

**INFLUENCE OF MAIZE MANAGEMENT PRACTISES ON FOOD SECURITY  
AMONG FARMERS IN MOIBENSUB-COUNTY,  
UASIN GISHU COUNTY, KENYA.**

**BY**

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**Research Project report Submitted in Partial Fulfillment of the requirements for the  
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of Nairobi.**

**2014**

**DECLARATION**

This research project is my original work and has not been presented by anyone else for examination in any other institution of learning.

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**Declaration by the Supervisor**

This research project has been submitted for examination with my approval as a University of Nairobi supervisor.

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## **DEDICATION**

I dedicate this work to the loving memory of my father the late Michael Kibiwott Cherop, mother Mrs. AnacletaTilak and my grandmother Mrs. Susan Kaino.

## **ACKNOWLEDGEMENT**

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## ACRONYMS AND ABBREVIATIONS

<b>ACDI</b>	- Agricultural Cooperative Development Initiative
<b>AGOA</b>	- African Growth and Opportunities Act
<b>AGRA</b>	-Alliance for Green Revolution in Africa
<b>ASCU</b>	-Agricultural Sector coordinating Unit
<b>CE</b>	-Commodity Exchange
<b>CIGs</b>	-Common Interest Groups
<b>CIYMMT</b>	- International Maize and Wheat Improvement Center
<b>D.A.P</b>	-Diammonium phosphate
<b>EACS</b>	-East African Community Standards
<b>EAGC</b>	- Eastern African Grain Council
<b>EAC</b>	-East African Community
<b>EC</b>	- European Commission
<b>ELISA</b>	- Enzyme Linked Immunosorbent Assay
<b>ERS</b>	-economic Recovery Strategy
<b>FAO</b>	-Food and Agricultural Organization of United Nations
<b>FOASTAT</b>	- Food and Agricultural Organization –Statistics
<b>FSD</b>	-Financial Sector Deepening Trust
<b>GDP</b>	-Gross Domestic Product
<b>GIZ/GTZ</b>	-German International Cooperation

<b>GOK</b>	-Government of Kenya
<b>ICT</b>	- Information Communication Technology
<b>IFAD</b>	-International Fund for Agricultural Development
<b>IFPRI</b>	-International Food Policy Research Institute
<b>IITA</b>	- International Institute of Tropical Agriculture
<b>ISO</b>	- International Standards Organization
<b>KACE</b>	- Kenya Agricultural Commodity Exchange
<b>KARI</b>	-Kenya Agricultural Research Organization
<b>KEBS</b>	-Kenya Bureau of Standard
<b>KEPHIS</b>	-Kenya Plant Health Inspectorate Services
<b>KMDP</b>	- Kenya Maize Development Programme
<b>KSC</b>	- Kenya Seed Company
<b>KSEAS</b>	-Kenya Standard-East African Standard
<b>KShs</b>	-Kenya Shillings
<b>MASL</b>	- Meters above Sea Level
<b>MDG</b>	-Millennium Development Goals
<b>MoA</b>	- Ministry of Agriculture
<b>MSV</b>	- Maize Streak Virus
<b>NAEP</b>	-National Development Extension Agency
<b>NALEP</b>	- National Agricultural Extension Programme
<b>NCPB</b>	- National Cereals and Produce Board

<b>NGO's</b>	- Non-Governmental Organizations
<b>NMK</b>	-NjaaMarufuku Kenya
<b>PRSP</b>	- Poverty Reduction Strategy Paper
<b>SRA</b>	-Strategy for Revitalizing Agriculture
<b>UNCHR</b>	-United Nations Commission for Human Refugees
<b>WFP</b>	-World Food Programme
<b>WHO</b>	- World Health Organizations
<b>WRS</b>	-Warehouse Receipt System.

## ABSTRACT

Maize is the main staple food for the inhabitants of Moiben sub County as well as other parts of Country. However, its production is facing some challenges that have led to decline in yield. Improving maize production is considered one of the most important strategies of solving the problems of food insecurity in the countries where rapid population increase is a major challenge especially in Sub-Sahara Africa, this therefore, can be achieved by improving management practices of maize production. It's the main source of employment and income for the poor rural people. Maize accounts for 30–50% of low-income household expenditures in Eastern and Southern Africa and when the price of this commodity is increased, it's the poor who suffer most. In addition, the grains are rich in vitamins A, C and E, carbohydrates, essential minerals, and contain 9% protein, they also rich in dietary fiber and calories which are a good source of energy. The purpose of this study was to determine the influence of maize management practices on food security among farmers in Moiben sub-county. The objectives of the study included; to establish the role of planning of planting of maize on food security in Moiben sub-county, to determine how growth control mechanisms influence food security, to establish the impact of maize storage on food security in Moiben sub-county and to establish effects of maize marketing and marketing strategies on food security in Moiben sub-county. The total population of Moiben sub-county is 138,409 people with 17,299 households. Since we are interested with household families that grow maize for commercial or for subsistence, 368 households were chosen through stratified sampling. Primary data was collected through, questionnaires, interviews, observations, and focus group discussions, secondary data was collected through review of articles, journals, internet search and text books. Analysis was done using descriptive statistics with an aid of Statistical Package for Social Science (SPSS) software and Microsoft excel. The findings of this study guided the researcher in recommending appropriate strategies that policy makers can use to assist the maize producers in their efforts to tackle maize production challenges in relation to food security. Planning of planting of maize has an influence on the total yield of maize. Ploughing in time ,acquisition of inputs in time enable the farmer to plant on time. Timely weeding is essential to ensure that the crop does not compete with weeds for resources. Top dressing is important because it increases the vegetative growth of the crop hence guarantee high yield. Storage of the maize grain bridges the gap between surplus at harvest time and scarcity during off season. The price of maize grain is affected by middlemen who exploit the farmers, competition from other crops e.g. wheat and millet and imported maize. This study recommends that farmers be sensitized on importance of soil testing, the farmers should form co-operative societies to assist them market their produce and buy inputs in bulk in order to benefit from collective bargaining power.

# CHAPTER ONE

## Introduction

### 1.1 Background of the Study

Maize is a cereal crop that is grown widely throughout the world in a range of agro-ecological environments. More maize is produced annually than any other grain hence ensures food security if well managed. About 50 species exist and consist of different colors, textures and grain shapes and sizes. White, yellow and red are the most common types. The white and yellow varieties are preferred by most people depending on the region. (Mendoza, 2014).

Maize is the most important cereal crop in sub-Saharan Africa (SSA) and an important staple food for more than 1.2 billion people in SSA and Latin America. All parts of the crop can be used for food and non-food products. In industrialized countries, maize is largely used as livestock feed and as a raw material for industrial products. Maize accounts for 30–50% of low-income household expenditures in Eastern and Southern Africa. A heavy reliance on maize in the diet, however, can lead to malnutrition and vitamin deficiency diseases such as night blindness and kwashiorkor, (Casas, 2013).

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 from countries outside the continent. Most maize production in Africa is rain fed. Irregular rainfall can trigger famines during occasional droughts and due to this farmers need to time and plan well for planting maize so as make sure that there is no shortage hence food security.

Worldwide consumption of maize is more than 116 million tons, with Africa consuming 30%. However, Lesotho has the largest consumption per capita with 174 kg per year. Eastern and Southern Africa uses 85% of its production as food, while Africa as a whole uses 95%, compared to other world regions that use most of its maize as animal feed, (FAO 2012).

Ninety percent of white maize consumption is in Africa and Central America. It fetches premium prices in Southern Africa where it represents the main staple food. Yellow maize is preferred in

most parts of South America and the Caribbean, (IITA 2010) it is also the preferred animal feed in many regions as it gives a yellow color to poultry, egg yolks and animal fat. Maize is processed and prepared in various forms depending on the country. Ground maize is prepared into porridge in Eastern and Southern Africa, while maize flour is prepared into porridge in West Africa. Ground maize is also fried or baked in many countries. In all parts of Africa, green (fresh) maize is boiled or roasted on its cob and served as a snack. Popcorn is also a popular snack, (Preet, Edythe 2010).

The U.S.A. has the highest output of maize amongst the countries involved in maize growing. In 1964 it produced more than half of the total world maize growth, accounting for 104 million tons grown by the nation. Today the world harvests almost as much maize as wheat. Maize is exceptional in yield per unit area. The harvest may vary from 2.5 to 6 tons per acre according to the soil and its cultivation. Yields above 7 tons per acre have often been recorded, (Tedlock, 2012).

Maize management has vital effects on food security in USA, in a classic study, (Witt, 1992) stated that production resources are used more efficiently when they are all at their optimum level which depends on proper management of maize hence increased food security. Accordingly, high yield levels are related to high resource-use efficiencies due to optimization of growing conditions and maximum maize management practices. (Preet, 2012).

Paradoxically, resource-use efficiency in high-yield cropping systems is often perceived to be intrinsically low due to large inputs applications which are not maximized due lack of management practices e.g lack of proper timing of operations. This is not good for food security. (e.g., N fertilizer, irrigation water and associated environmental degradation (Keating *et al.*, 2010). There are, however, well-managed field-scale experiments that document the potential to achieve both high yields with high resource-use efficiency with precise management of all production factors in time and space (Cassman, 1999; Dobermann *et al.*, 2002; Vermaet *et al.*, 2005). Trends towards higher yield levels with higher resource-use efficiency also have been reported for some intensive cropping systems of maize as a result of better crop and inputs management. (Cassman *et al.*, 2002).

Since intensive cropping systems account for a significant fraction of total maize production, identification of avenues for improvement of resource-use efficiency without yield penalties is critical to guarantee global food security and preserve natural resources for future generations. Storage facilities not only offer the opportunity to smooth hunger between staple maize harvests but farmers are possibly able to improve farm incomes by storing crops and selling at premium prices when demand outstrips supply later in the post-harvest period (Florkowski & Xi-Ling, 1990). As quality is an important determination of crop retail prices (Kohl & Uhl, 1998: 24), effective storage is crucial to improve agricultural incomes and food security for small scale farmers. Crop storage efficiency depends on storage length, losses during storage (including quality deterioration) and storage volume. Losses are largely due to disease, pests and oxidative damage (Salunke & Desai, 1986:8-12). Therefore, air-tight storage is important (Lindbland & Druben 1980). For storage to be effective, crop losses must be minimized (Takavarasha & Rukovo, 1989:63-72). The widespread and continued use of traditional storage practices by South Africa's small scale and subsistence farmers despite considerable losses, warrants investigation with respect to improved storage and finding appropriate, efficient and inexpensive post-harvest technologies for small scale farmers.

The switch by many farmers in Kenya's Rift Valley province from staple cereals to more profitable coffee is likely to increase the country's dependence on grain imports and possibly affect food security, agricultural experts have warned. It is unsafe to use our land for crops with the hopes of being fed by other countries due to poor managing skills, (Nyoro, 2003). Kenya imported 2.3 million tonnes of cereal during the 2011-2012 marketing year to meet demand, a year-on-year increase of 37 percent, according to the UN Food and Agricultural Organization, which estimated domestic harvests of maize - a staple for 90 percent of Kenyans - at 2.5 million tonnes, down 18 percent because of poor weather. This import dependency and the threat posed by increased coffee growing could be mitigated with the use of improved inputs by cereal growers, (Nyoro, 2003). Another food security specialist recommended improving storage conditions of grain after it is harvested, where some 30 percent of production is traditionally lost. In the meantime, any additional costs accrued by importing will be passed on to consumers, (Buziba and Rotich, 2005).



Currently, the farmers are adopting high value and high yielding horticultural crops that include: passion fruit, chilies, French beans among others. According to Anderson (2003) and Gockowski and Michel (2004), horticultural crops have high market value and yield more and regularly and hence suit the needs of smallholder farmers who face resource constraint and have no marketable surplus. Kuyiahet *al.* (2006) also found that high-value farm enterprises are suitable for smallholder farmers because they give more returns out of the scarce resources. Furthermore, farm enterprises such as horticulture, tea and dairy farming can increase farm incomes even under conditions of risk (Obareet *al.*, 2003).this will reduce farm land under maize production and because maize is a staple food in the region,decreased production will make the people to be food insecure.

The agricultural incomes have also been argued to be improved through use of high yielding varieties and adequate input use such as; fertilizers, seeds, credit as well as availability of good rural infrastructure and no doubt good results have been achieved due to improved management skills (Ishtiaqet *al.*, 2005). However, use of yield enhancing inputs has been considered by many studies as insufficient in improving the farmer's income because, exploitation of such opportunities have been exhausted in many rural farming areas in the world and Moiben sub-county is not an exception. Farm diversification at optimal levels therefore remains as one of the best alternative strategies to alleviate poverty through increase and stable farm income under conditions of resource constrain and price instability. In Uasin-Gishu County, farm enterprise diversification happens in two ways: Enterprise dumping (total enterprise substitution) and enterprise trade-off (partial enterprise substitution). However, farmers face problems when choosing optimal combination of enterprises to produce due to resource constrains, (Lindblade and Giesecker, 2008).

According to Ishtiaqet *al.* (2005), farmer's profit maximization objective cannot be achieved if cropping mix chosen is not optimal. Combination of some agricultural enterprises at sub-optimal levels leads to reduction in farm incomes. Therefore, for farmers to make informed decisions regarding farm enterprise combination, it is important to understand Gross Margins and technical efficiencies of the different farm enterprises in question,(Azziz-Baumgartner,2011).

