Kenya have intermediate to high agricultural potential and

represent a favourable maize environment (Deichann, 1994). Maize production which is a staple food for over 90% of Kenya's population and mostly produced under rain fed agricultural systems has been declining at an alarming rate leading to food insecurity (Kietiem et al, 2008). A study of the climate within the maize growing areas of the west rift areas of the Kenya highlands shows that rainfall is the major meteorological variable. The average yields of maize within this region are markedly affected by changes in Seasonal rainfall (J.Glover, 2009). Some studies in the ASALs areas indicate that climate variability and change affects weather patterns and seasonal shifts with serious repercussion on rural households. Semi-arid environments such as Kitui county, are extremely vulnerable to climate change because their production systems are climate sensitive and a large segment of the population is least able to buffer and rebound from climate stress(Oremo,2011). The people's ability to maintain food security in the face of climate and weather changes will depend significantly on their adaptive capacity. Adaptive capacity is significantly influenced by access to and control over critical resources e.g. information and knowledge on climatic change, land and water for agriculture, and opportunities for earning sustainable income.

2.3 World food security status

Agriculture is one of the oldest economic activities in the world, and to date it is still a major contributor of the world's economic activity. Agriculture remains the economic growth engine in much of Africa, along with other numerous countries in Latin America, Asia and central Asia which previously were part of the former Soviet Union (IFDC 2009-2010). According to United Nations Environment Programme (2007), each day 200,000 more people are added to the world food demand. These people will need housing, food, and other natural resources. FAO (2010) indicated that 36 countries in the world require

external food assistance, with 28 countries coming from African countries. According to FAO (2009), worldwide production of maize is 785 million tons with the largest producer, the United States, producing 42%. Africa produces 6.5% and the largest African producer is Nigeria with nearly 8 million tons, followed by South Africa. Africa imports 28% of the required maize production from countries outside the continent, Most maize production in Africa is rain fed, and irregular rainfall can trigger famines during occasional droughts (FAO,2009). The major challenge to food security in Africa is the underdeveloped agricultural sector that is characterized by over reliance on primary agriculture, low soil fertility, minimum use of external farm inputs, land environmental degradation among others. Ninety five percent (95%) of the food is grown under rain fed agriculture. Hence food production is vulnerable to adverse weather conditions (IFPRI, 2002).

2.4 Food security status in Kenya

The agriculture sector is the backbone of Kenya's economy and a means of livelihood for most of the population (Agriculture Sector Development Strategy, 2010-2020). In Kenya, the achievement of national food security is a key objective of the agricultural sector. The food and agricultural policy, though reviewed severally, revolves around food availability, accessibility and nutritional adequacy (Food security report by KALRO, 2012).

According to Government of Kenya (2011) food security report, half of Kenyans are poor, some 7.5 million people live in extreme poverty, and over 10 million people suffer from chronic food insecurity and poor nutrition. It is estimated that that at one time about 2 million people require food assistance. In times of drought, heavy rains and during floods, the number of people in need of food could double. Food availability, according to the Kenya National Food and Nutritional policy (2011), has over time been understood in terms of cereals surplus and food security in terms of having enough maize. Food and Agriculture

Organization (2000) referred maize as the staple food for Kenya, averaging 80% of the total cereals produced. Olielo (2013) found that 'Ugali' is the maize staple carbohydrate food consumed by 88% of the households at least four times a week. The Famine Early Warning Systems (2013), the Government of Kenya and World Food Program on the outlook of food security in Kenya from October 2012 to March 2013, indicated that the total maize output over this period was likely to be below average and thus affect food security. Maize is vital for global food security and poverty reduction. In Africa maize is the most widely grown staple crop and is rapidly expanding to Asia. Due to the increasing demand for feed and bio-energy, the demand for maize is growing and is expected to double by 2050 (Rosegrant et al. 2007). Unfortunately for many farmers in Africa, maize yields (output per acre) have declined in the last decade in spite of improvements in agricultural technologies (Suri ,2011). Therefore examining the influence of utilizing modern farming techniques on maize yields in this study will address food insecurity in Ruguru ward and in the dry highlands in general.

2.5 Food security status in Nyeri County

Climate variability has a great significance on food security and biodiversity conservation in rural livelihoods in Nyeri County. The adverse effects of climate variability, leads to variations of weather patterns and global warming causing crop failure, reduced yields and loss of biodiversity. To cope with the adverse effects of climate variability the farmers should also be encouraged to grow drought resistant crops, intensify food preservation, storage and planting of indigenous trees. The farmers should be advised to adopt water harvesting strategies such as damming of flush floods and harvesting from rooftops. Proper utilization of harvested water for domestic use and farming through efficient irrigation such as drip irrigation should be encouraged. This enhances sustainable utilization of resources in

the County and eventually will help the rural communities to conserve the environment, reduce food shortage and poverty. According to Mathira West Food security report as at February 2015, 13,600 people in Ruguru ward (about 50%) are food insecure. This calls for deliberate efforts to examine the possible mitigation measures to address the food insecurity.

2.6 Modern farming technologies and food security

In Sub-Saharan Africa, the resource poor smallholder farmer battles against weeds, diseases and adverse weather conditions leading to poor harvests. Their counterparts in Asia, Latin America and elsewhere in the developing world enjoy improved crop yields through the aid of modern agricultural technologies. One of the notable efforts to improve food security was the green revolution. Green Revolution refers to a series of research, development and technology transfer initiatives, occurring between the 1940s and the late 1960s, that increased agricultural production worldwide (Hasel, 2009).The initiatives were led by Norman Borlaug, the "Father of the Green Revolution". These initiatives were credited with saving over a billion people from starvation and involved the development of high-yielding varieties of cereal grains, expansion of irrigation infrastructure, modernization of management techniques, distribution of hybridized seeds, synthetic fertilizers, and pesticides to farmers (FAO, 2009). Green revolution started in the USA in 1968 and spread to Mexico, India and Philippines among other places. However attempts to introduce the successful concepts from the Mexican and Indian projects into Africa have generally been less successful. Reasons cited include widespread corruption, insecurity, a lack of infrastructure, and a general lack of will on the part of the governments. Also environmental factors, such as the availability of water for irrigation, the high diversity in slope and soil types in one given area are also reasons why the Green Revolution is not so successful in

Africa (Emile Frison, 2008). Maize yields in central Kenya are low due to impoverished soils, unfavourable climatic conditions, pests and diseases (Ampofo, 1986). These among other constraints present a serious threat to livelihoods and food security. Food insecurity is a growing concern throughout the developing world. The options for improved food security includes soil and water conservation, planting of early maturing crops, planting of drought tolerant crops, water harvesting and irrigated agriculture among other practices.

2.6.1 Early maturing maize varieties and food security

Increasing agricultural productivity and hence production using improved agricultural technologies has been identified as a precondition for achieving food security (Lanyintuo et al.2008). As long as farmers continue to use traditional or low yielding crop varieties, agricultural productivity will remain low. Small scale farmers depending especially on subsistence agriculture have the potential to increase their welfare and food security situation if they adopt improved production technologies. This is especially true for staple food crops such as maize cultivated by the majority of farmers i

n Kenya. Between 2001 and 2005, though maize production was generally fluctuating averaging 2%, the marginal growth in production was driven more by use of productivity-enhancing technologies than increase in acreage (Smale & Jayne 2003, MOA 2004). Among agricultural inputs, seed is recognized to have the greatest ability of increasing on-farm productivity since seed determines the upper limit of crop yields and the productivity of all other agriculture inputs (MOA, 2004). This means that to sustain as well as to increase production volumes, it will be critical to find mechanisms that guarantee farmer access to high yielding certified seed varieties. Moreover, such a mechanism is paramount for successful variety improvement for sustainable agriculture (Hellin, 2007). Seed producing companies usually have a planting guide for their various crop varieties. These crop

planting guides, if well used, will assist in attaining good crop yields. Table 2.1 gives a maize planting guide from Kenya Seed Company, one of the major seed producing companies in Kenya.

Table 2.1 Maize Planting Guide from Kenya Seed Company

HYBRID	**ALTITUDE (METRES)**	**LENGTH RAINY SEASON**	**POTENTIAL AVERAGE YIELD - BAGS/HA**
H 614D	1500 - 2100	5 - 7 MONTHS	94
H 625	1500 - 2100	5 - 7 MONTHS	98
H 626	1500 - 2100	5 - 7 MONTHS	102
H 627	1500 - 2100	5 - 7 MONTHS	112
H 628	1500 – 2100	5 - 7 MONTHS	118
H 622	1000 - 1800	4 -6 MONTHS	67
H 623	1000 – 1800	4 - 6 MONTHS	71
H 513	800 - 1500	4 -5 MONTHS	50
H 516	800 – 1500	4- 5 MONTHS	65
DH 01	600 - 1300	2 -3 MONTHS	38
DH 02	600 – 1300	2 - 3 MONTHS	40
PH 1	0 – 1200	3 -5 MONTHS	58
PH 4	0 - 1200	3 - 5 MONTHS	60
COAST COMP.	0 – 1200	4 -5 MONTHS	45

2.6.2 Use of fertilizers and food security

There is an overall decline in farm input investment including fertilizers, seeds, and low technologies adoption. Access to fertilizer use is constrained by market liberation and trade policies that increase fertilizer prices relative to commodity prices, limited access to markets and infrastructure, limited development of output, input and credit markets, poverty

and cash constraints that limit farmer's ability to purchase fertilizer and other inputs (Kherallah et al , 2002). Thus the soils continue to degrade leading to reduction in the productivity of the farms. Some of the causes of soil fertility depletion in Africa is due to the limited adoption of fertility replenishment strategies and soil conservation measures, including the use and length of fallow periods. In Sub- Saharan Africa, greater use of mineral fertilizers is crucial to increasing food production and slowing the rate of environmental degradation. Regional growth rates in fertilizer consumption have never been particularly high in part because the real price of fertilizer is higher in Africa than in many other developing regions (Heisey, P.W. ,1996). Most of the soils in Kenya have been experiencing declining fertility status over the years and very few areas can still support crop production without supplementary nutrients through addition of fertilizers. Given that land holdings are not increasing while population growth is on the upward trends, and some arable land being lost to desertification, ways must be found to increase the productivity per unit land of the remaining arable parts. In many areas when farmers grow crops, the crop residues are fed to livestock either on the farms or are carried elsewhere resulting in double loss of essential elements from the soil. This means that in order to continue farming, these important elements must be added through fertilizers and manures.