## 1.2 Statement of the problem

Maize is one of the most important cereal crops that provide staple food to large number of human population in Moiben sub County. Food security and social-economical welfare of the farming population depends on maize cultivation (Ajani and Onwubuya, 2012). Maize is the main source of food for the poor rural people. The grains are rich in vitamins A, C and E, carbohydrates, essential minerals, and contain 9% protein, they are also rich in dietary fiber and calories which are a good source of energy (Mghenyi, 2006). Improving maize productivity will not only reduce food insecurity and government spending but will also increase opportunities to many jobless youths and other non-maize producer farmers through commodity production value chain. The country suffered a maize deficit of 6.8 million bags in 2012 and spends millions of shillings for maize importation, (Muendo, 2012), at the start of this year (2014) the deficit was also reported to have increased to 10 million bags by the ministry of Agriculture and they recommended that the shortfall to be bridged by importation from the neighbouring countries. It's only through this research that the government, stakeholders and farmers can realize the challenges farmers face in production and make right decision towards improved yield thus, minimizes the expenditures.

**Table 1.1 Top 5 Countries in Sub-Saharan African and European Maize production (2007)**

Sub-Saharan Africa		Europe	
Country	yield (Kg per Ha)	country	yield (Kg per Ha)
Mauritius	7667	Belgium	10335
Reunion	7000	Spain	10005
South Africa	2876	Italy	9144
Ethiopia	2725	Austria	9105
Guinea-Bissau	2370	Germany	9085

*Source: (Gap minder Agriculture, 2007)*

European Top5-countries' maize yields 9.5 tons per hectare, which is more than twice as much as in Sub-Saharan Africa. Another comparison among each continent's country with the highest respective productivity rate tells the same story. Belgian maize harvest exceeds the one in Mauritius (7.7 tons per hectare) by 35 per cent.

**Table 2.2 Bottom5 countries in Sub-Saharan African and European Maize production (2007)**

<b>Sub-Saharan Africa</b>		<b>Europe</b>	
<b>Country</b>	<b>Yield (kg/ha)</b>	<b>country</b>	<b>Yield (kg/ha)</b>
Eritrea	159	Bulgaria	1459
Botswana	214	Romania	1740
Somalia	421	Slovakia	4275
Lesotho	425	Lithuania	4815
Angola	511	Portugal	5540

*Source: (Gap minder Agriculture2007)*

The productivity gap further increases among Sub-Saharan countries: a comparison between Sub-Saharan countries with high (Top5) and low productivity (Bottom5) reveals that the Top5 productivity is between three and 13 times higher. The same comparison among EU-countries shows that Top5-productivity is only thrice as high as Bottom5-productivity. These results illustrate that productivity is higher and better balanced among European countries. (World Bank, 2008).

The study therefore, sought to determine the factors underlying yield gaps which are necessary in increasing future food production capacity and help in formulating policies that can bring the situation back to normal.

### **1.3 Purpose of the study**

The purpose of the study was to establish the influence of maize management practices on food security among farmers in Moiben sub-county, Uasin Gishu, Kenya.

### **1.4 Objectives of the study**

The objectives of the study were:

1. To establish the role of planning of planting of maize on food security in Moiben sub-county.
2. To determine how growth control mechanisms of maize influence food production and security.
3. To establish the impact of maize storage on food security in Moiben sub-county.
4. To establish influence of maize marketing and marketing strategies on food security in Moiben sub-county.

### **1.4 Research questions**

The research questions were:

1. What is the role of planning of planting of maize on food security in Moiben sub-county?
2. Is there effect of control during growth stage of maize on food security in Moiben sub-county?
3. What impact do the maize storage practices have on food security in Moiben sub-county?
4. What are the effects of maize marketing and marketing strategies on food security in Moiben sub-county?

### **1.6 Significance of the Study**

Proper management practices for the growth of maize have always ensured good food production and security across the country. Cultivation of maize has been in existence throughout the history of mankind. People have always needed to eat and get a source of income through the exchange of goods or services for other goods or services popularly known as Barter Trade for satisfaction of basic human wants. Therefore this study is useful to farmers because the research will help

them identify and seize business opportunities and threat which arise and develop strategies which help in decision making for effective planning for future progression. Agricultural activities are the core source of basic market commodities. The research aim to establish better ways of managing growth of maize hence promoting food security. The research will assist the Agricultural officers to promote maize growing activities or management practices and exposure of positive maize management practices thus leading to a peaceful co-existence due to food security in the community. This study will enable learners to acquire the necessary knowledge and skills for better maize management skills for food security.

### **1.7 Basic assumptions of the Study**

During the study, the following assumptions were made: That the respondents were willing to answer the questions asked, the sample was the representative of the target population and that literature review materials were available and adequate.

### **1.8 Limitations of the Study**

The research was conducted during planting and weeding seasons when most of the farmers were busy in their farms, it was difficult to locate the individual farmers, and the farmers did not give objective response due to fear of the unknown. Due to poor state of the roads in Moiben sub-county, it was not possible to reach all the farmers. This is because the study was conducted during the long rains season.

In view of the above, the farmers were given the questionnaire to fill at home; they were also informed that their responses will be treated as confidential. To access the inaccessible areas a motorbike was hired as a means of transport.

### **1.9 Delimitations of the Study**

The research was carried out in Moiben Sub-County where it targeted maize farmers and agricultural officers. The study delimited itself to management practices of maize as regards its production, storage and marketing.

### **1.10 Organization of the Study**

The study is organized into five chapters: chapter one entails introduction, background of the study, statement of the problem, purpose of the study, objectives of the study, research

questions, significance of the study , assumptions, limitations, delimitations, definitions of significant terms and organization of the study. In chapter two, the study deals with literature review basing its discussion on the objectives of the study, theoretical framework and finally conceptual frame work while chapter three mainly deals with research methodology starting with introduction, research design, target population, sample selection, sample size, sample selection procedure, data collection methods, validity of research instruments, reliability of the instrument and data analysis, chapter four entails data analysis, interpretation and presentation Chapter five contains summary of findings, discussions, conclusions and recommendations.

### 1.11 Definition of significant terms

**Food security**

it refers to a situation when all people, at all times, 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.

**Individual or household food security**

Relates to income, access to resources, and affordability of food. It is largely a question of purchasing power, but can also suggest localized issues such as ‘food deserts’.

**Maize management**

This is the application of good agricultural practices on maize growing in the farm right from planting, growth, harvesting, consumption and marketing of maize to ensure adequate production of maize grains

**Food production**

This is a process of provision of food ready for use after numerous stages like planting, growth management, harvesting and the making food available for use.

**Food availability**

this means the presence of food, and its reliability.

## CHAPTER TWO

### LITERATURE REVIEW

#### 2.1 Introduction

Maize growing management practises plays a dominant role in Kenya's food security and economy despite the fact that upwards of 85 percent of Kenya is classified as arid or semi-arid (leaving arable land at a mere 15 percent of the total land area) and over-dependence on rain-fed agriculture sector leaves the country vulnerable to the vagaries of weather. Agriculture contributes 65% of total exports (KSHS 194 billion). The agricultural sector is divided into four subsectors, namely, industrial crops, food crops, horticulture, and livestock and fisheries. Food crops contribute to 32% of the agricultural GDP, with maize crops contributing 15%.

#### 2.2 Food production

Food security exists when all people, at all times, have physical and economic access to sufficient safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life( 1996 World Food Summit). 90% of the rural households in Kenya grow maize and production is dominated by small scale farmers who produce 75% of the overall production. The other 25% is grown by large scale farmers. In recent years there has been an expansion of land used for maize production as evidenced by 1.7 million hectares in 2008 and 1.8 million hectares in 2009. This was actually less than the 2009 Ministry of Agriculture targets which aimed for 2.2 million hectares producing 36 million bags. The available figures showed that 2009 production reached 2.4 million tonnes,( FAOSTAT, 2011) Kenyan maize production has been fluctuating over the last 10 years but there has been an increasing demand due to the high rate of population growth (estimated at 2.9% per annum). The national maize production ranges between 24 and 33 million bags per annum which does not keep pace with the domestic consumption levels e.g. in 2008, the consumption was estimated over 36 million bags. (ARC, 2000).

Improving agricultural production is essential to achieve a sustainable development process that will contribute to reducing poverty and enhancing food security and income growth. Research at CGIAR and other institutions has contributed to make this development possible. High yielding



varieties and new production technology have vastly increased the world's agricultural potential and provided rural income sources and affordable food for large parts of the population. But the production of food and other agricultural products does not end when the crop is harvested. Increasingly, agricultural products are not consumed in their raw form, and postharvest activities such as transport, storage, processing, and marketing account for a growing part of their final value. While research on the improvement of agricultural production has received considerable attention and funding, until recently postharvest activities have not attracted much attention from international research organizations,(Autrups andWasunna, 1987). One reason for this lack of consideration and funding may be that postharvest systems include very diverse activities, including product quality, harvest and storage, utilization and marketing, and policies and institutions. Given the complexity of the postharvest systems, it seems difficult to pinpoint the entry point for investment in research and for evaluation of impact of postharvest research. Yet, there is an emerging consensus on the critical role that postharvest research can play in meeting the overall goals of income growth, food security, poverty alleviation, and sustainable agriculture particularly in developing countries, (Seremet and Wakhisi,2009).

### **2.3 Planning of planting of maize on food security**

Maize thrives best in a warm climate and is now grown in most of the countries that have suitable climatic conditions. Its growth depends more on high summer temperatures than on a high mean temperature. It will ripen in a short hot summer and will withstand extreme heat. A large amount of water is needed during the growth of the maize. Its average maturing period is relatively short and this makes it possible to grow at fairly high latitudes, for maize to be planted the aspect of planning is very crucial as it determines total yield per size of plot. For the sake of food security, management of maize during planting relies on availability of water. ( Weber and Charles 2007).

The U.S.A. has the highest output of maize amongst the countries involved in maize growing due to good management practises. In 1964 it produced more than half of the total world maize growth, accounting for 104 million tons grown by the nation. Today the world harvests almost as much maize as wheat. Maize is exceptional in yield per unit area. The harvest may vary from 2.5 to 6 tons per acre according to the soil and its cultivation. Yields above 7 tons per acre have often

been recorded,( Idouraine and Luisa,2005).There are about 50 different species of maize having their own characteristic features and kernel sizes.Colour and structure, as well as the shape of the kernel, differ from one species to another. White, Red and Yellow are the most common basic colors of maize, but it is possible to find a wide range of shades, from Red-Brown to Light Red and from a Pale Yellow to Orange,(Marasas, Wingfieldand Hell,2005).

Maize crops around the world have their own unique production cycles of planting and harvest timeframes depending on climatic conditions and management practices. Grain prices tend to fluctuate the most during the growing seasons, as supply expectations can shift significantly due to planted acreage, weather and growing conditions,( Government of Kenya, 2007).

In the United States, most of the corn crop is grown in the Midwest. Typically, the southernmost areas will begin planting first and then the most northern areas will begin planting as the snow is gone and the soil is thawed.In the United States of America , planting of maize is done beginning in April and last into June. Harvest of maize is mainly in October and is finished by the end of November,(FAO,2013).

In China, maize is planted in mid-March through early June. Harvesting is done inAugust through October, (FAO, 2013).In European Union, planting is done from mid-April through to early June and harvesting of maize is donemid-August through late October, (FAO, 2013).In Brazil, planting of maize is done early August through November and harvesting February through May,(FAO,2013).In Argentina, planting is done on October throughNovember and Harvesting is from March through May, (FAO, 2013).

### **2.3.1 Climate change and planting of maize**

If climate-change projections are right, we'll need to improve yields per acre by as much as 12 per cent between 2016 and 2035 just to maintain today's total production.But according to scientists who studied how the weather affects French maize yield, the results of a new study reveal a real threat to our food supply in the coming decades. It turns out that maize yields drop significantly for every day when temperatures climb over around 32°C, and that heat stress has been as important an influence on maize yield as variation in rainfall since the turn of the century. This has been challenging to farmers and it may cause food insecurity,(FAO, 2013).

Over the past 50 years, the average number of days over this dangerous threshold has already risen from around three per year to more than five, and it is predicted to grow to around ten a year over the next two decades. In some major maize-growing regions it could be as much as 15 days per year above this damaging threshold. It's a serious risk to food security, Crop yields increased fourfold since the 2010, largely due to better technology such as pesticides and fertilizers, but this improvement has slowed in recent decades and the current rate of increase in technology may not be enough to maintain current production levels. Better farming methods and new crop varieties will help, but there's no guarantee we can meet the target,(Hawkins, 2008).The Hawkins' team analyzed the influence on maize yields of rainfall and high temperatures over the last years, combining historical crop data with climate model simulations. They then used projections of future daily maximum temperatures to predict the effects of heat stress on yields in the future, assuming that the historical relationship between climate and yield variations continues to hold, and tested these predictions against historical data to make sure they represent the world accurately,( Hawkins,2013).

The findings show that extremes of temperature have gained in importance relative to variability in rainfall since the 2010. Hawkins says this is probably because French farmers have greatly increased their use of irrigation, so that dry spells don't do so much harm to their crops. But irrigation gives no protection against extreme heat; during the 2003 heat wave, the nation's maize yields fell by around 20 per cent compared to the year before.Predicting rainfall is very difficult compared to predicting temperatures.Climate models predict strong temperature increases over the twenty-first century with relative confidence, due to continued growth in greenhouse gas emissions, whereas rainfall changes are less certain.,(American-Eurasian Agric,2011).The falloff in rates of yield improvement since the heady days of the so-called 'green revolution' may be partly due to the temperature rise we've already had. But it may also be because of the obvious steps to boost yields with steps like breeding better seeds, greater use of machinery and heavier use of fertilizers and pesticides have already been taken, and that future improvements will be much harder to achieve.

Different crops have varying tolerance for heat, but all have a threshold above which they suffer damage. Techniques like genetic modification or more efficient selective breeding may be able to help farmers develop new varieties that can handle hotter conditions, but it's not certain how

far this process can go. If climate change continues unabated, farmers might need to start switching to entirely new crops that are currently grown in hotter parts of the world,(Hawkins,2013).

### **2.3.2 Ecological requirements for maize production**

According to Global Agricultural Productivity (GAP), there are only two ways to expand agricultural production: increase the area planted or increase the production per unit of land, which may, where the climate permits, entail growing more than one crop on the same land each year. Farmers could double the number of hectares of land in production; however, there is only about 10% more potentially arable land that is not forested, highly erodible or subject to desertification,( University of Wisconsin,2013).Expansion beyond this would involve massive destruction of forests and, with them, wildlife habitat, biodiversity and carbon sequestration capacity, which would accelerate global warming. Most of the potentially arable land is inferior to that already in production and is located in remote areas of sub-Saharan Africa and South America where infrastructure is minimal. To sustainably double agricultural production will require that most of the expansion come from increasing the production per unit of land already in use,(GAP, 2013).

The availability of fresh water to agriculture may be an even greater constraint to doubling production than the availability of land. Farmers use about 70% of the world's fresh water. With more than half of the world's population now living in cities, there is no way the world's farmers will have access to 70% of the fresh water. Cities will outbid farmers for available water. Whereas farmers may have to double the average productivity of the land already in agricultural production, they may have to triple the "crop per drop", the output per unit of fresh water they use, (GAP,2013).

East and South Asia have more than twice as much of the world's population than their proportion of arable land, and while the Middle East and North Africa has similar proportions, it lacks water for agricultural production. The population and income of these three regions are projected to grow significantly, placing greater demands on the world food system. Sub-Saharan Africa, with the fastest growing population, has similar proportions of arable land and population, and its relative abundance of land is one reason the land-scarce countries of Asia and

water-scarce countries of the Middle East are interested in acquiring land there,(World Bank,2013).

Most of the world's world crop production regions lie in the northern hemisphere. South Asia, with the largest total population and the largest number of extremely low-income people, as do the densely populated regions of East and South-East Asia. In these regions, as well as in North America and Eastern Europe – two of the world's great grain baskets – most of the arable land is already in crop production. South America and Sub-Saharan Africa have most of the additional land that could be brought into production, ( Wisconsin,2013).

Low temperatures and insufficient moisture constrain the land in crop production. Long-term climate change projections suggest that the average temperature will increase more in the high latitudes of the Northern Hemisphere than at the Equator. This should shift the margin of crop production further north into Canada, Russia and Alaska, expanding the area of potentially arable land in those countries. Long-term changes in the volume and timing of precipitation will also affect the extent and location of arable land in the future; however, the various climate projection models differ more on future trends in precipitation than in temperature, (International Institute for Applied Systems, 2009). The inherent quality of the soil in regions without severe climatic constraints is categorized into performance (fertility) and resilience (resistance to erosion). Soils with the highest performance and resilience are seen in the Midwest of the United States, the Pampa of Argentina and the region north of the Black Sea. In the savannah region of Brazil (cerrado), where cropland was recently expanded, the soils have low–medium performance and medium–high resilience. They can be made very productive with purchased inputs, but have a higher unit cost of production. Most of the 10–12% potentially arable land is found in South America and sub-Saharan Africa, (Natural Resources Conservation Service, U.S. Department of Agriculture, 2013).

There are great differences among regions of the world in maize yields (agricultural production per unit of land) with the highest maize grain yields in Western Europe, East Asia and the Midwest of the United States; yields of about the world average in South America, Central Europe, Southeast Asia and Australia; and low yields in sub-Saharan Africa, South and Central Asia, north-eastern Brazil and Central America. The wide differences in yield suggest that it should be possible to significantly increase productivity per unit of land. With their low yields,

many low-income countries' farm sectors are contributing less to their national food supply and global food security than they could,( University of Wisconsin,2013).

In Mexico, maize is cultivated on 8,000,000 hectares, most of which is rain-fed and involves non-industrial farming (Fernandez, Wise and Garvey 2012: 7). The farming, milling, and cooking of maize is a key part of everyday life in the countryside. The crop is so central to the rural diet that a meal is considered incomplete without tortillas. In many indigenous regions of the Americas, maize seed retains a strong spiritual significance and is the focus of a variety of rituals involving the blessing of seed, celebrating the harvest, and so on. For many indigenous peoples, like the Zapotecs of Oaxaca, maize has a soul, (Gonzalez 2001).In rural Colombia, while maize is also regularly eaten in both rural and urban areas, generally speaking it is not required to complete a meal. It is grown on approximately 460,000 hectares, largely along the Atlantic Coast in the department of Córdoba, followed by Sucre and Cesar, but also in the interior departments of Tolima, Meta, Valle and Huila (Fenalce 2011). While maize represents a way of life for those indigenous groups like the Zenú who grow the crop, it is not central to the idea of the nation as a whole –what it means to be Colombian—to the extent it is in Mexico, (Gonzalez 2001).

The commercial planting of biotech crops around the globe went from 1.7 million hectares in 1996 to 160 million hectares in 2011 (ISAAA 2011). Food scholars have suggested that genetic engineering and its regulation are central to an emergent neoliberal food regime (Pechlaner and Otero 2008) – or the institutional structures, norms and practices of food trade, governance and political economy (McMichael 2009). This regime is sometimes discussed as a feature of a contemporary capitalism or bio-capitalism which involves the harnessing and management of biological processes and resources in order to generate profit. Transgenic seed is often accompanied by intellectual property rights (IPRs) which require users to pay a licensing fee in addition to the initial seed purchase. IPR runs counter to the widespread practice of agriculturalists to save and exchange seed for replanting, and provides another way to overcome the free reproduction of seed or seed's biological barrier to commoditization, (Kloppenborg 1988). The commercialization of seed, including IPRs, contributes to “accumulation by dispossession,” or the accumulation of capital by undermining a group's access and control over the resources that it needs to maintain its livelihood (Harvey 2003, 147–48).

Another feature of the current food regime worth mentioning here is how trade agreements and the World Trade Organization protect farm subsidies in the global north, while countries from the global south import staple foods that they themselves produce. Both Mexico and Colombia have seen rising corn imports in recent years for use as animal feed, food, and industrial purposes. In Mexico imports reach 8 to 9 million metric tons per year (or higher in years of production shortfalls). However, with the right policies, Mexico could once again be self-sufficient in maize production (Fernandez *et al*, 2012). In Colombia, imports have increased since the 1990s, reaching 3.3 million metric tons in 2010, although a new government program hopes to reduce imports (Fenalce, 2011: 4). Despite prevailing trends, sufficient local resistance to agricultural bio-technology could modify or even derail, the technology's role in individual nations, and accordingly, in the unfolding food regime as a whole. (Pechlaner and Otero, 2008: 352). Indeed, many anti-GM activists act as policy watchdogs and in places like Mexico have been quite successful in raising public concern around the import, testing and commercial production of transgenic maize.

The ability of farmers in Africa to continue cultivating maize in the future using current production practices is questionable, given climate change projections showing with high confidence that some degree of warming is inevitable (IPCC, 2007a). According to the IPCC Fourth Assessment Report, (AR4),

Developed countries in temperate zones will likely benefit from higher crop yields under current global warming patterns while crops in tropical regions are already at the upper limit of their temperature sensitivity. Many scientists also predicted that a small local temperature increase of 1°C to 2°C in dry tropical regions would result in a decrease in crop yield, (Lobell *et al.*, 2008, O'Neill, 2007). Yields of cereals at lower latitudes, where Ghana, (latitudes 4.51N and 11.51N and longitude 3.51 W and 1.31E) is located, are likely to fall between 10% and 20% by 2050 because of warming and drying and crop yields from rain-fed agriculture could reduce up to 50% in some countries by 2020. Maize (*Zeamays*) is the most important grain crop in South Africa and is produced throughout the country under diverse environments. Successful maize production depends on the correct application of production inputs that will sustain the environment as well as agricultural production. These inputs are, inter alia, adapted cultivars, plant population, soil tillage, fertilization, weed, insect and disease control, harvesting,

marketing and financial resources,(Brown,L.R. 1963).In developed countries, maize is consumed mainly as second-cycle produce, in the form of meat, eggs and dairy products. In developing countries, maize is consumed directly and serves as staple diet for some 200 million people. Most people regard maize as a breakfast cereal. However, in a processed form it is also found as fuel (ethanol) and starch. Starch in turn involves enzymatic conversion into products such as sorbitol, dextrin, sorbicand lactic acid, and appears in household items such as beer, ice cream, syrup, shoe polish, glue, fireworks, ink, batteries, mustard, cosmetics, aspirin and paint. Approximately 8.0million tons of maize grain is produced in South Africa annually on approximately 3.1 million ha of land. Half of the production consists of white maize, for human food consumption, (Byerlee and Derek. 1997).

Maize needs 450 to 600 mm of water per season, which is mainly acquired from the soil moisture reserves. About 15.0 kg of grain is produced for each millimeter of water consumed. At maturity, each plant will have consumed 250 L of water. The total leaf area at maturity may exceed one square meter per plant. The assimilation of nitrogen, phosphorus and potassium reaches a peak during flowering. At maturity the total nutrient uptake of a single maize plant is 8.7 g of nitrogen, 5.1 g of phosphorus, and 4.0 g of potassium. Each ton of grain produced removes 15.0 to 18.0 kg of nitrogen, 2.5 to 3.0 kg of phosphorus and 3.0 to 4.0 kg of potassium from the soil. No other crop utilizes sunlight more effectively than maize, and its yield per ha is the highest of all grain crops. At maturity, the total energy used by one plant is equivalent to that of 8 29315 W electric globes in an hour,( ARC, 2000).

The number of kernel rows may vary between four and 40, depending on the variety. Up to 1 000 kernels may be produced by a single plant. In spite of only one pollen grain being required to produce one kernel, each tassel produces some 25 000,000 pollen grains, i. e. 25 000 grains for each kernel. As a result, up to 40 % of the tassels in a planting may be lost without affecting pollination, other factors remaining optimal, (ARC, (2000)).Seeds planted in Kenya vary from local landraces to composites and hybrids. Local landraces are poor yielding but have the greater advantage of being suited to the local conditions. They are disease and pest resistant in addition to being more palatable to local tastes. It is also possible that these varieties might be more resistant to fungal attack than the improved composites and hybrids. Composite varieties are certainly better yielding than local landraces, for example, the Katumani composite from KARI



which is well suited to the dry land zone. There are now many types of hybrids and it is now easy to find types suitable for all agro-ecological zones, (ARC, 2000).

The Kenyan government has no policy on maize despite its importance in the Kenyan diet. The seed companies are driven by a business approach that appeals to their clientele; increase in the number of bags harvested per hectare. This has been pushed by efforts of various government policy papers (ERS) that considers having food security as important in development of Kenya. In this regard, the seed companies have concentrated their efforts on high yielding varieties which meet a partial goal of food security – quantity but have compromised on the safety, (GoK, 2012). In Kenya maize is grown in different time depending on the place and land condition. Maize is mainly cultivated mainly during short and long rain seasons. However, considering that aflatoxin outbreaks have occurred in the country since 1960 with the highest epidemic levels in 2004, the priority should now be for the development of seed varieties that are less susceptible to fungal attack and aflatoxin accumulation, especially for the Eastern aflatoxin susceptible belt. It is very likely farmers will be willing to pay for new strains that are resistant to aflatoxin contamination, given the success the seed companies had with selling seed varieties resistant to maize streak virus and Striga, (Ministry of Agriculture, 2013).

#### **2.4 Maize growth control and food security**

Maize farmers should seek advice from government extension officers and other non-governmental organizations in the region (EAGC) on agronomical practices to ensure food security. They should procure their seeds and agrochemicals from reputable seed and agrochemical companies who also offer extension services. The maize farmers should use agrochemicals to control weeds as hand weeding is not practical on large acreage where maize is growing, (Ministry of Agriculture, 2013). Use of these agrochemicals helps the maize plant grow healthy and therefore resistant to fungal infestation at the pre-harvest period. It is known that plants can be stressed due to weed infestation and adverse weather conditions and that this stress predisposes the plants to fungal infestation and that may cause food insecurity, (FAO, 2011). There is a need though to undertake further scientific projects to investigate how other agronomic practices, for example those related to drought management, can increase or decrease fungal contamination, (WHO, 2012).

Many smallholder farmers, who account for most of the agricultural sector in Malawi, use rudimentary agricultural techniques, plant haphazardly and pay little attention to the quality of maize and the use of fertilizers. As a result, productivity has been extremely low and soil fertility has gradually declined. This further worsens the farmers' situation and keeps them in a cycle of extreme poverty hence food insecurity, (Agricultural Research Council, 2002).

The Rural Livelihood Support Programme (RLSP) started in 2004 to help the most vulnerable farmers move away from extreme poverty. The programme, which works closely with local authorities such as Village Development Committees (VDCs), uses a participatory approach in which the farmers identify the areas where they need the most support. It is being implemented in three southernmost districts of Malawi – Chiradzulu, Nsanje and Thyolo – which are characterized by high population density, small farms, almost total dependence on agricultural livelihoods and a very high incidence of extreme poverty, (Ajebesone, 2010).