2.6.3 Water harvesting and food security

Ensuring that the world's food needs are met by 2050 will take a doubling of global food production (McIntyre et al.,2009). To improve agricultural yields on that scale will require a radical rethink of global water management strategies and policies. Thus meeting global food needs requires strategies for storing rainwater and retaining soil moisture to bridge dry spells. Sub-Saharan Africa is the epicenter of this challenge. The region's population is set to more than double by 2050 to almost 2.5 billion, or 25% of the world's projected

population. Half of its current one billion inhabitants live in extreme poverty, one-quarter is undernourished, and one-fifth faces serious water shortages. Although almost two-thirds of the population are rural, agriculture on much of the land is limited by scarce, variable and unpredictable water resources (Rockstrom, J. et al, 2014). Rainfall is becoming more erratic. Zambia, Malawi and Zimbabwe have experienced later rainy seasons, longer dry spells and fewer rainy days over the past 50 years than before.

When crops fail, the reason is usually an extended dry spell, or one at a crucial point in the growing season, such as the flowering period, rather than low rainfall. Several weeks without rain are common and may occur each season, sometimes with a devastating effect. For instance in 2000, when an early onset of the rainy season followed by 6–9 weeks without rain prevented staple crops such as maize from growing in Kenya, 4 million people across the country faced severe food shortages. Rain water can be retained through collecting run-off; improving the infiltration of rain in soils; and managing land, water and crops across watersheds to increase water storage in soils, wetlands and the water table. Small-scale water harvesting methods include terracing to conserve soil moisture, as in the famous Fanya-juu terraces of Machakos, Kenya; or using dams and ditches to channel run-off into fields, as widely used in Eritrea and Israel. Storage systems such as ponds, tanks and sub-surface storage in sand and soil, used in places such as northern Mexico, Ethiopia, Sudan and India, offer another approach. Together these systems can hold the equivalent of a few rainy-season deluges, enough to bridge month-long dry spells. Water harvesting has been introduced to several parts of Africa, including Kenya, since the 1980s by non-governmental and development organizations including the United Nations.

2.7 Farmers training and food security

Farmer's performance is directly linked to their human capital endowment, which encompasses both innate and learned skills (Anderson and Feder, 2004). The rationale for extension services, farmer education programs, and various forms of formal and informal training is the desire to enhance and expand farmers' human capital. Farmers also undertake initiatives to acquire knowledge from other sources such as published media, radio, as well as from their own experiences and experimentation. A key source of information for farmers is other farmers because it is readily available and its utilization does not impose high transaction costs (Rees, et al., 2000). The proper use of acquired knowledge and information by farmers is paramount for improved farm outputs.

2.8 Government food security policies

Global food security will remain a worldwide concern for the next 50 years and beyond. Recently, crop yield has fallen in many areas because of declining investments in research and infrastructure, increasing water scarcity, climate change and HIV/AIDS. Although agro ecological approaches offer some promise for improving yields, food security in developing countries could be substantially improved by increased investment and policy reforms.

In 2009 at the G-8 Summit in L'Aquila, Italy, President Obama called on global leaders to reverse a decades-long decline in investment in agriculture and to strengthen global efforts to reduce poverty, hunger and under nutrition. As a result, countries committed more than $22 billion in investments in agricultural development and food security. The president also launched Feed the Future, the U.S. Government's global food security initiative, designed to transform agriculture in 19 focus countries so they can grow enough to feed their own people. In 2012 at the Camp David G-8 Summit, President Obama again led global food security efforts by launching the New Alliance for Food Security and Nutrition, a

partnership designed to increase private sector investment in African agriculture. More than 70 global and local companies have committed to invest over $3.75 billion on the continent. The Netherlands has a strong commitment to food security and singles out food security as one of its 'spearheads' for bilateral development, with a focus on four pillars of food security - increased sustainable agricultural production, access to better nutrition, more efficient markets, and a better business climate (IFPRI, 2000).

The New Partnership for Africa's Development (NEPAD), an African Union strategic framework for pan-African socio-economic development, is both a vision and a policy framework for Africa in the twenty-first century. NEPAD was spearheaded by African leaders to address critical challenges facing the continent: poverty, development and Africa's marginalization internationally. NEPAD provides unique opportunities for African countries to take full control of their development agenda, to work more closely together, and to cooperate more effectively with international partners.
The Comprehensive Africa Agriculture Development Program (CAADP) was endorsed at the African Union Heads of State Summit in July 2003,in Maputo. The explicit goal of CAADP was to eliminate hunger and reduce poverty through agriculture. In pursuit of this aim, African governments committed two targets. The first was to achieve a six percent annual growth in agricultural productivity by 2015. The second was to increase the allocation of national budgets directed to the agricultural sector to at least ten percent. To date most of the African countries have formalized CAADP compacts by identifying and certifying national agricultural development priorities.
According to NEPAD 2011 annual report; 8 countries had surpassed the 10% target budget allocation to the agriculture sector and 10 countries had surpassed the 6% target of growth in agricultural production. As at June 2012, 40 African countries had engaged the CAADP

process, some 30 had engaged CAADP compacts and 23 had finalized investment plans (Bwalya, 2012). In 2006, Alliance for Green Revolution in Africa (AGRA) was founded through a partnership between the Rockefeller Foundation and the Bill & Melinda Gates Foundation. AGRA works in Seventeen African countries to help small-scale farmers and their families lift themselves out of poverty and hunger. Its programs develop practical solutions to significantly boost farm productivity and incomes for the poor while safeguarding the environment. AGRA advocates for policies that support its work across all key aspects of the African agricultural value chain - from seeds, soil health, and water to markets and agricultural education. AGRA headquarters are located in Nairobi, Kenya. The East African Agricultural Productivity Programme (EAAPP) was conceived in 2009 by the governments Ethiopia, Kenya, Tanzania and Uganda in partnership with ASARECA and the World Bank. Under EAAPP, the four countries undertook to establish Regional Centre's of Excellence (RCoEs) for agricultural research by investing in commodities identified by ASARECA as being of sub-regional importance to mitigate food insecurity. Kenya identified to be the centre of excellence for dairy, Uganda for cassava, Ethiopia wheat and Tanzania for rice. The countries have pledged to manage investment in these commodities to benefit the sub-region. Regional Centre's of Excellence are a great opportunity for transforming the sub-region's agriculture from subsistence to an innovative, productive, commercially oriented and competitive agriculture through the agricultural value chain approach

In 2006, the Republic of Malawi designed a Farm input subsidy programme (FISP). FISP was designed to reduce poverty and ensure the country's food security by enhancing farmer productivity, increased income and increasing crop yields. The program targeted 1.5 million rural farm households (about 50% of all farmers in Malawi). Each beneficiary received input vouchers which were redeemable for a two 50kg of fertilizer. The beneficiary paid a

small redemption fee, with 2/3 or more of the fertilizer being subsidized. This resulted in improved maize performance from 1.06 million metric tonnes (in 2005/06) to 3.62 million metric tonnes in 2011/12 (Government of Malawi, 2012).

The Government of Kenya is selling subsidized fertilizers to the farmers through the NCPB network in the country. Diammonium Phosphate (DAP), Nitrogen phosphate phosphorus (NPK) 23:23:0 , 17:17:0 are currently selling at Ksh1,800 per 50kg bag (about 60% of the market price). Calcium Ammonium Nitrate (CAN) is selling at Ksh1,500 (about70% of the market price).This improved farmer access to an important farm input is expected to contribute to higher yields, household food self-sufficiency and the generation of surpluses for sale. Kenya Agricultural Productivity and Agribusiness Project(KAPAP), supported by the World Bank, contributes to the development of the agriculture sector through empowerment of farmers by strengthening producer organizations, improvement of the agricultural extension system, establishment of an efficient agricultural research system, encouraging growth of agribusiness, and improvement of environmental management. The project is multi-institutional and multi-sectoral and its design hinges on the premise that separate and poorly linked systems of research and extension yield low returns. The design therefore envisages an integrated approach in order to synchronize research, extension and farmer empowerment and other stakeholders' initiatives. The Project objective is to increase agricultural productivity and incomes of smallholder farmers from agricultural and agribusiness activities. The Project activities will contribute to this objective by transforming and improving the performance of the agricultural technology systems, empowering men and women, stakeholders and promoting the development of agribusiness in the Project area. In the project areas, small scale farmers are mobilized to form commodity based groups for organized production and marketing. In Nyeri County ,

KAPAP supports groups on Irish potatoes, rabbitry, dairy, bananas, bulb onions among others. However, the performance of government food policies depends on the way they are implemented. Well thought out and appropriate policies are not an end but a means to an end. Bridging the gap between the intent and action is crucial to reviving the food and agricultural sector (Nyangweso at el, 2005).

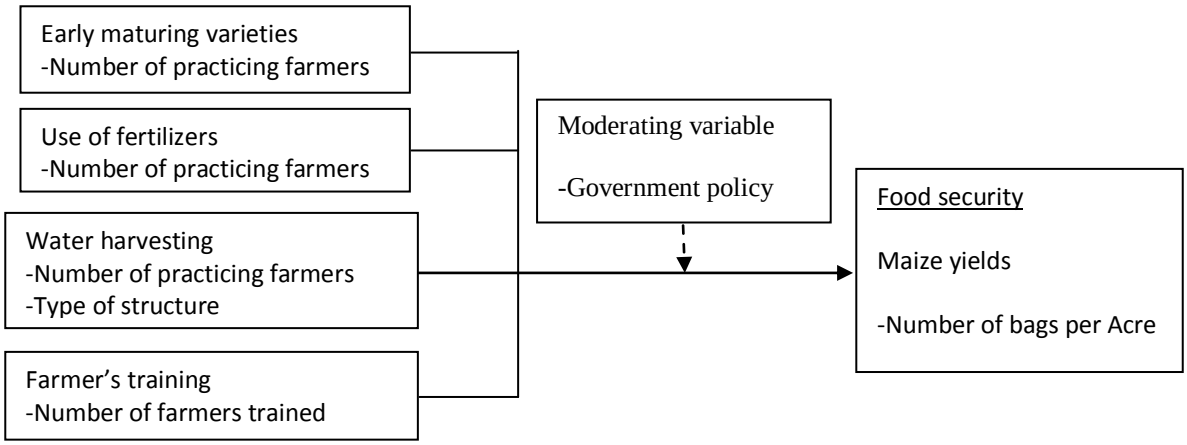
2.9 Theoretical framework

The amount of rainfall and its distribution has a positive relationship with maize yields. The unpredictable rainfall patterns, caused by global warming, is likely to lead to food insecurity in the affected areas. In its fifth assessment in 2014 the Intergovernmental Panel on Climate Change reported that scientists were more than 95% certain that most of global warming is caused by increasing concentrations of greenhouse gases and other human (anthropogenic) activities. The greenhouse gases theory offers the reason for global warming and subsequent effects. The effects of global warming are the environmental and social changes caused, directly or indirectly, by human emissions of greenhouse gases. Many impacts of climate change have already been observed including glazier retreat, changes in the timing of seasonal crop events and changes in agricultural productivity. However future effects of climate change will vary depending on climate change policies and social development. The two main policies to address climate change are reducing human greenhouse gas emissions (climate change mitigation) and adapting to the impacts of climate change. On the response by farmers to forces of food insecurity, it is assumed that this will be guided by the rational choice theory. Rational choice theory is an economic principle that assumes that individuals always make prudent and logical decisions that provide them with the greatest benefit or satisfaction and that are in their highest self-interest.

2.10 Conceptual framework

Conceptual frame work is defined as a set of broad ideas and principles taken from relevant fields of inquiry and used to structure a subsequent presentation (Reichel and Ramy, 1987). It identifies and indicates effects of independent and dependent variables. The independent variables in this study will be modern farming techniques: such as use of early maturing maize varieties, fertilizers, water harvesting and farmers training. The dependent variable is food security in terms of maize yield.

Figure 1: Conceptual Frame Work



Household income is a moderating variable, in that it affects the farmer's capacity to address food insecurity.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This chapter presents the research methodology that was used in this study, the target population, sampling procedures, sample size, data collection methods, data collection instruments and data analytical procedures that were employed in the study.

3.2 Research Design

The study used descriptive survey design. This survey design involves the selection of respondents and administering questionnaires or conducting interviews to gather information on variables of interest (McMillan and Schumacher, 1993). Mugenda and Mugenda, 1999 describes a survey design as an attempt to collect data from members of a population in order to determine the current status of that population with respect to one or more variables. The descriptive survey design is chosen because it is an efficient method of collecting descriptive data regarding characteristics of a sample of a population's current practices, conditions, and needs. This design allows the researcher to gather information regarding the respondent's opinion, perceptions and attitudes in a highly economical way. The data collected was both qualitative and quantitative in nature.

3.3 Target population

The target population was all farm households in Ruguru ward, Mathira West Sub County in Nyeri County. Ruguru ward has five locations namely Ruguru, Ngorano, Gatunganga,

Ruthagati and Hombe. The five locations have a total of 9133 farm households and a population of 31712, according to 2009 national census.

3.4 Sampling procedure and sample size

It is preferable to collect data from all the farm households in Ruguru ward. A smaller sample size carries a bigger sampling error, which is the discrepancy between the sample characteristic and the population characteristics (Mugenda and Mugenda, 1999). This study used probability sampling. The goal of probability sampling is to select a reasonable number of respondents that represent the target population. Probability sampling provides a researcher with accurate information about a group that is too large to study in their entirety (Mugenda and Mugenda, 1999). Probability sampling gives an efficient system of capturing in a small group the variations that exists in a target population (Kombo, Delno, and Tromp 2006).

In this survey the sample size was identified and selected using simple random sampling technique. This technique provides each element within the target population with equal chance to be selected. This sampling method obtains a representative group, which enables the researcher to gain information about an entire population when faced with limitations of time, funds and energy (Mugenda and Mugenda, 1999). The sampling frame includes all households in Ruguru, and the sample unit is the household.

Table 3. 1 Number of Households in Ruguru Ward

Location	Ngorano	Gatunganga	Ruthagati	Ruguru	Hombe	TOTAL
Households	943	1,232	1,233	3,576	2,149	9,133

To determine the sample size for target residents, this study adopted a formula used by Mutai (2000) as shown in equation below.

$$n = \frac{z^2 (1 - p)}{x^2 p}$$

Where 0<p, x<p, n is the sample size, z the confidence level, x the accuracy of sampling and p the proportion or percentage of the target residents. P is set at 0.5, at 95% confidence level, z = 1.94 and the sampling error, x^2, is taken to be 0.122^2. Consequently, the sample size n_e is calculated as follows:

$$n = \frac{1.94^2 (1 - 0.5)}{0.122^2 0.5}$$

$$n = \frac{3.7636(0.5)}{0.015(0.5)}$$

$$n = 250$$

These sample units were distributed proportionately to the locations as follows:

Table 3. 2 Sample Units per Location in Ruguru Ward

Location	**Households**	**Sample units**
Ngorano	943	10.5%=26
Gatunnganga	1,232	13.5%=34
Ruthagati	1,233	13.5%=34
Ruguru	3,576	39.2%=98
Hombe	2,149	23.5%=58

	9133	250

Information from six key informants from the study area; five (5) administrators in the five locations and one (1) from the agriculture office were obtained through a structured questionnaire.

3.5 Methods of data collection

The study relied on two complementary methods of data collection, primary and secondary. The primary sources of data were from the farm household respondents in Ruguru ward through semi structured questionnaires. Structured questionnaires were used because of the simplicity in their administration, scoring of items and analysis (Mugenda and Mugenda, 1999).Secondary data was obtained from document analysis (books, journal articles, government reports, and seminar papers).

3.6 Validity

Validity refers to the quality that a procedure or instrument or tool used in research is accurate, correct, true, and meaningful and right (Anastasia, 1982). A pre-test was conducted with randomly selected respondents to test the validity of the questionnaires from a neighboring ward. The objective of pretesting the questionnaire was to eliminate ambiguity of items, assess problems in the administration of instruments, test data collection instruments, establish the feasibility of the study, and amend any procedural difficulties.

3.7 Realiability

Reliability is the extent to which a measuring device is accurate, correct, true, meaningful and right (Razavier and Ary, 1996). Data collection instruments were made consistent and reliable by collecting the data from the respondents within a short time span. The

questionnaires were administered to the respondents through an interview session, but for the respondents who preferred to complete the questionnaires on their own these questionnaires were left with them. The study used closed and open ended questions to the respondent.

3.8 Operational definition of variables

The operational definition of variables is given in Table 3.3. The study has food security as the dependent variable. Food security referring to the ability to have sufficient food throughout the year. The indicator to be used is the output of the staple food crop in the area, maize yields.

Table 3. 3 Operational definition of variables

Objectives	**Variables**	**Indicators**	**Measures**	**Measurement scale**	**Data collection tool**	**Data analysis techniques**
	Independent					
To examine how the use of early maturing varieties influences maize yields in Ruguru ward	Planting of early maturing varieties	Practicing number of farmers	Number of farmers	Ratio	Structured questionnaire Observation	Descriptive
To establish the extent to which the use of fertilizer influences maize yields in Ruguru ward	Use of fertilizers	Practicing number of farmers	Number of farmers	Ratio	Structured questionnaire Observation	Descriptive

To establish how water harvesting influences maize yields in Ruguru ward	Water harvesting	Practicing number of farmers	Number of farmers	Ratio	Structured questionnaire observation	Descriptive
To determine how training affects maize yields in Ruguru ward	Training	Farmers trained	Number of farmers trained	Ratio	Structured questionnaire	Descriptive
	Dependent					
	Food security	Maize yields	Bags((90kg) Harvested	Ratio	Structured questionnaire	Descriptive C analysis

3.9 Methods of data analysis

Data analysis is the breaking down of large components of research data or information into simpler, easily synthesized and understood parts. According to Cohen and Marion (1994), once the data is collected, editing should be done to identify and eliminate errors. The questionnaires were edited for the purpose of checking on completeness, clarity and consistency in answering research questions. The data was cleaned, coded and entered into the computer for analysis. Data analysis was done using Statistical Package for Social Scientists and MS Excel computer software. Descriptive statistics were then computed. This was then summarized and presented using tables, pie charts and bar graphs.

3.10 Ethical considerations

The researcher received informed consent from respondents to be involved in the study. The researcher was honest with respondents and other participants throughout the study. He remained impartial and kept respondents and their responses confidential.

CHAPTER FOUR

DATA ANALYSIS, PRESENTATION AND INTERPRETATION

4.1 Introduction

This chapter presents the findings from the analysis of the data collected. The findings were in form of descriptive statistics. The findings were accompanied by detailed discussions on the various aspects under analysis. Essentially, the presentations of findings were in tandem with the research objectives and the study variables. The findings and discussions are presented relative to the background information of the respondents. The study utilizes descriptive statistics in discussing the findings.

4.2 Response rate

The sample size for the study was 250 respondents. As such the researcher used 250 questionnaires, out of which 228 were properly filled and returned. This comprised a response rate of 91.2 % for the study and this is a good response rate according to Magenta and Magenta (1999).

4.3 Gender of the respondent

The researcher sought to establish the distribution of the respondents by gender. The findings from the analysis were as represented in Table 4.1 below:

Table 4. 1 Gender of the Respondents

		Frequency	Percent
	Male	141	61.8
	Female	87	38.2
	Total	228	100.0

Table 4.1 indicates that a majority of the respondents were male comprising of 61.8% of the respondents. Female respondents comprised 38.2% of the total number of the respondents. This implies that the majority of the decision makers in regard to farming in Ruguru ward are males.

4.4 Age of the respondents

The study also sought to establish the age of the respondents participating in the study. The findings were as presented in Table 4.2

Table 4.2 Age Brackets

	Age Bracket	Frequency	Percent
	21-30 yrs	7	3.1
	31-40 yrs	35	15.4
	41-50 yrs	54	23.7
	51-60 yrs	79	34.6
	Above 60 yrs	53	23.2
	Total	228	100.0

The study established that the majority of the respondents were above 40 years of age comprising 81.5% of the respondents in the study. 18.4% of the respondents were aged below 40 years of age. As such, it was observed that the majority of the respondents in the study were more advanced in age also given that 57.8% were of 50 years and above. This is more than half the number of the respondents in this study. 23.2% of the respondents comprise of farmers aged 60 years and above. This age group is likely to be faced by the challenge of providing adequate labour force in their farms.

4.5 Respondent's level of education

The study further sought to establish the level of education of the respondents. This would enable the researcher establish the level of expertise of the respondents involved in the study. The findings for the study were as represented in Table 4.3 below.