### **2.5 Maize storage and food security**

Cereals, especially maize and legumes form a significant food source in the Sub-Saharan region. It is estimated that more than 75% of the local cereal production is provided by small scale farmers (FAO, 2011). For example, it is also estimated that about 90% of rural households in Kenya grow maize. However, the national maize supply by these small scale farmers annually decline due to a combination of crop failures in the predominantly short rains dependent region coupled with pre- and post-harvest losses which range from 20-30%. FAO in their 2011 report spoke of the “Missing Food” in which they estimated that currently, 1 out of every 5 kilos of grain produced in Sub Saharan Africa is lost to pests and decay. This lost food is enough to feed 48 million people for 12 months (Greener Journal of Agricultural Sciences, October 2012. [www.gjournals.org](http://www.gjournals.org) 280) and is valued at around \$4 Billion or ½ annual grain imports to Africa. This means that a reduction in grain losses could have an immediate and significant impact on people's livelihoods.

Furthermore, because cereals form a major part of the staple food of the sub-Saharan region, it is important that food security and safety concerns be identified so that appropriate control steps can be taken to prevent post harvest food losses and human health hazards. To date, the two major health concerns related to cereals in Africa are contamination with pesticide residues used in maize production and storage and fungal toxins that contaminate maize during pre and post

harvest periods especially the aflatoxins. Aflatoxins are toxic metabolites produced by fungal species during their growth under favorable conditions of temperature and moisture (Klich, 2007). The major aflatoxin producing species are *Aspergillus flavus* and *Aspergillus parasiticus*. The main cereals affected are maize, sorghum, rice and wheat and other crops like groundnuts and cassava (Cotty, 1997, Kabak et al., 2006). The Aflatoxins produced are classified as B1, B2, G1 and G2. Aflatoxin B1 is the most toxic of the four. While these toxins do not seem to have physiological functions for the fungus, they are now recognized as potential carcinogens, teratogens, mutagens, immune-suppressants and have estrogenic effects in humans (Amaike and Keller, 2011). This danger has not reduced in the major part of the Sub-Saharan region especially in Kenya and surprisingly it seems to be increasing. For instance, recently in 2010, one of the laboratories in Kenya tested 130 maize samples out of which only 47 samples had aflatoxin levels less than 10 ppb. The highest level of aflatoxin recorded in that year was 830 ppb (FAO, 2011).

The global Center for Disease Control has estimated that more than 4.5 billion people in developing countries are chronically exposed to aflatoxins in their diets. Cereals especially, maize grains, can be prone to aflatoxin contamination, particularly when they come into contact with infested soil during harvesting, threshing, and drying. Contamination can also occur when grains are in storage due to pest infestation and the poor conditions that lead to accelerated growth rates of *Aspergillus* fungi and aflatoxin production. Although aflatoxin is produced in minute quantities, its potency, prevalence, and the ease with which it can permeate farmers' fields and storage areas make this highly carcinogenic metabolite particularly dangerous (Wu, 2004). However many farmers and consumers are not aware that one cannot see, smell, feel, or taste aflatoxin in grains and that laboratory testing is required to discover its presence. You can, however, avoid the use of grains suspected to be contaminated. Some consumers assume that boiling of maize can destroy aflatoxin, but this is not the case as normal boiling cannot destroy aflatoxin. Others think that grinding contaminated grain can make it less dangerous and a large group of farmers also think that moldy cereals like maize can be fed to poultry, but chicken are even more susceptible to aflatoxin contamination and can furthermore be accumulated in the eggs which are consequently eaten by human. Some studies have shown that aflatoxin poisoning is accumulative in the human body. Acute exposure to high levels of aflatoxins leads to aflatoxicosis, which can result in rapid death from liver failure, (Amaike and Keller, 2011). In 2004, during the worst known outbreak of aflatoxicosis in Kenya, 317 cases were reported and

125 people died. The minimum level of aflatoxin exposure required to cause aflatoxicosis is not known, but the disease mostly affects children. Unfortunately, developing countries in many regions of the world, such as Sub-Saharan Africa, cannot afford the costs associated with the monitoring and mitigation of aflatoxin in food and feed crops. This has led to an increased risk of exposure to aflatoxin resulting in outbreaks of acute aflatoxin poisoning (Ngindus et al., 1982; Probstet *al.*, 2009).

### **2.5.1 Maize storage losses among farmers**

A storage loss of maize on small farms occurs when maize is hand harvested, dried, and placed in storage. Drying corn to 14% moisture or less is necessary to prevent growth of fungi. Storage in a secure container can prevent losses from rats and birds. Maize may be infested with insects such as maize weevils (*Sitophiluszeamais*) before harvest. Without proper management, losses of maize stored by subsistence farmers can be 100% of the crop. Local experts estimated that 22.4% of the 2008 maize crop in the countries of Southern and Eastern Africa was lost during storage (PHL Network 2011). Losses in the Kamuli district of Uganda are estimated at 40% (Musoke 2010). The value of postharvest losses of grain in Sub-Saharan Africa could be as much as US\$ 4 billion out of a grain production value of US\$ 27 billion for 2005-07. These losses represent a huge mass of grain that could be made available for food without use of additional land, seed, labor, water, and other inputs.

Hermetic grain storage systems strive to eliminate all exchange of gases between the inside and the outside of a grain storage container. If the gas exchange is low enough, living organisms such as insects within the container will deplete oxygen and produce carbon dioxide until they die or become inactive due to the low oxygen. Hermetic grain storage can be an appropriate method for many subsistence farmers. It eliminates the need for insecticides, which are costly and often inaccessible for these farmers. Misuse of insecticides by farmers is common and can cause health and environmental problems (Baributsaet *al.*, 2010). If maize is dried to 14% moisture or less, storage fungi can be controlled. A robust container protects the maize from birds and rodents. (Yakubuet *al.*, 2011) have developed a procedure to estimate the time required for complete mortality of adult maize weevils in a hermetically-sealed container of maize. Data from laboratory tests of hermetically-stored maize at Iowa State University formed the basis for this procedure. On average, weevil's die when oxygen level reaches 4%. Using container volume and

assuming maize kernel density at  $1.24 \text{ g cm}^3$ , along with the calculated oxygen utilization value, and assuming no leakage of oxygen into the barrel, the predicted time to 100% mortality is calculated to be nine days.

Hermetic storage systems include the Postcosecha galvanized steel silo which was developed in Central America in about 1980 for on-farm storage of grain and seed. Postcosecha (postharvest in Spanish) is a development program begun in Honduras in the 1980s, which has evolved into a technology production and dissemination organization operating in Central America and elsewhere in developing countries. The Swiss Agency for Development and Cooperation supported the original silo construction programs in El Salvador, Nicaragua, Honduras, and Guatemala where nearly 600,000 silos were built by 2008 (Martinez 2008). Postcosecha silos are built locally using simple tools, 26-gauge (0.7-mm) galvanized steel sheets, and lead-based solder. Grain capacities range from 180 to 1360 kg (7 to 53 bushels) Joints and seams use a 5-mm fold, which is crimped and soldered for strength and tightness. A 37-cm-diameter intake throat is built into the top of the silo for filling and inspection. The throat protrudes about 10 cm above the top and is fitted with a snug-fitting removable cap. A 15-cm diameter outlet port for removal of grain is located with its center 10.5 cm above the floor. It protrudes about 15 cm and is also fitted with a snug fitting removable cap. The intake throat and outlet port caps can be sealed with locally available products such as tallow, grease, soft soap, beeswax, or a bicycle tire innertube strip (SDC 2013).

Bulk products such as maize, beans, sorghum, rice, wheat, barley, as well as seeds can be stored in silos. The product must be clean and dry (below 14% moisture for maize) before being placed in the silo to prevent fungal spoilage. The silo has no provision for mechanical aeration. At the farm the silo is placed on a 15-cm-tall wood platform in the shade, under a roof, or inside the house. The outlet port allows small quantities of maize to be removed as needed for food. Storing grain in a silo also allows farmers to market surplus grain when prices are high, instead of selling at harvest when prices may be at year's lows. If clean maize at 14% moisture or below is placed in a silo and managed properly, losses during one year or more of storage will be near zero. If the silo is filled with maize and hermetically sealed, maize weevils and other insects will be kept under control. Insecticide tablets (Phostoxin, Detia, Quick Phos, and Gastion) are also available for chemical control of insects in the silo. There is evidence that the caps on these silos often are

not sealed well enough to kill insects due to lack of oxygen and insecticide tablets need to be used to keep the grain insect free (GrainPro Inc. Latinoamerica2010).

Purdue Improved maize Storage (PIMS) System was developed by a team at Purdue University which has improved maize storage and promoting its use in Western Africa with funds from the Gates Foundation. The program uses a triple plastic bagging system developed by entomologist Larry Murdock (Forbes, 2007). The PIMS system was developed for storage of maize in West and Central Africa and the project goal is to have 50% of the farm-stored maize in hermetic storage without insecticides by 2012, (Baribusta *et al.*, 2010). PIMS technology uses plastic bags to achieve hermetic storage of maize and other grains. Threshed maize grain, dried to an appropriate moisture level and free of crop debris, is placed into 50- or 100-kg capacity high-density polyethylene bags with 80- $\mu\text{m}$  thickness. A first bag is filled completely, but with a 20- to 30-cm neck, which is tied securely. Then, this bag is surrounded by a second bag with the same thickness. The second bag's neck is also tied securely. Finally, these two bags are placed in a third woven nylon or polypropylene bag used for its strength. With the third bag tied securely, the container can be handled without bursting the inner bags. Over the past three years, over one million bags have been produced and sold through this program (Baributsa *et al.*, 2010). Grain pro ultra-hermetic bags of Concord, Massachusetts, USA manufactures and markets an extensive line of ultra hermetic bags designed to achieve hermetic storage conditions. The bags are used to store a wide variety of agricultural commodity products and also many types of seeds, and are marketed worldwide (Villars *et al.*, 2010).

The Super Grain bag III is a type suitable for use by the small farmer to store maize on the farm. It is available with capacities of 30 to 100 kg of maize. Besides maize, it is applicable for coffee, paddy, milled rice, sorghum, millet, soybeans, wheat, cocoa, beans, peas, lentils, and all types of seeds. Product is placed in the 78- $\mu\text{m}$  multilayer polyethylene bag with a proprietary barrier layer that makes its permeability to oxygen far lower than polyethylene alone. It uses a two-track zipper and is sealed using a zipper slider. The sealed bag is then placed in a protective woven outer bag. With careful use, the bag will last for about five cycles. Punctures can be repaired with tape, (Villers, 2013). Recycled plastic containers can be used. Containers are readily available at low prices in markets in sub-Saharan Africa. One common type container is made of plastic and originally contained edible oil. In order to test the concept of using recycled edible oil containers

for hermetic maize storage; an experiment was conducted comparing 10-L hermetically-sealed containers and identical containers with screen caps. However, the hermetically sealed containers resulted in 100% adult weevil mortality. In the open containers, approximately 50% of the weevils were alive and actively feeding on the maize, which resulted in significant quality deterioration compared to hermetic storage.(villers,2013)

Pest management practices during storage of maize is also very important as it provides protection of maize grains against pests. The commonest storage pesticides (insecticides) applied as dusting powders are pirimiphosmethyl, an organophosphate (OP) compound mixed with Permethrin6 (a pyrethroid, common name Actellic). Other dusts powders include Malathion (OP), permethrin (pyrethrin), fenitrothion (Op) and fenvalerate (pyrethrin). While these pesticides are used to prolong storage and control pest infestation during storage, no data is available of the residue levels of these pesticides, (ARC, 2000).The data that is available on grains shows that the residue levels are highest on the seed testa , therefore residues could be high on whole meals and whole meal products. It is possible to use most of the approved agricultural chemicals with little food safety impact, provided good practices are used. However there may be need for some investigations to be undertaken to ascertain if these practices are being actively followed in the production of maize. (WHO, 2005).

Management of Maize grading standards is another critical issue on maize marketing. Since the acute poisoning of the 125 persons in 2004, it has been an on-going challenge to bring the contaminated maize problems in Kenya under control. The Government of Kenya through the Kenya Bureau of Standards and the East African standards harmonization process have established quality standards. This means that there is a mandatory maize grading system for the purpose of trade within the East African community (EAS2:2005) which is also implemented on the Kenyan domestic market by the Kenya Bureau of Standards (known as KS-EAS2:2005).Farmers' harvesting practices can also determine food security. During harvesting the farmers cut the maize and make stakes in the field. The maize was left to dry and the cobs removed later. During this period, the maize cobs are thrown on the ground as they remove the cobs from the husks and later picked up for storage before shelling. This practice exposes the maize cobs to fungal spores in the soil and this increases the risk of Aflatoxins contamination in later steps in maize processing, (Ministry of Agriculture, 2013).Timing of the harvesting for

when the maize is mature and dry is critical in helping reduce the moisture levels and therefore the fungal growth and Aflatoxins production rates, yet it was identified that the farmers did not have any idea on when it is best to harvest. (FAO, 2011.)