Table 4.3 Level of Education

	Frequency	Percent
No Education	8	3.5
Primary	99	43.4
Secondary	87	38.2
Advanced level	20	8.8
Diploma	13	5.7
Degree	1	.4
Total	228	100.0

From Table 4.3 above, we note that 3.8% of the respondents had no education at all while 43.4% had attained primary level of education. 38.2%, 8.8%, 5.7% and 0.4% of the respondents had attained secondary, advanced level, diploma and degree certificates respectively. Therefore the main observation from this is that most of the respondents did not have any specialized training as they had only acquired basic primary and secondary school education.

4.6 Marital status of the respondents

The study also sought to establish the marital status of the respondents and the findings were represented in Table 4.4 below.

Table 4. 4 Marital Status

	Frequency	Percent
Single	31	13.6
Married	197	86.4
Total	228	100.0

From Table 4.4 above, 86.4 % of the respondents were married while only 13.6% of them were single. This meant that a majority of these respondents had family commitments to attend to in their day to day activities.

4.7 Household size

The household size referred to the number of family members who still rely on the farming activities carried out for food and other basic requirement. The findings from the analysis were as presented in Table 4.5 below

Table 4.5: Household Size

Persons	Frequency	Percent
1-2	23	10.1
3-4	46	20.2
5-6	148	64.9
6 and above	11	4.8
Total	228	100.0

The above findings indicate that the majority of the respondents, 64.9% comprise of 5 to 6 members of the household. The respondents whose household size is 1-2, 3-4,6 and above were 10.1%, 20.2%, and 4.8% respectively. Each member of a household would require one

and half 90kg bag of maize per year (MOA, Mathira West food security report as at February 2015). This implies that most the households with an average of 6 members would require 9 bags of maize per year for their food supply.

4.8 Farm Size

This study indicated the acreage on which each respondent was conducting their farming activities. This would show the potential their farming activities have in terms of income obtained from their farming activities. The findings from the analysis were as presented in Table 4.6 below.

Table 4.6 Farm Size

	Farm size	Frequency	Percent
	0.5-1 acre	69	30.3
	1-3	110	48.2
	3-6	43	18.9
	6-10	6	2.6
	Total	228	100.0

78.5 % of the respondents had less than three acres of land for their farming. 18.9 % and 2.6% had between 3-6 and 6-10 acres respectively. The results indicate that most of the respondents are subsistence farmers as they had small pieces of lands. Most of the maize is grown for home consumption.

4.9 Land ownership

On land possessed by the respondents, the findings for the analysis were as presented in Table 4.7 below.

Table 4.7: Land Ownership

	Frequency	Percent
Family Land	199	87.3
Leased	8	3.5
Bought	21	9.2
Total	228	100.0

The findings indicated that 87.9 % of the respondent were farming on family land, 3.5 % had leased land while 9.2% had bought their own lands. Most of the family land have been subdivided to the members of a household.

4.10 Sources of income

The study also sought to establish the respondents' sources of income. This would assist in determining the commitment the respondents had in their farming. The findings from the analysis were as presented in Table 4.8 below

Table 4.8 Other Sources of Income

	Frequency	Percent
Off farm formal Employment	67	29.4
Business	54	23.7
Casual Labour	107	46.9
Total	228	100.0

The findings indicated that apart from farming, 29.4 %, 23.7 % and 46.9% of the respondents were off farm formal employees, business people and casual labourers respectively. This implies that most farmers also engage in casual work outside their farms in order to meet their family needs. The respondents engaged in off farm employment comprise of the skilled man power, for instance teachers and masonries.

4.11 Maize seed and maize yields

4.11.1 Respondents practicing maize farming

Regarding the number of respondents involved maize farming in their farms, the findings are as presented in Table 4.9 below:

Table 4.9: Respondents Practicing Maize Farming in their Farms for the Last 3 Years

	Frequency	Percent
Yes	216	94.7
No	12	5.3
Total	228	100.0

Table 4.9 above indicated that 94.7% of the respondents had been practicing maize farming for the last three years while 5.3% of these respondents were not practicing maize farming in their farms. This implies that maize is an important crop for most of the respondents.

4.11.2 Maize seed and maize yields

The study examined the influence of the growing period of various maize varieties on the average yields obtained per acre. The findings are as tabulated in Table 4.10 below:

Table 4.10 : Maize Growing Periods and Average Yields per Acre

Maize growing Period	No. of respondents	Percent	Average maize yields per acre
2-3 months	123	53.9	7 bags
4-6 months	49	21.5	5 bags
5-7 months	34	15.0	4 bags
Mixed	22	9.6	3 bags
Total	228	100.0	

The findings indicated that the majority of the respondents (53.9 %) planted early maturing maize varieties, taking 2-3 months and producing an average yield of 7 bags (90kg) per acre. 21.7% respondents planted moderate maturing maize varieties, whereas 15% planted long maturing maize varieties, with an average 5 and 4bags per acre respectively. Only 9.6 of the respondents planted a combination of various maize varieties with different maturity periods presumably to prevent very low or no yields. The maize varieties planted by the respondents included among the following DH02, DH04, WH403, PH1 for the early maturing varieties, H513, H516, H520, DECAB for the moderate maturing varieties, and H614, H629, H625, H626 for the long maturing maize varieties. From table 4.7 above, the average maize yields obtained from the respondents were far below the optimal yields which are 16 bags per acre for the early maturing varieties, 20 bags per acre for the moderate maturing varieties and 40 bags per acre for the long maturing varieties (Kenya seed maize planting guide). However the early maturing maize varieties were performing better than the moderate and long maturing maize varieties under the prevailing conditions in the study area. The early maturing maize varieties gave 2 bags (29%) more than the moderate maturing maize varieties, and 3 bags (43%) more than the long maturing maize

varieties. This implies that the use of early maturing maize varieties in the study would give higher maize yields in comparison with moderate maturing and long maturing maize varieties.

4.11.3 Source of maize seed

The source of seed for the maize farmers was inquired and the findings from the analysis are as in Table 4.11 below:

Table 4.11: Source of Maize Seed

	Frequency	Percent
Local seed	41	18.0
Agrovet	187	82.0
Total	228	100.0

Majority of the farmers indicated that they got their maize seeds from the Agrochemical and veterinary stores comprising 82% of the respondents while 18% said that they used their local seeds in their planting. The use of certified maize seed would lead to better yields, all other factors held constant.

4.11.4 Factors considered in choosing maize variety

The study also sought to establish the factors considered by the respondents in choosing their maize variety to plant. The findings for the analysis were as indicated in Table 4.12 below

Table 4.12 Factors Considered in Choosing the Maize Variety to Plant

	Frequency	Percent
High Yielding	44	19.3
Early maturing	125	54.8
Disease Resistant	22	9.6
Drought Tolerant	37	16.2

	Frequency	Percent
High Yielding	44	19.3
Early maturing	125	54.8
Disease Resistant	22	9.6
Drought Tolerant	37	16.2
Total	228	100.0

From table 4.12 above, it was observed that 54.8% of the respondents considered early maturity as the main reason they would select a particular variety of maize. 19.3%, 9.6% and 16.2 % considered high yielding, disease resistant and drought tolerant maize varieties respectively. Therefore, early maturity emerged as the major factor for the consideration of any maize variety.

4.12 Changes in rainfall patterns

The study inquired the respondent observations as regards to rainfall patterns in their area for the last five years. This was important to deduce whether there were any significant changes in the rainfall pattern that could have led to the change in productivity levels of maize farmers in this region. The findings for the analysis are as presented in Table 4.13 below.

Table 4.13: Changes in Rainfall Pattern in Your Area for the Last Five Years

	Frequency	Percent
Heavy Rainfall	8	3.5
Light Rainfall	49	21.5
Uneven Distributed Rainfall	103	45.2
Evenly Distributed Rainfall	20	8.8
Timely onset of Rainfall	8	3.5
Delayed rain onset	28	12.3
Early Subsiding Rain	12	5.3
Total	228	100.0

The findings indicated that 45.2 % of the respondents had observed an uneven distribution of rainfall throughout the year in the last five years. Further, 21.5% and 12.3% observed light rainfall and delayed rain onset within the last five years. These unfavourable rainfall conditions observed by the respondents point to the need to carefully consider the maize varieties to be planted in the dry highlands. Other observations made included heavy rainfall, evenly distributed rainfall, timely onset of rainfall and early subsiding rains which comprised of 3.5%, 8.8%, 3.5% and 5.3 % respectively.

4.13 Use of fertilizer and food security

The study sought the usage of manure for the maize farming. The results are as portrayed in Table 4.14.

Table 4.14: Usage of Manure/Fertilizer in Maize Farming

	Frequency	Percent
Yes	214	93.9
No	14	6.1
Total	228	100.0

Table 4.14 above indicates that 93.9% of the respondents were using manure/fertilizer in their maize farming. Only 6.1 % were not using manure in their farms.

Also the study examined the influence of using manure/fertilizer on average maize yields. The findings are in Table 4.15 below

Table 4.15 : Usage of Manure/Fertilizer and Average Yields per Acre

	No. of respondents	Percent	Average maize yields per acre
Manure only	68	29.8	4 bags
Fertilizer only	108	47.4	6 bags
Manure +fertilizer	38	16.7	8 bags
Nothing	14	6.1	1 bags
Total	228	100.0	

The result of the study indicate that 29.8% of the respondents used manure only, whereas 47.4%, 16.7%, and 6.1 used fertilizers only, manure +fertilizer, and nothing respectively. More maize yields were obtained by respondents using a combination of manure and fertilizer. The respondents who used manure only on maize production obtained 3 bags(75%) more than those who used nothing, those respondents who used fertilizer only got 5 bags(83%) more than those who used nothing, and those respondents who used a combination of manure and fertilizer obtained 7 bags(88%) more than those who used nothing.

For the farmers who used manure for their maize farming activities, the source of the manure was sought. The findings are in Table 4.16 below:

Table 4.16 Sources of Manure

	Frequency	Percent
On-farm livestock	160	70.2
Compost	43	18.9
Off-Farm Buying	25	11.0
Total	228	100.0

The result of the findings indicated that 70.2 % obtained their manure from on-farm livestock . 18.8% and 11% used compost manure and off farm buying respectively.

The study also established sources of fertilizer for the respondents maize production. The findings for the analysis were as in table 4.17 below.

Table 4.17: Source of Fertilizer for Maize Production

		Frequency	Percent
	Agrovet	126	55.3
	Govt subsidized Fertilizer	95	41.7
	Donation	7	3.1
	Total	228	100.0

From Table 4.17 above, 55.3 % and 41.7% were obtaining their fertilizer from Agrovets and Government subsidized fertilizer respectively. 3.1 % were depending on donations as their source of fertilizer for their maize farming. At the time of this study the government subsidized planting fertilizer was sold at Ksh1800 (64% of the market price) whereas the subsidized fertilizer was sold at Ksh1500 (65% of the market value), MOA Mathira West Sub County third quarter agribusiness report.

4.14 Water harvesting and food security

The study sought to establish the water harvesting structures used by the farmers in this locality. The findings were as in table 4.18 below.

Table 4.18: Water Harvesting Structures/Measures found in the Farm

		Frequency	Percent
	Terraces	85	37.3
	Water pan	16	7.0
	Water Well	33	14.5
	Grass Strips	55	24.1
	Water tank	39	17.1
Total		228	100.0

Table 4.18 indicates that 36.7%, 24.3 % and 17.3% used terraces, grass strips and water tank respectively as their measures for water harvesting. 14.6% and 7.1% used water wells and water pan respectively in water harvesting.

The respondents were further questioned on their opinions as regards to sufficiency of the water harvesting measures for maize production. The results are as in Table 4.19 below.

Table 4.19 Rating of Water Harvesting Measures for Maize Crop Production

		Frequency	Percent
	Sufficient	48	21.1
	Not Sufficient	180	78.9
	Total	228	100.0

Of the 228 respondents, 180 of them comprising 78.9 % considered their water harvesting measures as insufficient in the maize crop production. The remaining 21.1 % considered their water harvesting measures to be sufficient for their maize crop production.

4.15 Farmers training and food security

On the matter of training, the study established whether the respondents had received any training on maize production. The findings from the analysis were as presented in Table 4.20 below.

Table 4.20: Training on Maize Production

		Frequency	Percent
	Yes	167	73.2
	No	61	26.8
	Total	228	100.0

From table 4.16 above, 73.2 % of the respondents agreed to having received training on maize production while 26.8% had not received any training on maize production.

On the source of the trainings, the findings were as in Table 4.21 below

Table 4.21: Sources of Training

		Frequency	Percent
Valid	Friends	31	13.6
	Govt Extension staff	114	50.0
	Private service Providers	33	14.5
	Media	50	21.9
	Total	228	100.0

A majority of the respondents comprising 50% had received training on maize production from the government extension officers. 21.9%, 14.5% and 13.6% had received their training from media, private service providers and friends respectively.

Regarding whether the respondents required any further training on maize production, the findings from the analysis were as in Table 4.22 below.

Table 4.22: Additional Training on Maize Production

		Frequency	Percent
	Yes	208	91.2
	No	20	8.8
	Total	228	100.0

The findings indicated that 91.2 % of the respondents saw the need for further training in maize production while 8.8 % did not see any need for further training.

The study also sought to establish the challenges farmers faced in their maize production. The findings were as in table 4.23 below.

Table 4.23: Challenges Faced in Maize Production

		Frequency	Percent
	Pests	22	9.6
	Diseases	48	21.1
	Inadequate Rainfall	110	48.2
	Lack of capital	48	21.1
	Total	228	100.0

The main challenge facing the farmers in maize production as indicated in Table 4.23 above was inadequate rainfall. This challenge was given high response percentage of 48.2%. Lack of capital and diseases were rated at 21.1% each while pests were 9.6%.

Finally, the respondents were requested to give their suggestions for the improvements of maize yields in the study area. In summary the respondents gave the following issues: supply of water for irrigation, Supply of more Government subsidized fertilizer and in time, Use of early maturing maize varieties, enhanced soil and water conservation measures, Improvements of soil fertility through use of manures, and more training on maize agronomy and related aspects.

CHAPTER FIVE

SUMMARY OF FINDINGS, DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

After the data was collected and analyzed in form of descriptive statistics, this was followed by a summary of major research findings. Conclusions were then drawn from the summary of the study findings. Finally pertinent recommendations in line with the effect of independent variables on the dependent variable were made.

5.2 Summary of Findings

The findings indicated that most of the farmers (78.5%) were subsistent farmers as they owned small pieces of lands measuring less than three acres. 87.9% of these lands were family lands which had been sub divided among family members. 64.9% of the respondents had 5-6 members of a household. Each member of a household would require one and half bags (135 Kg) of maize per year. This implies that most the households with an average of 6 members would require 9 bags (1215 Kg) of maize per year for their food supply.

The findings indicated that a majority of the respondents (94.7%) practiced maize farming in their lands. It was observed that most of the respondents (54.8%) considered early maturity in their choice of the maize variety to plant in their farms. The findings indicated that the majority of the respondents (53.9 %) planted early maturing maize varieties, taking 2-3 months and producing an average yield of 7 bags (90kg) per acre. 21.7% respondents planted moderate maturing maize varieties, whereas 15% planted long maturing maize varieties, with an average 5 and 4bags per acre respectively. Only 9.6 of the respondents planted a combination of various maize varieties with different maturity periods presumably

to prevent very low or no yields. It was noted that the average maize yields obtained from the respondents were far below the optimal yields which are 16 bags per acre for the early maturing varieties, 20 bags per acre for the moderate maturing varieties and 40 bags per acre for the long maturing varieties. However the early maturing maize varieties were performing better than the moderate and long maturing maize varieties under the prevailing conditions in the study area. The early maturing maize varieties gave 2 bags (29%) more than the moderate maturing maize varieties and 3 bags (43%) more than the long maturing maize varieties. This implies that the use of early maturing maize varieties in the study gave higher maize yields in comparison with moderate maturing and long maturing maize varieties. The study established that most of the respondents (93.9%) used manure and fertilizer in their maize farming. They sourced most of their manure from on-farm livestock (70.2%), while others used compost manures (18.8%) and a few depended on off-farm buying (11%). For their fertilizer, the respondents depended on agro vets (53.3%) and government subsidized fertilizers (41.7%). The average maize yields obtained were 4 bags, 6 bags, 8 bags, and 1 bag for manure only, fertilizer only, manure and fertilizer, and nothing respectively. More maize yields were obtained by respondents using a combination of manure and fertilizer. The respondents who used manure only on maize production obtained 3 bags (75%) more than those who used nothing, those respondents who used fertilizer only got 5 bags (83%) more than those who used nothing and those respondents who used a combination of manure and fertilizer obtained 7 bags (88%) more than those who used nothing. The good maize yields obtained from a combination of manure and fertilizer resulted from the improved soil fertility and productivity capacity. Respondents who used neither manure nor fertilizer obtained very low maize yields implying that the soils in the study area quite poor in terms of fertility.

Over a period of five years, 45.2% of the respondents had observed that there was uneven distribution of rainfall across the year in those five years. Others observed that there had been light rainfall that portrayed delayed onset and early subsiding. The respondents used terraces (37.3%), water pan (7.0%), water wells (14.5%), grass strips (24.1%), and water tanks (17.1%) as their water harvesting measures. Most of the farmers (61.4%) used terraces and grass strips for conserving water for maize production in their farms. However 78.9% of maize farmers observed that the terraces and grass strips were not sufficient for their maize production. This was evident from the observed lower actual maize yields in relation the expected maximum yields while using favourable early maturing maize varieties, manures and inorganic fertilizers. The use of early maturing maize varieties gave an actual maize yield of 7 bags per acre against the expected maximum of 16 bags per acre. The average maize yield obtained where a combination of manure and fertilizer was used, was 8 bags per acre. This is still low for an early maturing maize variety which has a potential of 16 bags per acre. The relative yield loss, maximum yield minus actual yield, implies that full water requirements were not met (Doorenbos, J., 1980).

Most of the farmers (73.2%) had received training on maize production but 26.8% had not received any form of training on maize farming. The trained respondents cited friends (13.6%), government extension officers (50%), private service providers (14.5%) and media (21.9%) as their source of training. Majority of the respondents got their training from government extension officers. Farmers' training being a human capacity building service is expected to improve the use of production practices aimed at improving crop yields and food security at the household level. The farming practices involved in the study were the choice of maize varieties and use of fertilizer. On the maize variety used, 53.9% of the farmers chose the early maturing variety which yielded 7 bags per acre. For the use of

fertilizers, only 6.1% of the respondents did not use any form of fertilizer getting 1 bag per acre. 47.4% of the respondents used inorganic fertilizer only, 29.8% manure only, and 16.7% a combination of manure and fertilizer. These farmers got 4-8 bags of maize acre. The resulting maize yield difference of between 75% and 87.5% is an indicator of informed farmers able to make fairly good production decision. 91.2% of the respondents agreed that they needed further training on maize production. This would enable them to respond to the challenges facing maize production in the study area: inadequate rainfall, pests, diseases and lack of capital.

5.3 Discussion of findings

A discussion of the study is presented based on the objectives.

The findings indicated that a majority of the respondents (94.7%) practiced maize farming in their lands. This agrees Food and Agriculture Organization report (2000) which referred maize as the staple food for Kenya. 53.9 % of the respondents planted early maturing maize varieties, taking 2-3 months and producing an average yield of 7 bags (90kg) per acre. 21.7% respondents planted moderate maturing maize varieties, whereas 15% planted long maturing maize varieties, with an average 5 and 4bags per acre respectively. 9.6% of the respondents planted a combination of various maize varieties with different maturity period. The planting of more early maturing maize varieties was an adaptive strategy against declining average maize yields brought about by unevenly distributed seasonal rainfall (J. Glover, 2009). It was noted that the average maize yields obtained from the respondents were far below the optimal yields which are 16 bags per acre for the early maturing varieties, 20 bags per acre for the moderate maturing varieties and 40 bags per acre for the long maturing varieties. The study displayed declining maize yields despite improvement in agricultural technologies as indicated by Suri,2011. However the early maturing maize

varieties were performing better than the moderate and long maturing maize varieties under the prevailing conditions in the study area. This was contrary to maize planting guide given to the farmers based on the altitude (Kenya Seed Company).