Farmer's maize drying practices and food security are inseparable in that maize drying is a step in reducing the moisture content, thus preventing fungal growth, Aflatoxins production and consequent contamination. The farmers should dry the maize in the field before cobs are removed. It is further dried while in store before shelling with the use of tractor propelled shelling machines. If the shelling machine is not calibrated for the maize varieties and type (flint or dent maize), it may result in broken grains that increase the chances of fungal mycelia penetrating the maize grains and grow and producing the Aflatoxins which make maize unfit for human consumption hence food insecurity. The calibration of these machines is critical if farmers want to further mitigate fungal infestation and Aflatoxins contamination, (Ministry of Agriculture, 2013). Maize is further dried before it is bagged for sale especially to markets which have grading systems to check the moisture content. In these circumstances, maize is dried on the ground on canvas thus preventing contact with the soil. In many instances, such maize is dried along the road sides or in open fields where soil is easily blown onto the drying maize on canvas. Dust laden with fungal spores from passing vehicles can easily be deposited on the maize drying canvas, (KARI, 1999).

Farmers sorting practices are required to be taken into account, farmers rarely sort and select maize after shelling. Sorting and selection is done in the field when cobs are being removed from the maize stakes. This selection is not adequate as many cobs rotten to various levels may be passed depending on the judgment of those harvesting. The clean maize is usually found to contain rotten and moldy grains which are not sorted and selected later. The assumption is that the level of rotten grains allowable by the grading system will not be exceeded. The criterion of 2 and 4% rotten grains for Grades one and two maize respectively should be made stricter to make sure that no rotten maize is allowed at this point, thus reducing the risk of fungal growth and aflatoxin contamination of maize during further storage, (ECAMAW, 2005). The very rotten cobs separated from the good cobs and later shelled separately and the grain used for making animal feeds. The practice is to mix one bag of clean maize with two bags of rotten maize, mill and use these as animal feeds. This practice of dilution does not reduce drastically the amount of



Aflatoxins in animal feeds. It is important to note that milk from areas surrounding the maize growing areas (Eldoret Municipality) was found to contain Aflatoxins M1 and feeds having high levels of total Aflatoxins exceeding the allowable limits by FAO/WHO (Kang'ethe and Langat 2010).

The post harvest period is that part in the food life cycle which covers all stages after harvest and includes cleaning, grading, transportation, storage, processing and packaging and marketing. In terms of economics, it is the period when the highest value is added to the grain product before it gets to the consumer. If any grain is not handled in a way that maintains its quality, that product can lose its value and hence affect the livelihoods of all those involved in the supply chain. Moreover, the post-harvest losses are also supposed to be inclusive of the inputs, such as land, labour, fertilizer, water which are all scarce resources involved in agricultural production, (ARC, 2009). Effective postharvest management can contribute to conservation of scarce resources while minimizing the need to produce more food to cover the losses caused by lack of appropriate postharvest technologies and strategies, (KARI, 2008). By the year 2025 it is estimated that the global food output must increase by about 75% to feed a population estimated to be close to 9 billion. Hence by then we shall need 2.8 billion tones of cereals, 5.3 billion tones of other crops, 1.6 billion tones of animal products. Hence, it is currently important to consider post-harvest grain management as strategic policy concern especially in the Sub-Saharan region where there is a dramatic increase in population growth and reducing agricultural land, (Hounhouigan, 2002).

Post-harvest management is a crucial component of food production in developed countries. However, it is still neglected in the developing countries where large losses from farm to plate have been attributed to poor handling, distribution, storage, and purchase/consumption behavior. Although the main investment in addressing global hunger has been on increasing food production, it needs to be complemented with comprehensive programs which address the huge postharvest losses especially in the famine prone Sub-Saharan countries, (WHO, 2011). Recent studies have shown that this is surely one of the most sustainable alternatives to increasing food security. The highlight of this review, which links food security, farm management, Aflatoxin mitigation, agribusiness and crop diversification to post-harvest management, justifies an investment in reducing post harvest losses in any country, (ARC, 2012).

## **2.6 Marketing of maize and food security**

The overall context of a shift to a more open, and less subsidy-dependent, trading environment, the issue of the nation's food security policy is often raised. The Strategy for Sustainable Farming and Food (SFFS) does not define a particular structure of farming that the Government wants to promote. Its emphasis has been on a competitive and environmentally sensitive farming sector that is responsive to the market; in which profitability matters more than production; sustainability more than size; efficiency more than self-sufficiency,( Hounhouigan,2002).In recent years, food security has become increasingly discussed as a matter of concern in some developed countries, including in the UK. Two main triggers appear to be at work: In the UK, the self-sufficiency ratio of domestic production to consumption has been in noticeable decline over the last decade. The 'decoupling' reforms of the CAP, together with the prospect of trade liberalization in agricultural products, are expected to reduce domestic agricultural production in the UK and Europe. In the context of climate change, international energy concerns, geopolitical tensions and international terrorism, a growing sense of the potential for disruption to domestic food supplies in an uncertain world,( Hounhouigan,2002).Within the UK, other factors have emerged, which, coinciding with the falling self-sufficiency ratio, have contributed to a sense of growing unease: the power of globally-sourcing supermarkets; a sharp decline in farm incomes; public health concerns with food safety; growing awareness of environmental issues; the potential for short-term interruptions to fuel supply, and longer-term concerns over energy security and climate change.

A closer look at U.S. corn exports finds that trade disruptions could pose food security concerns for U.S. trading partners, largely because few countries export the amount of corn that the U.S. does,( Fandohan ,P., Zoumenou,2011).The paper explains that corn is at the center of global food security because the demand for meat and fuel is growing. Corn also serves as a raw material in producing starch, oil, protein, alcohol, food sweeteners and as a dietary staple, thus disruptions in one major exporter's supplies could bring on price shocks(Hounhouigan, 2002).Disruptions to corn exports could pose food security risks for U.S. trade partners. The U.S. has an important role in meeting the demand because according to trade patterns from 2000-2009, the U.S. is easily the largest exporter, exporting four times as much corn as the runner-up, Argentina,( WHO, 2002).In knowing that the U.S. and Argentina are large exporters, the researchers then examined United Nations Commodity Trade data to determine if any patterns depict trading

within small sub-groups, or "clusters" of importers. About three main clusters were identified around Europe, Argentina and the United States,( Mary W. Corn in Clay,2000).The patterns showed that nations which import corn primarily from only one other nation may be vulnerable to any changes in their exporters' ability to produce and ship maize, the statistics show that the vast majority of nations are exporting to or importing from only one or a small number of nations. For example, Japan, Egypt, South Korea, and Taiwan import 90%, 40%, 85% and 80% of corn from the U.S (WHO, 2002). The results suggest that of the top five corn-importing nations worldwide, four of them are very heavily dependent upon U.S. corn exports, and have stayed this way or are increasingly this way over the past decade, Hence, U.S. maize exports play a critical role in ensuring maize security for top maize importers,(Eubanks, 2001).

While it's uncertain what the actual risks will be – such as a drought for example – it's also uncertain what exactly could spur a full-on disruption. In response, the authors suggest the largest maize producers should consider potential solutions for adverse effects. But, they point out, if major disruptions were to occur in the corn supply, other cereal grains may be able to fill gaps and soften the impact of a poor corn production or trade.

In Uganda, cost – benefit analysis of maize growing at the current indicative farm gate prices of Ug. Shs 120 – 150/= per kilogram (kg) does not pay back the farmers in real financial terms and therefore compounds the poverty levels of communities growing maize for economic benefit. This ultimately makes maize growing a silent loss making farming venture and it may lead to food insecurity,( Brown,1963).The loss however, is felt more by the dry grain producers while the middlemen/ processors reap the economic gains or put simply as the sweat of the innocent poor rural farmers. It's this category of rural producers that experience high post harvest losses and a big challenge of storage pests. The breakeven price would be achieved at Ug.shs. 192.33/= per kilogram of dry grain maize at the above estimated cost per acre. This price is not easily realizable in most rural areas of Uganda.However, the same maize when processed, as floor goes for Ug. Shs 500 –1200/= per kilogram depending on the location. This despite the fact that milling maize costs between Ug. Shs 30– 60/= per kilogram also depending on the number of layers of husks removed. This therefore implies that to the marketer/processor, the bulk of the cost reflected in the final product price (flour) is attributed to the profit margin and transportation costs that are high, (Red Cross, 2013).

While also, higher returns would be accessed where early growers sell maize inform of fresh cobs for roasting. This is also short-lived depending on the season in place (scarcity),( Economic review of agriculture, 2008).The above scenario has long-term sector and structural implications particularly with the shift of emphasis from the traditional cash crops that have continued to fall on the world market in preference to the annual crops (Non –traditional export crops) where maize dominates. Traditionally, maize is an easy crop to produce, with less cost, easy to manage, most times resistant to water and heat stress and is widely adoptable to most soils in most parts of Uganda. The above assumptions hold only if, the right seed material is selected and planted in adequate soil moisture with basic fertility levels to provide adequate nutrients for normal growth. In some communities, maize stands out as a key income-earning crop and has phased out coffee, cotton, and other cash crops .This implies that most of the household earnings and thus poverty fluctuate with maize prices. This is because earnings from maize determine a bigger proportion of household income. The few options that have made maize crop thrive are the low wage costs that vary from region to region, (FAO, 2013).While in very rare cases and only practiced by a few average farmers, maize is processed and sold as flour. The above concerns compounded with low maize quality, quantity, rain fed agriculture (bumper harvest at same harvest time – causing spiral price fluctuations). No clear marketing structures due to liberalization of the economy are in place for the ordinary small farmers with poor bargaining power (FAO, 2013). Furthermore, there aren't any national food storage facilities in form of silos to handle stock fluctuations. This scenario has hastened the degree of vulnerability and susceptibility to regular exploitation by the middlemen in the maize marketing chain. Because, rural farmers have few alternative sources of income and facilities to secure credit, rarely are they patient to bulk the maize produce and obtain higher bargains through commodity exchange outlets, quality and quantity notwithstanding, (Field, 2000).

Contrary, however, farmers are neither willing to mill nor sell flour instead of dry maize grain due to absence of alternative sources of income for recurrent expenditure. This is where, Village Banks (VBI) and Village Savings and Loan Associations (VSLA) must redefine their roles and occupy a new market niche, through farmers financial insurance and or linking farmers to better markets / bargains by enabling farmers to bulk their produce to fetch higher prices. It's also evident that the government hurriedly and prematurely liberalized the economy without attempting to address the structural bottlenecks in the agriculture sector. The structural linkage

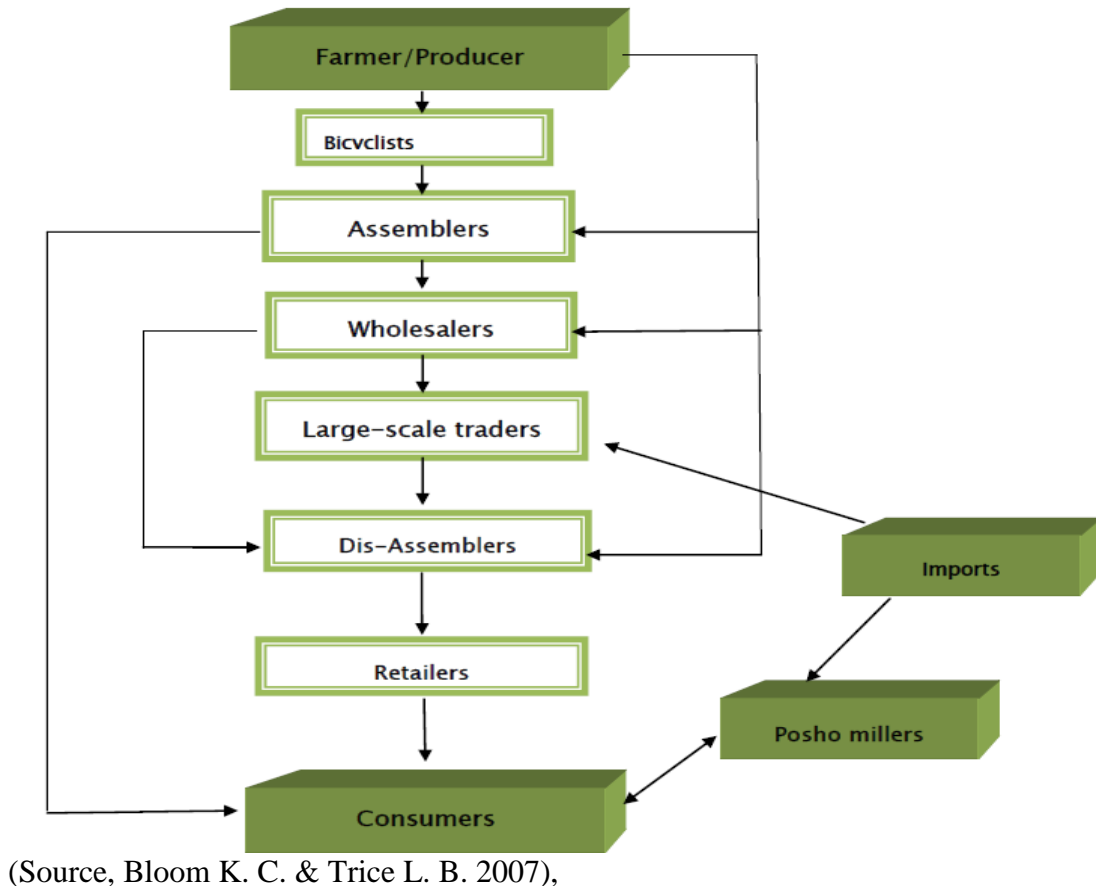
through growth in the agro-processing industries is quite small and fragmented, making it difficult to add value to most agricultural produce, which is primarily smallholder in nature. This is among major reasons why Uganda continues to export primary products without value addition, (UBOS, 2006).