The study established that most of the respondents (93.9%) used manure and or fertilizer in their maize farming. The average maize yields obtained were 4 bags, 6 bags, 8 bags, and 1 bag for manure only, fertilizer only, manure and fertilizer, and nothing respectively. More maize yields were obtained by respondents using a combination of manure and fertilizer. The respondents who used manure only on maize production obtained 3 bags (75%) more than those who used nothing, those respondents who used fertilizer only got 5 bags (83%) more than those who used nothing and those respondents who used a combination of manure and fertilizer obtained 7 bags (88%) more than those who used nothing. The good maize yields obtained from a combination of manure and fertilizer resulted from the improved soil fertility and productivity capacity. Respondents who used neither manure nor fertilizer obtained very low maize yields implying that the soils in the study area are quite poor in terms of fertility. The study supported the fact that most soils in Kenya have been experiencing declining fertility status over the years and very few areas can still support crop production without supplementary nutrients through addition of fertilizers (Heisey,1996). 41.7% of the respondents used Government subsidized fertilizer for maize production. This led to improved maize performance in line with the situation witnessed in Malawi in 2012 through farm input subsidy program.

The respondents used terraces (37.3%), water pan (7.0%), water wells (14.5%), grass strips (24.1%), and water tanks (17.1%) as their water harvesting measures. 45.2% of the respondents had observed that there was uneven distribution of rainfall across the year in the last five years. Others observed that there had been light rainfall that portrayed delayed

onset and early subsiding. Most of the farmers (61.4%) used terraces and grass strips for conserving water for maize production in their farms. The use of early maturing maize varieties gave an actual maize yield of 7 bags per acre against the expected maximum of 16 bags per acre. The average maize yield obtained where a combination of manure and fertilizer was used, was 8 bags per acre. This is still low for an early maturing maize variety which has a potential of 16 bags per acre. The relative yield loss, maximum yield minus actual yield, implies that full water requirements were not met (Doorenbos, J., 1980). Low crop production implied that agriculture on most lands is limited by scarce, variable and unpredictable water resources (Rockstrom, 2014). Elaborate water harvesting would be done through collection of runoff and improved of infiltration of rain in the soils.

Most of the farmers (73.2%) had received training on maize production. The trained respondents cited friends (13.6%), government extension officers (50%), private service providers (14.5%) and media (21.9%) as their source of training. Majority of the respondents got their training from government extension officers, which was contrary to what Rees, 2000 indicated that a key source of information for farmers is other farmers. However the farmer's performance is directly linked to their human capital endowment which encompasses both innate and learned skills (Anderson and Feder, 2004). Farmers' training being a human capacity building service is expected to improve the use of production practices aimed at improving crop yields and food security at the household level. The farming practices involved in the study were the choice of maize varieties and use of fertilizer. On the maize variety used, 53.9% of the farmers chose the early maturing variety which yielded 7 bags per acre. For the use of fertilizers, only 6.1% of the respondents did not use any form of fertilizer getting 1 bag per acre. 47.4% of the respondents used inorganic fertilizer only, 29.8% manure only, and 16.7% a combination of

manure and fertilizer. These farmers got 4-8 bags of maize acre. The resulting maize yield difference of between 75% and 87.5% is an indicator of informed farmers able to make fairly good production decision. The people's ability to maintain food security in the face of climate and weather changes will depend significantly on their adaptive capacity.

5.4 Conclusions

The findings of the study indicate that most of the farmers in Ruguru ward were subsistence farmers only practicing agriculture to augment their food requirements'. Further the study found that most of the farmers utilized lands inherited from the family. The findings indicated that the majority of the respondents (53.9 %) planted early maturing maize varieties, taking 2-3 months and producing an average yield of 7 bags (90kg) per acre. The early maturing maize varieties gave 2 bags (29%) more than the moderate maturing maize varieties and 3 bags (43%) more than the long maturing maize varieties. This implies that the conditions prevailing in the study area, a dry highland, are more favourable for the production of early maturing maize varieties. The indicated level of maize yields was not satisfactory for food security in the area but there is potential for improvement.

Most of the respondents (93.9%) used manure and fertilizer in their maize farming. The average maize yield obtained was 1 bag per acre for farmers using no form of fertilizer. More maize yields were obtained by respondents using a combination of manure and fertilizer. The respondents who used manure only on maize production obtained 3 bags (75%) more than those who used nothing, those respondents who used fertilizer only got 5 bags (83%) more than those who used nothing and those respondents who used a combination of manure and fertilizer obtained 7 bags (88%) more than those who used nothing. This indicates that the fertility of the soils within the study area is very low, and that the use of manure and inorganic fertilizer improves maize yields.

On water harvesting, 45.2% of the respondents had observed that there was uneven distribution of rainfall across the year in the last five years. Majority of the farmers (61.4%) used terraces and grass strips for conserving water for maize production in their farms. These measures were not sufficient for their maize production as was evident from the observed lower actual maize yields in relation the expected maximum yields while using early maturing maize varieties, manures and inorganic fertilizers.

The findings of the study indicated that most of the farmers (73.2%) had received training on maize production. This led to more farmers using production practices aimed at improving crop yields and food security at the household level. A good number of the respondents made informed decisions with 53.9% choosing the early maturing variety, and 93.9% using manures and fertilizers.

5.5 Recommendations

From the study it is recommended that the government should increase the subsidized fertilizers supply to the farmers to increase farmers' access to fertilizers and enhance their maize production. Further, the government should reign in and drill boreholes, dig dams and offer support to community irrigation schemes to supplement the farmers water harvesting measures. This will ensure sufficient harvesting of water and enable farmers to adapt irrigation methods in their maize farming. This will ensure all round year maize production and enhance food security in the region. More training on maize agronomy and related aspects to be given to the farmers through government extension officers and farmers training institutions. Individual farmers should enhance soil and water conservation measures, adopt the use of early of maturing maize varieties, and improve soil fertility through the use of manures and inorganic fertilizers.

5.6 Suggestion for further Research

The study only focused on the influence of modern farming techniques on food security in one area of the dry highlands, Ruguru ward. Another study can be conducted in other areas for comparison purposes. The findings from the study can also stimulate further research in this area where a different methodology may be applied. For instance while this study used cross-sectional data set, a future study may utilize time series approach in which data for chosen variables are collected over a longer period of time and any trends and/or relationships between the variables are established.

5.7 Contribution to Knowledge

The contributions to the existing body of influence of utilization of modern farming techniques on food security in the dry highlands are summarized in Table 5.1 below:

Table 5.1 Contribution to Knowledge

Objectives	Contribution to Knowledge
1. To examine how the use of early maturing crop varieties influences maize yields in Ruguru ward	▪ Majority of the respondents (53.9 %) planted early maturing maize varieties, taking 2-3 months and producing an average yield of 7 bags (90kg) per acre. 21.7% respondents planted moderate maturing maize varieties, whereas 15% planted long maturing maize varieties, with an average 5 and 4bags per acre respectively. 9.6% of the respondents planted a combination of various maize varieties getting 3 bags per acre.
2. To establish the extent to which the use of fertilizer influences maize yields in Ruguru ward	▪ Most of the respondents (93.9%) used manure and fertilizer in their maize farming. The average maize yields obtained were 4 bags, 6 bags, 8 bags, and 1 bag for manure only, fertilizer only, manure and fertilizer, and nothing respectively.
3. To establish how water harvesting influences maize yields in Ruguru ward	▪ Most of the respondents (61.4%) used terraces and grass strips for conserving water for maize production in their farms. These measures were not sufficient for their maize production. This was depicted by relative yield loss, for instance use of early maturing maize varieties gave an actual maize yield of 7 bags per acre against the expected 16 bags per acre.
4. To determine how training affects maize yields in Ruguru ward	▪ 73.2% of the respondents had received training on maize production. These farmers were able to make informed choices of good production techniques resulting to maize yield increase between 75% and 87.5% .

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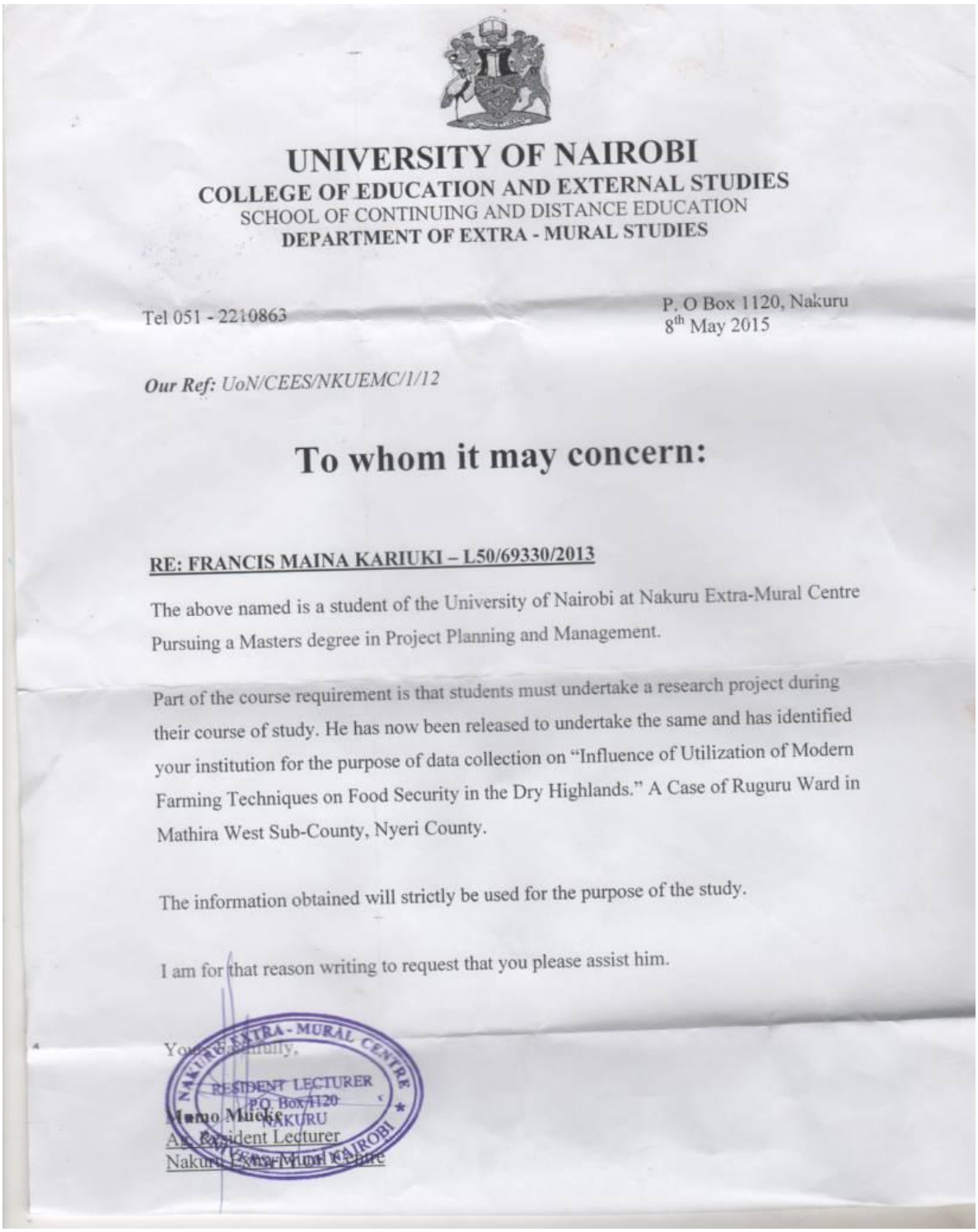
APPENDICES

APPENDIX 1: INTRODUCTION LETTER



UNIVERSITY OF NAIROBI
COLLEGE OF EDUCATION AND EXTERNAL STUDIES
SCHOOL OF CONTINUING AND DISTANCE EDUCATION
DEPARTMENT OF EXTRA - MURAL STUDIES

Tel 051 - 2210863

P. O Box 1120, Nakuru
8th May 2015

Our Ref: *UoN/CEES/NKUEMC/1/12*

To whom it may concern:

RE: FRANCIS MAINA KARIUKI – L50/69330/2013

The above named is a student of the University of Nairobi at Nakuru Extra-Mural Centre Pursuing a Masters degree in Project Planning and Management.

Part of the course requirement is that students must undertake a research project during their course of study. He has now been released to undertake the same and has identified your institution for the purpose of data collection on "Influence of Utilization of Modern Farming Techniques on Food Security in the Dry Highlands." A Case of Ruguru Ward in Mathira West Sub-County, Nyeri County.

The information obtained will strictly be used for the purpose of the study.

I am for that reason writing to request that you please assist him.

Yours faithfully,

NAKURU EXTRA - MURAL CENTRE
RESIDENT LECTURER
P.O. Box 1120
NAKURU
UNIVERSITY OF NAIROBI

Mumo Mutie
Ag. Resident Lecturer
Nakuru Extra-Mural Centre

APPENDIX 2:LETTER REQUESTING TRANSMITAL FROM ADMINISTRATION

FRANCIS MAINA KARIUKI
L50/69330/2013
P.O BOX 198,
KARATINA.
25/5/2015

DEPUTY COUNTY COMMISSIONER
MATHIRA WEST SUB COUNTY
P.O BOX 52,
KARATINA.

RE: RESEARCH AUTHORIZATION

I am a graduate student undertaking Masters degree in project planning and management at the University of Nairobi. As part of the course requirement , I would like to conduct a research study entitled "**Influence of utilization of modern farming techniques on food security in the dry highlands: a case of Ruguru ward in Mathira west Sub county - Nyeri county".**

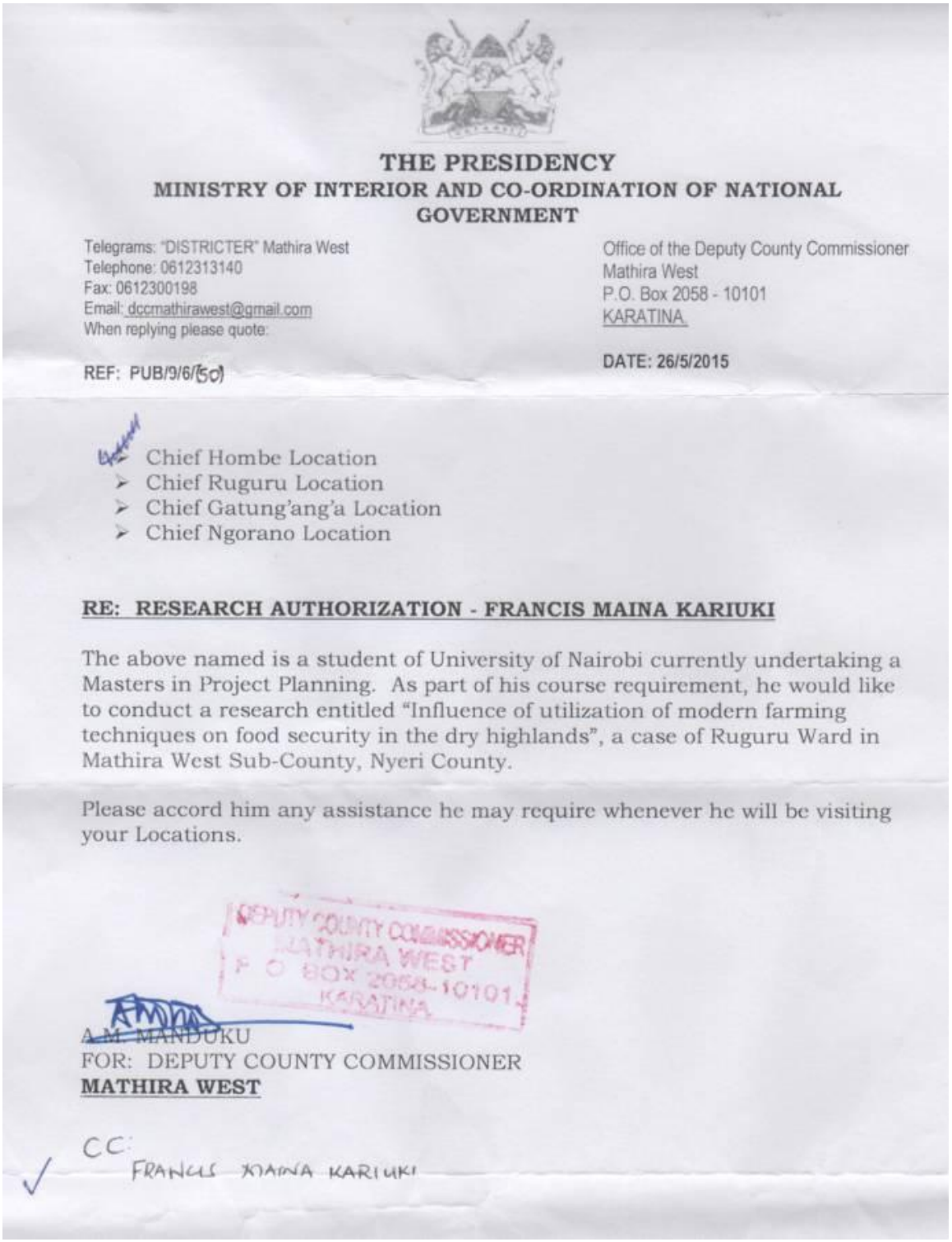
Thus am kindly requesting your authority to collect data from sampled farmers and chiefs within Mathira Sub county. This exercise is estimated to take about one month. The information gathered will be treated with confidentiality and only used for academic purposes.

I have hereby attached an introduction letter from the University of Nairobi.

Thank you

FRANCIS MAINA KARIUKI

APPENDIX 3:LETTER GRANTING TRANSMITAL FROM ADMINSTRATION



THE PRESIDENCY
MINISTRY OF INTERIOR AND CO-ORDINATION OF NATIONAL GOVERNMENT

Telegrams: "DISTRICTER" Mathira West
Telephone: 0612313140
Fax: 0612300198
Email: dccmathirawest@gmail.com
When replying please quote:

Office of the Deputy County Commissioner
Mathira West
P.O. Box 2058 - 10101
KARATINA

REF: PUB/9/6/(50)

DATE: 26/5/2015

- Chief Hombe Location
- Chief Ruguru Location
- Chief Gatung'ang'a Location
- Chief Ngorano Location

RE: RESEARCH AUTHORIZATION - FRANCIS MAINA KARIUKI

The above named is a student of University of Nairobi currently undertaking a Masters in Project Planning. As part of his course requirement, he would like to conduct a research entitled "Influence of utilization of modern farming techniques on food security in the dry highlands", a case of Ruguru Ward in Mathira West Sub-County, Nyeri County.

Please accord him any assistance he may require whenever he will be visiting your Locations.

DEPUTY COUNTY COMMISSIONER
MATHIRA WEST
P O BOX 2058-10101
KARATINA

A.M. MANDUKU
FOR: DEPUTY COUNTY COMMISSIONER
MATHIRA WEST

CC:
FRANCIS MAINA KARIUKI

APPENDIX 4:LETTER REQUESTING TRANSMITAL FROM RESPONDENTS

FRANCIS MAINA KARIUKI

P.O BOX 13023 – 20100,

NAKURU.

5th June 2015

Dear Sir/Madam,

I am a graduate student undertaking Masters of Arts in Project Planning and Management at the University of Nairobi. As part of the course requirement, I am undertaking a research study entitled '' Influence of utilization of modern farming techniques on food security in the dry highlands. A case of Ruguru ward in Mathira West Subcounty, Nyeri County.'' You have been selected to assist in providing the required information because your views are considered important to this study.

Therefore I am kindly requesting you to assist in filling this questionnaire. Please note that any information given will be treated with utmost confidentiality and will only be used for the purpose of this study.

Thank you.

Yours faithfully,

FRANCIS M. KARIUKI

L50/69330/2013

APPENDIX 5: RESEARCH PERMIT

THIS IS TO CERTIFY THAT:
MR. FRANCIS MAINA KARIUKI
of UNIVERSITY OF NAIROBI, 0-2000
Nakuru,has been permitted to conduct
research in *Nyeri County*

on the topic: *INFLUENCE OF MODERN FARMING TECHNIQUES ON FOOD SECURITY A CASE OF RUGURU WARD, MATHIRA WEST SUB-COUNTY, NYERI COUNTY*

for the period ending:
6th November,2015

.....
Applicant's Signature

Permit No : NACOSTI/P/15/8411/6351
Date Of Issue : 1st July,2015
Fee Recieved :Ksh 1,000

.....
Director General
National Commission for Science, Technology & Innovation

APPENDIX 6:RESEARCH QUESTIONNAIRE FOR HOUSEHOLDS

The purpose of this questionnaire is to obtain information on farming techniques and their influence on food security.

Please fill in the blank space or tick in the relevant box.