Maize contributes significantly to income generation for rural households. About 98% of the 3.5 million small-scale farmers in Kenya are engaged in maize production. The small- and medium-scale sector produces about 75% of the nation's maize crop, while the large-scale sector (farms over 25 acres) produce the other 25%. On average, 1.5 million hectares are planted to maize annually, with annual production ranging between 26 and 36 million bags (2.3 and 3.3 million metric tons (MT)) depending on weather and market conditions. National maize consumption is about 37 million bags (2.9 million MT) annually. Yet, despite the centrality of maize to the Kenyan food system, the country has for the last several decades been trending toward a structural deficit in maize. Effectively coping with recurrent maize deficits is critical for enhancing food security in Kenya and promoting economic growth in the smallholder farmer sector, (District agricultural office report, and 2013).

The sector is whoever, both technologically and organizationally complex mainly due to dynamic nature of farming characterized by low productivity and low use of farm inputs, poor infrastructure, lack of rural finance and poorly developed markets. The major constraints affecting growth of the maize sub-sector include low soil fertility, unreliable rainfall, pest infestation, poor infrastructure, marketing and policy bottlenecks and low profitability attributed to a combination of low yields and poor marketing strategies (GOK, 1997; ICIPE 2000). This maize shortfall is because of the: increase in urbanization, high reliance on maize based diets as the staple food (evidenced by the high consumption figures of 98kg/capita/year), low per capita production and changing lifestyles.

The small traders buy maize directly from smallholder farmers and assemble in bulk to deliver to small market retail traders, large trading companies or maize millers. The large trading companies sell to National Cereals and Produce Board (NCPB), national or international relief organizations or millers. In order to access the NCPB and the large maize millers' markets the maize. Trading companies clean, bag, fumigate, grade, test for moisture content and aflatoxin and store the grain until appropriate market conditions are reached for sale. Because traders store

maize for long periods before release, quality and safety parameters are essential for a product that meets aflatoxin standards at the time of sale,( FAO,2005).There are over six categories of marketing agents in the maize marketing chain. These are assemblers, wholesalers, retailers, and dis-assemblers, posho millers and large-scale millers (See Figure 1). In addition, a smaller category of traders using bicycles purchase and bulk maize at the farm level and deliver to the assemblers, retailers, or posho millers.



**Figure 2.1.maize marketing and supply chain**

Assemblers are usually the first commercial purchasers of maize in the marketing chain. They usually begin as farmers who graduate to the next stage in the system, i.e. bulking up surpluses of neighboring farmers to capture scale economies in transport to local market. Those that are farmers raise their working capital from the sale of their own maize immediately after the harvest, (Agricultural extension report, 2013).Wholesalers are traders who buy maize from surplus districts (usually from assemblers) and transport the grain to deficit areas where they sell

to dis-assemblers, retailers or millers. Most wholesalers are also vertically integrated into assembly, as most of the volumes they purchase in the post-harvest months are direct from farmers, (Munyoro, 2012). Dis-assemblers are a category of maize traders who buy maize mainly from large wholesalers in the deficit areas, and break-down the volumes for resale to smaller-scale retailers and final consumers. Dis-assemblers are usually local traders who raise their initial capital from either salaried employment or from their involvement in other business activities. Retailers are a category of market agents consist of those traders who buy and sell in small quantities and were directly selling to consumer for home consumption. Retailers are found in the deficit regions with a few of them in the urban areas. The retailers in the surplus regions are over shadowed in business by the assemblers who take to disassembling and retailing activities during the slack periods, (Bloom K. C. & Trice L. B. 2007). The posho millers are a category of traders involved in the processing of maize grain into maize meal. They employ a simple hammer milling technology where the germ and the bran of the maize grain are milled together with the kernel into flour. Small-scale millers are specialized in custom milling whereby the customer provides the grain. Some posho millers have invested in dehullers to produce a more refined product, (KARI, 2012). Large Scale Millers are processors who deal with large volumes of maize and do their own packaging. These millers are characterized by large-scale, capital intensive, roller-milling technology. Most of the large-scale millers are concentrated in maize deficit areas with a few of them in the surplus regions of Kitale, Eldoret and Nakuru. Most millers acquire maize from wholesalers, farmers, and the NCPB stores depending on the season. In order to cope with the inter-seasonal variations of maize availability or supplies millers hire storage facilities, including silos in the maize surplus areas where maize is stored.

Maize Warehousing receipt system is a marketing mechanism used to address seasonality, supply and quality constituency of grains. This is being championed by Eastern African Grain Council (EAGC). Under this system, suitable warehouses will be graded and certified by the EAGC who will be able to receive grains, handle and store grains at fee and issue a warehouse receipt. This system emphasis safety as grains will be graded and tested before acceptance into and out of the warehouses. This system also offers good grain storage facilities. This warehouse receipting system is being introduced in Kenya with support from Financial Sector Deepening Trust (FSD), USAID-COMPETE, Kenya Maize Development Programme (KMDP) and Alliance for Green Revolution in Africa (AGRA). While the warehousing receipt system is being carried

out it is not yet very popular as many smallholder farmers are not aware of its value. It would be one of the best mechanisms available to maize producers. This may be achieved if maize producers formed farmer groups in order to attain the bulk size (minimum of 10 metric tonnes) required to use the warehousing receipt system. If they adopted this approach, they would be able to have a better bargaining power when selling their produce. They would also be able to sell their produce when the market prices are good in order to make maximum profits. At the moment very few small scale farmers are able to use this facility, (EAGC, 2013).

The domestic maize prices in the major markets of Nairobi, Mombasa, Nakuru, Eldoret and Kisumu have been on an upward trend since 2002, with sharp increases from 2008. However, between January and August 2009, prices in other markets were increasing while those in Mombasa and Kisumu were generally declining, a situation that may be attributed to a price moderating effect of imports from Uganda and Tanzania. A comparison of local and import prices in Nairobi over the 2000-2010 period indicates that imported maize was more expensive than domestically produced maize up to February/March 2009, the only time when there would have been an incentive to import maize. Indeed, the waiver granted in January 2009 has restrained the increase in grain prices, with the gap between local and parity prices reducing. The proportion of imports in the stocks held by traders has increased in most markets, being about 80% in Nakuru, (Nairobi stock exchange, 2013).

## **2.7 Theoretical framework**

Maize management is believed to spark a strain on the increase of food security. This study adopted systems theory propounded by the biologist Ludwig von Bertalanffy.

### **2.7.1 System Theory**

Systems theory focuses on the arrangement of and relations between the parts which connect them into a whole. This particular organization determines a system of interaction between planning of planting, weeding, fertilizer application, pest and disease control to influence the total yield of maize and subsequently affects storage and marketing of grains, (Klir, Facets of Systems Science, 1991). In the food security context, systems theory has been most obviously applied in the context of the sub-area of maize production and service systems where the emphasis is on the



planning of such systems for different styles of maize production and offering related service options leading food security, (Johns and Jones, 1999).

### 2.8 Conceptual framework

A conceptual framework represents the way ideas are organized to achieve a research project’s purpose. It is an analytical tool with several variations and contexts that is used to make conceptual distinctions and organize ideas.

#### Independent variables

#### Dependent variables

#### Maize management practices

#### Food security

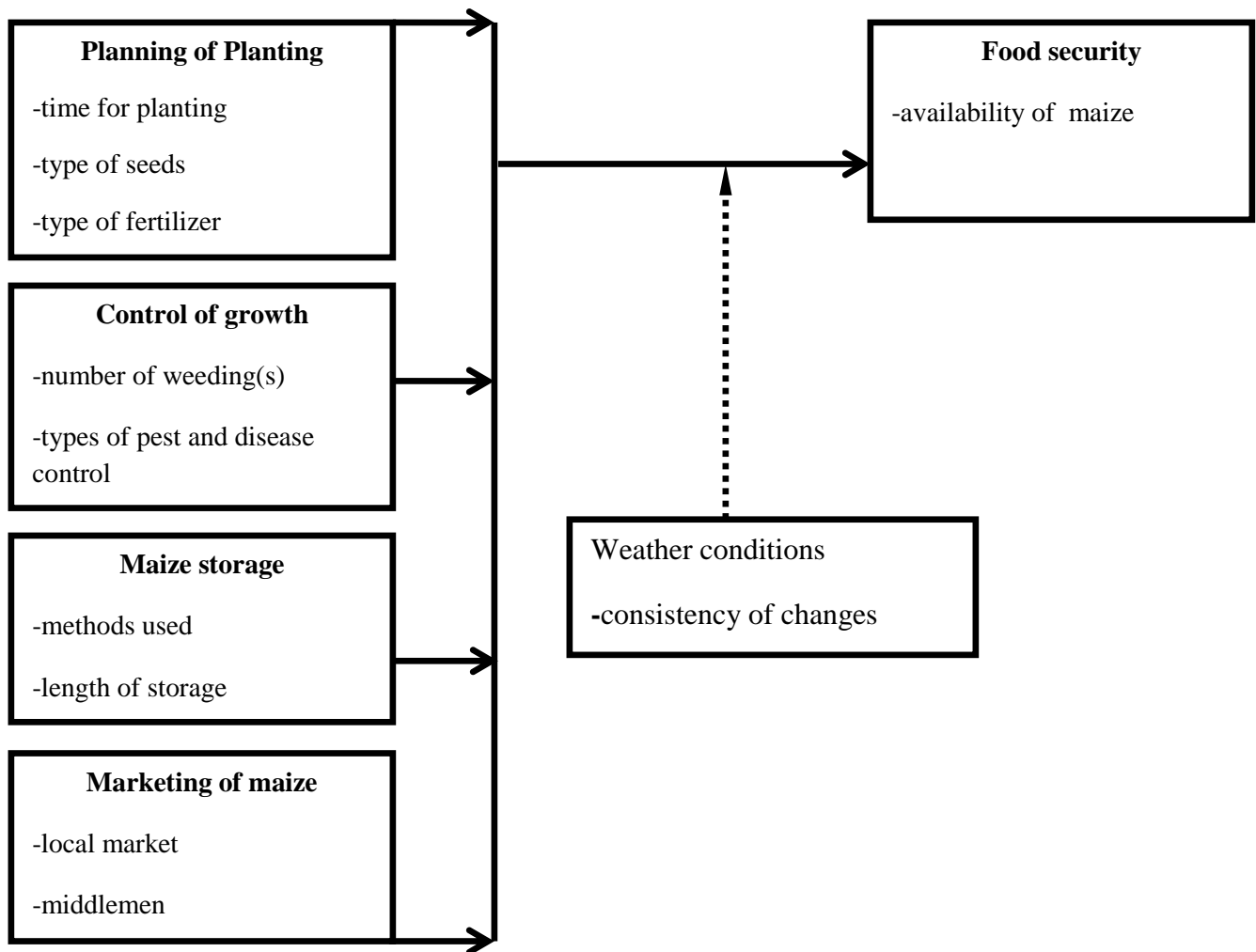


Figure 2.2 Conceptual framework

In order to ensure food security proper management should start at maize planting stage. Planting can commence as soon as groundwater and soil temperature are suitable for good germination. If a minimum air temperature of 10 to 15 °C is maintained for seven successive days, germination should proceed normally. Virtually no germination or growth takes place below 10 °C. Planting should be scheduled such that the most heat and water sensitive growth stage of maize, i.e. the flowering stage, does not coincide with midsummer droughts, (KARI, 2012).

For food production reason there is need for proper management practices on fertilizer application. It is of the utmost importance that the correct soil sampling methods be used when submitting samples for laboratory analysis. With maize drying being a critical step in the control of Aflatoxins, adequate strategies should be developed to ensure that maize is properly dried before and during storage. With the current vagaries of weather there is need for proper management of at this stage to ensure food availability. Maize marketing system should be improved as it determines the state of food security. In the recent years especially after liberalization of the sector in 1995 there are many actors in the chain which eliminates monopolistic tendencies and brings about competition. This is very vital particularly in the input and output markets, (WHO, 2013).

## **2.9 Knowledge gap in literature review**

From the reviewed literature it is apparent that the effects of storage and marketing of maize on food security has been extensively covered. However planning for planting and control during growth stages of maize has not been covered much. It is against this backdrop that this study seeks to find out the influence of maize management practises on food security in Moiben Sub-County.

## CHAPTER THREE

### RESEARCH METHODOLOGY

#### 3.1 Introduction

This chapter deals with research methodology which includes:- the research design for the study, target population, sampling design and sample size, research instrument, data collection and procedures, validity and reliability of the instruments and data analysis techniques.

#### 3.2 Research Design

The research was expected to establish whether maize management practises has an effect on food production and security in Moiben sub-county. The research embraced qualitative approach of research. The design took the descriptive survey format. Descriptive survey research design allows the collection of quantitative and qualitative data that can be used to establish causes of specific events or happenings (Weiss, 1998). The study sought to establish the underlying causes of food insecurity in Moiben sub-County. This will enhance the discovery of new insights that might help in explaining the likely causes of poor maize production.

#### 3.3 Study Area and Target Population

The study targeted a total population of 138409. The sample included small scale farmers, medium scale, large scale farmers and agricultural officers.

**Table 3.1 Administrative wards of Moiben sub-county.**

Name	Population (2009 National Census)	No. of households
Tembelio	28,021	3502
Sergoit	16,220	2027
Karuna/Meibeki	26,048	3256
Moiben	25,774	3221
Kimumu	42,346	5293
<b>Total</b>	<b>138,409</b>	<b>17,299</b>

**Source: Kenya Demographic health survey, 2009**

The study targeted the small, medium and large scale farmers and agricultural officers from their respective wards. This target population was selected because it was easily accessible and had

right information about the influence of maize management practices on food security in the sub-county.

### 3.4 Sample size and sampling selection

This study applied stratified, purposive and simple random sampling techniques. Simple random sampling was used to select maize farmers from different categories i.e.; small scale, medium scale, large scale and agricultural officers. In simple sampling technique, the sample is selected without bias to arrive at specific respondents from each stratum. A total of 368 respondents were selected. Purposive sampling was used to get the agricultural officers who were interviewed.

**Table 3.2**the random selected sample wards.

<b>Name</b>	<b>Population (2009 National Census)</b>	<b>No. of households</b>
Sergoit	16,220	2027
Karuna/Meibeki	26,048	3256
Moiben	25,774	3221
<b>Total</b>	<b>68042</b>	<b>8504</b>

**Source: Kenya Demographic health survey, (2009).**

The Morgan and Krejcie, (1970) table was used to determine the sample size for this study .Given the total target population 8504 homesteads the corresponding will be 368 homesteads as shown in table below. There were interviews from five agricultural officers. The researcher issued questionnaires to farmers.

### 3.5 Research Instruments

The instrument that was used during the study was a questionnaire which contained both open ended and closed ended questions. The questionnaire was made up of five parts. Part A consisted demographic information of the respondents; Part B consisted different elements testing the presence of planning of planting .Part C consisted of the opinion of respondents on growth control mechanisms, part D consisted of questions which test various aspects of storage, part E contained questions on the effects of marketing and marketing strategies that the farmers have. Interviews for the agricultural officers was conducted. The data was collected from maize

farmers and stakeholders in Moiben sub-county. Questionnaire was used to gather information because it is a less costly way to reach more people, including people at some distance. It can be swiftly done and data analysis can begin right away. The questionnaire keeps away from interviewer bias, guiding and cues that can impact the legitimacy and reliability of the data collection. This research also used face to face interview and focus group discussion to validate views, opinions, perception, feelings and attitudes of the respondents.

### **3.6 Data collection procedure**

A letter of identification from University of Nairobi, department of extra mural studies, was used to obtain research permit from National Council of Science and Technology .Permission was sought from Moiben sub-county administrator prior to commencement of the research study. Researcher reported to the sub-county education officer and sub-county agricultural officer before proceeding to the field. A letter of transmittal was used to introduce the researcher to the respondents and assure them of confidentiality .The researcher administered the questionnaires personally to all the respondents. The researcher preferred to administer the questionnaires personally to ensure the right data was collected from the respondents in time. Moreover the respondents had a chance to clarify their queries on the spot and also the researcher had an opportunity to motivate respondents to respond to questions. The interviews were conducted in pre-arranged dates.

### **3.7 Validity of the research instrument.**

Validity refers to the extent an instrument used in the study is accurate, true and meaningful, (Mugenda *et. al*, (1996). It is the degree to which an instrument measures what it was intended to measure. To ensure validity of the research tools, the supervisor together with research experts were consulted and advice from them was taken. It involved assessing the relevancy of the questionnaires to research objectives through carrying out a pilot study. Cross checking of questionnaires was done and it was modified after the pilot study.

### **3.8 Reliability of the research instrument.**

Reliability according to Mugenda, (1996) refers to the degree to which a measuring instrument used in research is consistent. Therefore the reason behind the pilot (pre-testing) is to assess the

clarity of the questionnaire items. Those items that are found to be inadequate or vague are modified and some replaced to improve the quality of the research instruments thus increasing their reliability. In order to improve the reliability of the research instruments the researcher employed test- retest method. The researcher then assessed the consistency of the responses on each pair of the pilot questionnaires to make a judgment on the reliability, (Mugenda *et. al*, 1996).

### **3.6 Data analysis and presentation**

Descriptive Statistics was used to process all the responses from the questionnaires. Data collected was examined, sorted, categorized and tabulated with aid of SPSS and excel computer programmes. These were used to establish the relationship among variables. The result of the study is presented using frequency tables and percentages to deduce conclusions.

### **3.7 Ethical considerations**

Ethics has been defined as the branch of philosophy which deals with one's conduct and serves as a guide to one's behavior, (Mugenda and Mugenda, 2003). Moreover, these principles are intended to protect research participants from harm, (Sieber and Stanley, 1988). Volunteer participation was clearly explained to the participants before they filled the questionnaire. Participants had the freedom to withdraw from the study at any stage. Cohen and Manion, (1994) suggested that informed consent is an important issue that has to be considered. The purpose of the study was explained to the participants so that they make their own informed choices. The study ensured that words and language that seemed to be sensitive were avoided.

### **3.8 Operational definition of variables**

To achieve the objectives of the study the researcher investigated the influence of maize management practices on food security among farmers in Moiben sub-county UasinGishu, Kenya. The objective of the study included: To establish the role of planning of planting of maize on food security in Moiben sub-county, to determine how growth control mechanisms influence maize production and food security, to establish the impact of maize storage on food Security and to establish the influence of maize marketing on food Security in Moiben sub-country.

**Table 3.3 Operational definition of variables**

Objective	Variables	Indicators	Measurement scale	Tools of analysis	Types of tools
To establish the influence of planning of planting of maize.	independent	Ploughing on time, seed and fertilizer acquisition, timely planting	Ordinal	Descriptive	Frequency distribution table, percentages
To determine how growth control mechanisms of maize influence food security	independent	Weed free fields, pest free crops, and vigorously growing crops.	Nominal	Descriptive	Frequency distribution tables, percentages
To establishment the impact of maize Storage on food security	independent	Presence of stores, in homesteads, availability of maize throughout the year,	Ordinal	Descriptive	Frequency distribution tables, percentages
To establish influence of maize marketing on food Security.	independent	Presence of middlemen, assembling store, presence of NCPB depot.	Nominal	Descriptive	Frequency distribution tables, percentages

## **CHAPTER FOUR**

### **Data Analysis, Interpretation and Presentation**

#### **4.1 Introduction**

This chapter presents the findings from the study. Data from the field was coded and edited for completeness. It was then analyzed in form of percentages and presented in form of frequency distribution tables. In analyzing the data, the responses to the items in the questionnaire, the researcher assigned each response a number. The data collected were then analyzed by use of descriptive statistics where frequency distributions and percentages were calculated and displayed in tabular form.

#### **4.2 Return rate**

The questionnaires were administered to 368 respondents/farmers and interviews conducted for 5 agricultural officers. A total of 350 questionnaires were returned, this translates to 95 % return rate thus the respondents were positive towards the study

#### **4.3 Demographic information**

Since the research topic was a sensitive issue, the researcher found it necessary to establish the background information of the respondents. The demographic information includes, gender, age, education level, working experience of the respondents, which will form the basis of knowing what kind of individuals the researcher is dealing with.

##### **4.3.1 Gender of Respondents**

Gender of the respondents was sought out. It also meant to determine whether maize production provides equal opportunity for both men and women in farming. The results for these findings are indicated on table 4.1 below.



**Table 4.1 Gender of the respondents**

<b>Gender</b>	<b>Frequency</b>	<b>Percentage</b>
Male	239	68.3
Female	111	31.7
<b>Total</b>	<b>350</b>	<b>100</b>

From the findings, 240 respondents were male farmers representing 68.3%, while 111 respondents were female farmers representing 31.7%. The findings indicate a clear gender imbalance of farmers in Moiben Sub-county. This shows that women have a challenge in accessing land for practicing maize production. From the findings gender orientation has an influence on maize production with Cramer's  $p=0.5$ .

#### **4.3.2 Age bracket.**

The researcher was keen to determine the age of the respondents of farmers in Moiben Sub-county. To a greater extent age affects production of maize hence food security. Older tend to be more traditional in terms of field management practices i.e. we have always done it like that. Age is also a critical factor in experience, older farmers are likely to be more experienced than relatively younger farmers, and a more experienced farmer is in a better position to relate production trend to food security. The findings to this issue are presented in table 4.2

**Table 4.2 Age of respondents**

Age	Frequency	percentages
20-30	32	13
31-40	47	28
41-50	131	38
Over 50	76	21
<b>Total</b>	<b>350</b>	<b>100</b>

Majority of the respondents are aged 41-50 representing 38%. At the age of 21-30 brackets there are 50 (13%) famers in Moiben sub-county. There are 102 or 28 % of famers who are aged between 31-40 years while 76farmers representing 21% are aged over 50 years. The findings show that majority of farmers in Moiben sub-county are in their middle age, meaning that majority have experience in their current farming practices. The results from the research indicate that age has relationship with production with  $P= 0.954$  as shown in the table below.the younger farmers are enthusiastic and they take farming as a business venture hence they do everything possible to improve production of maize.

#### **4.3.3 Level of education for respondents.**

This was sought to give the researcher an insight of the level of education of the farmers in Moiben Sub-county. In delivery of quality maize production services and applying effectively field management skills, the level of education is a crucial variable that has to be put into account. There also exists a relationship between farmers' performance and qualification or level of education in the production of maize.

**Table 4.3 education level**

<b>Education level</b>	<b>Frequency</b>	<b>percentages</b>
O level	151	41
Diploma	110	30
Degree	69	19
Masters	39	10
Others		
<b>Total</b>	<b>350</b>	<b>100</b>

Majority of the respondents are O level holders as represented by 151 respondents or 41% ,110 respondents or 30 % hold diploma certificates. Some farmers69 (19%) are Degree holders while the remaining 39(10%) are master shoulders. These findings clearly show that majority of the farmers' level of education is quite low to understand the role the maize field management practices in facilitating the maize production performance. It also indicates that maize production applies some professionalism for better production hence food security. The findings indicated that the level of education affects the production of maize with Cramer's  $p=0.702$ .This could be due to the rate of adoption of new technologies of producing maize.

#### **4.3.4 Farmers maize production experience.**

Farmers with longer period of maize production can be in a better position of knowing the trends of maize production practices for high yield hence ensuring food security. More experienced famers are also more productive. The researcher therefore set out to determine how long the farmers had been growing maize in Moiben Sub-county. Their experience level indicates their responsiveness to deal with the challenges of maize production in place in enhancing food security. The findings are presented in the table 4.4 below.

**Table 4.4 Maize production experience**

<b>Education level</b>	<b>Frequency</b>	<b>percentages</b>
0-5	39	11.1
6-10	104	29.7
Over 10	207	59.1
<b>Total</b>	<b>350</b>	<b>100</b>

From the findings in table 4.4 above, majority of the farmers had been producing maize for over 10 years as represented by 59%, 29.7% had been producing maize between 6-10 years, and only 11.1% of farmers had been producing maize for less than 5 years. From the findings the experience of production of maize affects the production and this could be as a result of farmers' correctional measures so as to ensure increased production. Maize production experience has and influence on production with Cramer's'  $p=0.860$ .

#### **4.4 Planning of planting of maize**

The farmer's capabilities of acquiring land for production of maize in terms of land size determine the time to begin preparation. This has great influence on maize production. The researcher wanted to establish the extent to which planning to plant maize influences maize production.

##### **4.4.1 Ploughing time**

The table 4.4 shows the response on when famers begins to plough their lands as part of preparation for planting of maize.

**Table 4.5 ploughing time**

<b>Time of ploughing</b>	<b>Frequency</b>	<b>percentages</b>
January	138	39.3
February	132	37.6
March	60	17.1
April	19	5.4
<b>Total</b>	<b>350</b>	<b>100</b>

Majority of the farmers plough their land between the month of January to February as represented by 79.9%.17.1% of famers plough their land n the month of march while 5.4 % plough their land for maize production during the month of April. Ploughing in time means planting in good time hence high production of maize. There is an effect on the production of maize as per the findings with Cramer's  $p= 0.743$  hence planting immediately rainfalls is important because nitrogen flush is well utilized.

#### 4.4.2 Planting time

The table below shows planting time of maize amongst farmers of moiben sub-county.

**Table 4.6 planting time**

<b>Planting time</b>	<b>Frequency</b>	<b>percentages</b>
January	5	1.4
February	23	37.6
March	170	48.4
April	110	31.3
May	40	11.4
<b>Total</b>	<b>350</b>	<b>100</b>

48.4 % of the farmers plant their maize during the month of March, a further 31.3 % plant in the month of April, 37.6% plant in the month of February and in some rare instances 11.4 plants during the month of May and 1.4% plant in the month of January. Long rains in Moiben sub-county are expected to begin in the month of March through to May thus farmers are advised to plant before the onset of the rains. Planting time influences maize production with Cramer's  $p=0.571$ .

#### 4.4.3 Buying of fertilizers and seeds

**Table 4.7 Time when farmers buy their seeds and fertilizers**

<b>Buying time</b>	<b>Frequency</b>	<b>percentages</b>
January	124	35.3
February	135	38.5
March	90	25.6
<b>Total</b>	<b>350</b>	<b>100</b>

Majority of farmers purchase their farm inputs on the month of February as represented by 38.5% ,closely followed by the month of January by 35.3% while few farmer represented by 25.6% purchases their seeds and fertilizers on March. Early acquisition of seed and fertilizers enable the farmers to plant on time so as to maximize production of maize.

#### 4.4.4 Type of fertilizer used

The researcher wanted to find out the type of fertilizers used by farmers during planting and the collected data as shown below table.

**Table 4.8 type of fertilizer used during**

Type of fertilizer	Frequency	percentages
DAP	255	72.6
NPK	94	26.8
<b>Total</b>	<b>350</b>	<b>100</b>

Majority of the farmers use DAP fertilizer during planting of maize as represented by 72.6% and 26.8% use NPK. Most farmer prefers use of DAP, because it has a high phosphorus content which is good for proper root development.