Date _____

Location _____

Sub Location _____

Section one: Respondent profile

1. Gender

Male [ ]

Female [ ]

2. Age bracket

Below 20 years [ ]

21 – 30 years [ ]

31 – 40 years [ ]

41 – 50 years [ ]

51 – 60 years [ ]

Over 60 years [ ]

3. Highest level of education attained

Never went to school [ ]

Primary level [ ]

Secondary level [ ]

Advanced level [ ]

Diploma [ ]

Degree [ ]

4. Marital Status

Single [ ] Married [ ]

Others (Specify) _____

5. Your Household / Family size [ ]

6. (a) Total farm size (in acres) _____

(b) Land ownership: Family land [ ] Leased [ ] Bought[ ]

7. Apart from farming, what other income generating activities are you engaged in?

Off-farm formal employment [ ], Specify_____

Business [ ]

Casual labour [ ]

Section two: Influence of maize varieties on food security

8 (a) Have you been practicing maize farming in your farm for the last 3 years?

YES [ ] No [ ]

(b) If YES, fill in the following table below:

Season	Area planted (in acres)	Maize variety planted	Yield obtained (in 90 kg bags)
2014(short rains)			
2014(long rains)			
2013(short rains)			
2013(long rains)			

2012(short rains)			
2012(long rains)			

(c) If NO, give two main activities in your farm: _____ ; _____

9. Source of maize seed: Local seed [ ] Agrovet [ ]

10. What factors do you consider in choosing the maize variety to plant?

High yielding [ ]

Early maturing [ ]

Disease resistant [ ]

Drought tolerant [ ]

11. What have you noted on the rainfall pattern in your area for the last five years?

Heavy rainfall [ ]

Light rainfall [ ]

Uneven distributed rainfall [ ]

Evenly distributed rainfall [ ]

Timely onset of rainfall [ ]

Delayed onset of rainfall [ ]

Timely subsiding of rainfall [ ]

Early subsiding of rainfall [ ]

Any other (specify)_____

Section three: Use of fertilizer on food security

12 (a) Have you been using Manure/ Fertilizer in your maize farming? YES[ ] NO[ ]

(b) If YES, please fill in the table below:

Season	Area planted (in acres)	Amount of Manure (in kgs)	Planting fertilizer	Amount applied (in Kgs)	Top dressing fertilizer	Amount applied (in Kgs)	Yield obtained (in 90 kg bags)
2014(short rains)							
2014(long rains)							
2013(short rains)							
2013(long rains)							
2012(short rains)							
2012(long rains)							

13 (a) Source of manure for your farm:

On-farm livestock waste [ ] compost [ ] off-farm buying [ ]

(b) Source of fertilizer for your maize production:

Agrovet [ ] Government subsidized fertilizer [ ] Donation [ ]

Section Four: Water harvesting and food security

14 (a)Please indicate the water harvesting structures/measures found on your farm.

Terraces [ ] Water pan [ ] Water well [ ] Grass strips [ ] Water tank [ ]

Others (Specify)_____

(b)Which of the above water harvesting measures support maize crop production in your farm?

_____

(c) How do you rate the water harvesting measures, in (b) above, for maize crop production?

Sufficient [ ] Not Sufficient [ ]

Section Five: Farmers' training and food security

15.(a) Have you received any training on maize production? YES [ ] NO[ ]

(b)If YES, What was the source of the training?

Friends[ ] Government extension staff [ ] Private Service providers [ ]

Media [ ]

Others(Specify)_____

16. Do you require additional training on maize production? YES[ ] NO[ ]

17. What challenges have you faced in maize production?

Pests [ ] Diseases [ ] Inadequate rainfall [ ] Lack of capital[ ]

Others (Specify)_____

18. Give your suggestions for the improvement of maize yields in your area.

_____

_____

APPENDIX 7: RESEARCH QUESTIONNAIRE FOR KEY INFORMANTS

The purpose of this questionnaire is to obtain information on farming techniques and their influence on food security.

Please fill in the blank space or tick in the relevant box.

Date _____

Ward /Location _____

Section one: Respondent profile

1.Kindly indicate your gender

Male [ ]

Female [ ]

2.Please indicate your age bracket from the choices below.

21 – 30 years [ ]

31 – 40 years [ ]

41 – 50 years [ ]

51 – 60 years [ ]

Over 60 years [ ]

3.What is your highest level of education?

Primary level [ ]

Secondary level [ ]

Advanced level [ ]

College [ ]

University [ ]

4.What is your duty speficication?

_____

5. Marital Status: Single [ ] Married [ ] Others(specify)_____

Section two: Influence of maize varieties on food security

6.Please indicate the average maize yields per one acre obtained by farmers in your working area for the last 3 years.

Season	Maize yield obtained (in 90 kg bags) Per acre
2014(short rains)	
2014(long rains)	
2013(short rains)	
2013(long rains)	
2012(short rains)	
2012(long rains)	

7. Main source of maize seed: Local seed [ ] Agrovet [ ]

8. What factors do farmers consider in choosing the maize variety to plant?

High yielding [ ]

Early maturing [ ]

Disease resistant [ ]

Drought tolerant [ ]

9. What have you noted on the rainfall pattern in your area for the last five years?

Heavy rainfall [ ]

Light rainfall [ ]

Uneven distributed rainfall [ ]

Evenly distributed rainfall [ ]

Timely onset of rainfall [ ]

Delayed onset of rainfall [ ]

Timely subsiding of rainfall [ ]

Early subsiding of rainfall [ ]

Any other (specify)_____

Section three: Use of fertilizer on food security

10. Give an average percentage(%) of maize farmers who use the following in your area:

a) Manure only [ ]

b) Fertilizer only [ ]

c) Both Manure and Fertilizer [ ]

d) Nothing [ ]

11. (a) Main source of manure for maize production:

On-farm livestock waste [ ] compost [ ] off-farm buying [ ]

(b)Main source of fertilizer for maize production:

Agrovet [ ] Government subsidized fertilizer [ ] Donation [ ]

Section Three: Water harvesting and food security

12 (a)Please indicate the main water harvesting structures/measures found on the farms in your area.

Terraces [ ] Water pan [ ] Water well [ ] Grass strips [ ] Water tank [ ]

Others (Specify)_____

(b)Which of the above water harvesting measures support maize crop production in your area?

(c) How do you rate the water harvesting measures, in (b) above, for maize crop production?

Sufficient [ ] Not Sufficient [ ]

Section Three: Farmers' training and food security

13. What is the main source of farmers training on maize production in your area?

Friends[ ] Government extension staff [ ] Private Service providers [ ]

Media [ ]

Others(Specify)_____

14. Do the farmers in your area require additional training on maize production?

YES[ ] NO[ ]

15. What challenges do farmers in your area face in maize production?

Pests [ ] Diseases [ ] Inadequate rainfall [ ] Lack of capital[ ]

Wrong maize varieties [ ]

Others (Specify)_____

16. Give your suggestions for the improvement of maize yields in your area.

_____

_____

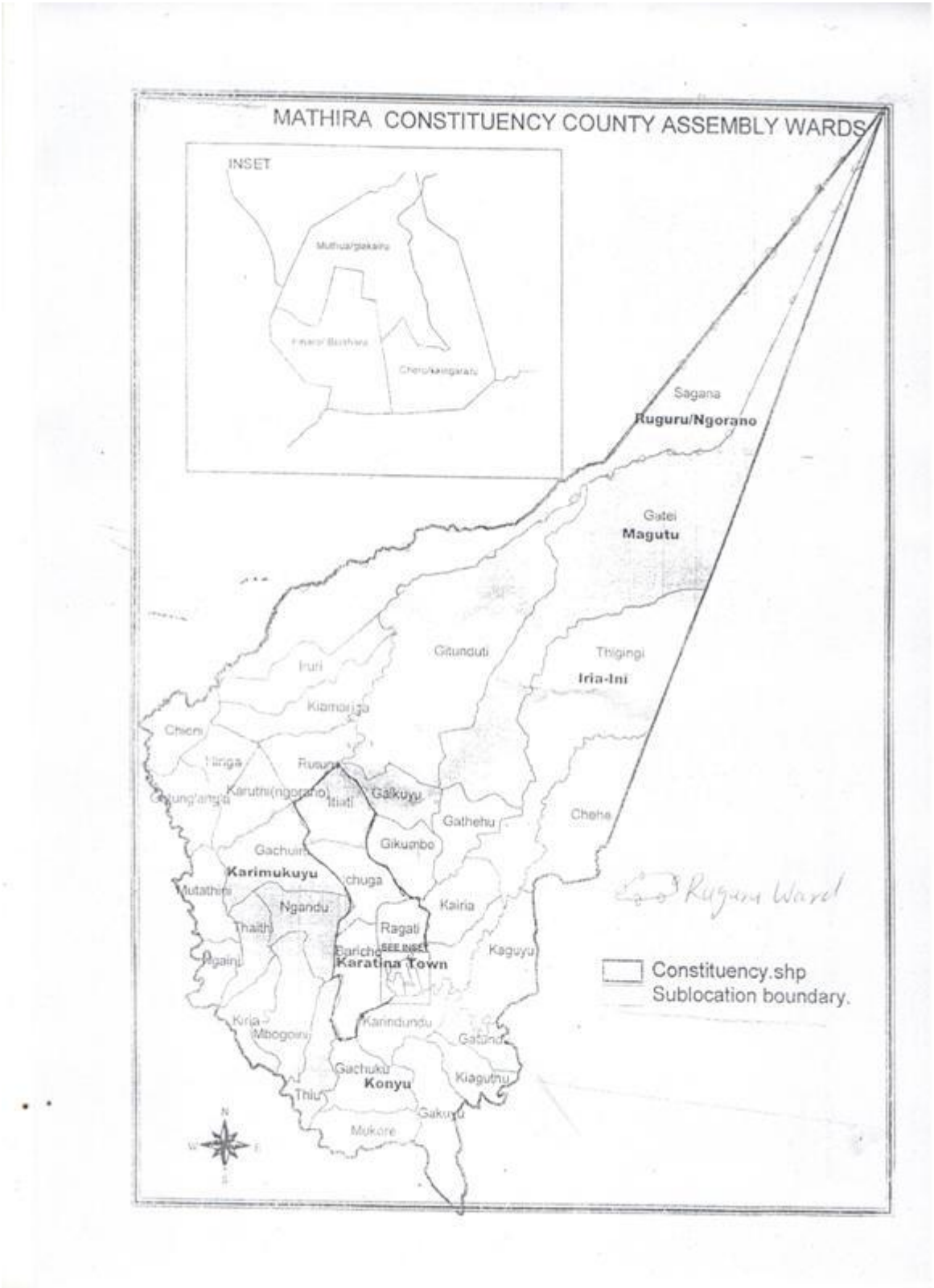



Figure 2 : Ruguru Ward