#### 4.4.5 Number of acres of land per farmer

The researcher established the number of acres owned per farmers as production of maize depends on the size of *shamba* owned by a farmer and the results are as tabulated below.

**Table 4.9 Number of acres of land per farmer**

No: of acres	Frequency	percentages
1-5	209	59.7
5-10	105	30.0
11-15	25	7.1
16-20	9	2.2
21-25	10	2.8
26-30	1	0.003
31-35	1	0.003
36-40	1	0.003
Above 40	1	0.003
<b>Total</b>	<b>350</b>	<b>100</b>

Majority of the farmers owns land between the range of 1-5 as represented by 59.7%,30% of farmers owns land between the range of 5-10, 7.1% of farmers own land parcels ranging from 11-15, while 0.003% represented the ranges between 26-30,31-35, 36-40 and above 40 respectively.

#### 4.7 Growth control of maize on food security

For optimum production maize crop should grow in an environment that is weed free. Weeds compete with the crop for nutrients, light and space therefore control of weeds in maize production is very critical.

##### 4.7.1 Growth control stage

The table below shows the time of weed control as practiced by farmers in Moiben.

**Table 4.10 Stage of weed control**

Stage	Frequency	percentages
After emergence	264	75.4
At knee level	85	24.3
<b>Total</b>	<b>350</b>	<b>100</b>

The results show that 75.4% of the famers control weeds after the emergence of the maize crop.24.3% control weeds when the maize crop has grown to knee high. There s a very strong influence that weed control has on maize production with Cramer's  $p=1.0$ .cotrol of weeds gives the maize crop a good environment for proper growth hence an increase in production.

##### 4.7.2 Control methods used

The table below shows the methods of weed control used by farmers.



**Table 4.11 Methods of weed control**

<b>Methods</b>	<b>Frequency</b>	<b>percentages</b>
Chemical spray	190	54.3
Uprooting	88	25.1
Weeding using jembe	72	20.6
<b>Total</b>	<b>350</b>	<b>100</b>

54.3% of the farmers use chemical method to control weeds because it is time saving and convenient, 25.1% use uprooting methods. The weeds that are uprooted are those which survived the herbicides and 20.6% weed using jembes. From the findings it is indicated that weeding has an influence on production with Cramer's  $p=1.00$ .

#### **4.7.3 Top dressing**

Top dressing is the application of fertilizers to a growing maize crop. The table below shows the type of fertilizer used for top dressing maize in Moiben sub-county.

**Table 4.9 fertilizer used for top dressing**

<b>Type of fertilizer</b>	<b>Frequency</b>	<b>percentages</b>
C.A.N	210	60.0
Urea	140	40.0
<b>Total</b>	<b>350</b>	<b>100</b>

Majority of the farmers use C.A.N for top dressing represented by 60.0% while 40.0% use urea. Most of the farmers use C.A.N for top dressing to neutralize the acidity of the soil created by prolonged use of D.A.P for planting. Top dressing of maize crop has an influence on the production of the crop with Cramer's'  $p=0.863$ .top dressing using nitrogenous fertilizers

increases the vegetative growth of maize .This increases the photosynthetic area of the crop hence high production.

#### 4.8 Storage method

Maize storage is important because it bridges the gap between surplus at harvest time and scarcity during the post-harvest period. The table below shows the storage methods used by farmers.

**Table 4.13 Storage methods**

<b>Methods</b>	<b>Frequency</b>	<b>percentages</b>
Modern storage	282	80.6
Traditional storage	68	19.4
<b>Total</b>	<b>350</b>	<b>100</b>

80.6% of the farmers use modern storage methods as they are effective compared to traditional methods which are presented by 19.4%.however the researcher observed that some households do not have stores on inquiring the farmers said that they convert a room in the house to act as stores for safety of maize against theft. Storage methods have an influence on food security.

#### 4.8.1 Impacts of poor storage on food security

**Table 4.14 Impacts of poor storage**

<b>Effects of poor storage</b>	<b>Frequency</b>	<b>percentages</b>
Weevil damage	186	53.1
Rodents damage	106	30.3
Theft	28	8.0
Aflatoxins	30	8.6
<b>Total</b>	<b>350</b>	<b>100</b>

53.1% of farmers face weevil damage as a result of poor storage.30.3% of farmers’ maize is damaged by rodents.8.0% of farmers affected by theft and 8.6% of farmers’ produce is affected by aflatoxins.

#### 4.9 Effects of marketing of maize

The table below shows some of the effects of maize marketing,

**Table 4.15 effects of marketing**

<b>Effects of markets</b>	<b>Frequency</b>	<b>percentages</b>
Selling at low prices	282	80.6
Food shortages	68	19.4
<b>Total</b>	<b>350</b>	<b>100</b>

From the results above, majority of the farmers in Moiben sub-county sell their maize produce immediately it is harvested, this has led to 80.6% of the farmers selling their produce at low prices .During harvesting the supply of maize grain is higher than its demand, and this lowers the selling price .19.4% of the farmers experience food shortage as a result of poor marketing. Lack of Market leads to selling of maize at low prices and food shortages with an influence of Cramer’s  $p=0.302$ .most ceremonies are carried out during the harvesting season therefore most farmers sell their maize grains at low prices in order to get enough money to facilitate the ceremonies.

#### 4.9.1Maize Marketing challenges

Farmers expressed their challenges as shown in the table below.

**Table 4.16 effects of marketing challenges**

<b>Market challenges</b>	<b>Frequency</b>	<b>percentages</b>
Low prices	135	38.6
Presence of middlemen	17	4.9
Lack of ready market	72	20.6
Competition	40	11.4
Imported maize	18	5.1
Price fluctuation	47	13.4
Poor infrastructure	21	6.0
<b>Total</b>	<b>350</b>	<b>100</b>

38.6% experiences low prices as their major challenge for maize marketing ,20.6% of farmers lacks ready market for their produce,13.4% claimed that the prices are not steady, they keep fluctuating,11.4% of farmers face competitions from other cereals like rice, wheat, sorghum and millet,6.0% of farmers indicated that they do have poor infrastructure that affects transportation of their produce to the market and 5.1% of farmer stated that the imported maize from other countries challenges them in that they end up losing market, this is because the imported maize is sold at a cheap price. Market challenges has an influence on food security with Cramer's  $p=0.347$  in that it delays the preparation of planting and the purchase of inputs as many farmers depend on sold maize as source of income.

## CHAPTER FIVE

### Summary of Findings, Discussions Conclusions and Recommendations

#### 5.1 Introduction

This chapter presents summary of findings, discussions, conclusions reached and recommendations following the objectives of the study. Growing of maize has been a major source of food in Kenya especially Moiben sub-county. This study was set out to find out the influence of maize management practices on food security among farmers in Moiben sub-county, Uasin gishu county, Kenya.

#### 5.2 Summary of findings

Relying on the responses given by the respondents, the researcher came up with findings which were used to make conclusions and give recommendations. The main findings are based the results of the analyzed data in chapter four as shown n the table 5.1 below.

**Table 5.1 Summary of findings**

Objectives	Findings
1. To establish the role of planning of planting of maize on food security in Moiben sub-county.	<ul style="list-style-type: none"><li>• Planning to plant maize entails ploughing time, buying of seeds and planting time of maize. All these have been find out that they have influence on the production of maize.</li><li>• Long rains in Moiben sub-county are expected to begin in the month of March through to May thus farmers are advised to plant before the onset of the rains. Planting time influences maize production, There is an effect on the production of maize as per the findings with Cramer's <math>p= 0.743</math> hence planting immediately rainfalls where nitrogen</li></ul>

	flush is well utilized.
<p>2. To determine how growth control mechanisms influence food production and security.</p>	<ul style="list-style-type: none"> <li>• Growth control involves: weed control, and top dressing.</li> <li>• There s a very strong influence that weed control has on maize production with Cramer's' <math>p=1.0</math>.cotrol of weeds gives the maize crop a good environment for proper growth hence an increase in production.</li> <li>• Top dressing of maize crop has an influence on the production of the crop with Cramer's' <math>p=0.863</math>.top dressing using nitrogenous fertilizers increases the vegetative growth of maize and consequently its production.</li> </ul>
<p>3. To establish the impact of maize storage on food security in Moiben sub-county.</p>	<ul style="list-style-type: none"> <li>• 80.6% represents usage of modern storage methods as they are effective compared to traditional methods which are presented by 19.4%.</li> <li>• 53.1% of farmers face weevil damage as a result of poor storage.30.3% of farmers' maize is damaged by rodents.8.0% of farmers affected by theft and 8.6% of farmers' produce is affected by aflatoxins.</li> </ul>

<p>4. To establish influence of maize marketing and marketing strategies on food security in Moiben sub-county.</p>	<ul style="list-style-type: none"> <li>• Lack of Market leads to selling of maize at low prices and food shortages with an influence of Cramer's <math>p=0.302</math></li> <li>• Market challenges has an influence on food security in that it delays the preparation of planting and the purchase of inputs as many farmers depend on sold maize as source of income.</li> </ul>
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### 5.3 Discussions of the findings

This section gives detailed discussion of the findings in this study.

#### 5.3.1 Planning of planting of maize

The farmer's capabilities of acquiring land for production of maize in terms of land size determine the time to begin preparation. This has great influence on food production. The researcher wanted to establish the extent to which planning to plant maize influences maize production.

Ploughing time is one of the main activities during planning where majority of the farmers plough their land between the months of January to February as represented by 79.9%.17.1% of famers plough their land in the month of March while 5.4 % plough their land for maize production during the month of April. Ploughing in time means planting in good time hence high production of maize. This has an effect on the production of maize as per the findings with Cramer's  $p= 0.743$  this could be due to planting immediately rainfalls where nitrogen flush is well utilized.

Planting time is also another issue which most farmers take into considerations. From the findings 48.4 % of the farmers plant their maize during the month of March, a further 31.3 % plant n the month of April ,37.6% plant n the month of February and in some rare instances 11.4 plant during the month of May and 1.4% plant in the month of January. Long rains in Moiben

sub-county are expected to begin in the month of March through to May thus farmers are advised to plant before the onset of the rains. Planting time influences maize production with Cramer's  $p=0.571$ .

Buying of fertilizers and seeds is also done at a particular time because of fluctuation of prices and to avoid congestion at selling centers during planting time as the demand is high. Findings show that majority of farmers purchase their farm inputs on the month of February as represented by 38.5% ,closely followed by the month of January by 35.3% while few farmer represented by 25.6% purchase their seeds and fertilizers on March. Early acquisition of seed and fertilizers enable the farmers to plant on time so as to maximize production of maize.

It was found out that majority of the farmers use DAP fertilizer during planting of maize as represented by 72.6% and 26.8% use NPK. Most farmer prefers use of DAP.

Number of acres of land per farmer was also another factor that the researcher took into considerations. The findings showed that majority of the farmers owns land between the range of 1-5 as represented by 59.7%, 30% of farmers owns land between the range of 5-10, 7.1% of farmers own land parcels ranging from 11-15, while 0.003% represented the ranges between 26-30,31-35, 36-40 and above 40 respectively. Land has greatly been subdivided for inheritance and some farmers have sold part of their farms for incomes.

### **5.3.2 Growth control mechanisms of maize and its effects on food security**

For optimum production, maize crop should grow in an environment that is weed free. Weeds compete with the crop for nutrients, light and space therefore control of weeds in maize production is very critical.

Growth control entails weeding which the findings established that is done in stages. The results show that 75.4% of the famers control weeds after the emergence of the maize crop.24.3% control weeds when the maize crop has grown to knee high. There is a very strong influence that weed control has on maize production with Cramer's'  $p=1.0$ .cotrol of weeds gives the maize crop a good environment for proper growth hence an increase in production.

The researcher also looked into weed control methods used and the findings showed that 54.3% of the farmers use chemical method to control weeds because it is time saving and convenient,



25.1% use uprooting methods. The weeds that are uprooted are those which survived the herbicides and 20.6% weed using jembes. From the findings it is indicated that weeding has an influence on maize production.

Top dressing is the application of fertilizers to a growing maize crop. Majority of the farmers use C.A.N for top dressing represented by 60.0% while 40.0% use urea. Most of the farmers use C.A.N for top dressing to neutralize the acidity of the soil created by prolonged use of D.A.P for planting .Top dressing of maize crop has an influence on the production of the crop with Cramer's'  $p=0.863$ .top dressing using nitrogenous fertilizers increases the vegetative growth of maize .This increases the photosynthetic area of the crop hence high production.

#### **5.3.4 Storage method**

Maize storage is important because it bridges the gap between surplus at harvest time and scarcity during the post-harvest period. 80.6% represents usage of modern storage methods as they are effective compared to traditional methods which are presented by 19.4%.however the researcher observed that some households do not have stores on inquiring the farmers said that they convert a room in the house to act as stores for safety of maize against theft. Storage methods has an influence food security with Cramer's'  $p=0.737$ .however,storage has limited influence on the total yield of maize.

From the study, 53.1% of farmers face weevil damage as a result of poor storage.30.3% of farmers' maize is damaged by rodents.8.0% of farmers affected by theft and 8.6% of farmers' produce is affected by Afflatoxins. Weevil attack is due to the fact that the grains are not properly dried to the recommended moisture level, making it easy for the pest to penetrate the grains.

#### **5.3.5 Effects of marketing of maize**

Majority of the farmers in Moiben sub-county sell their maize produce immediately it is harvested, this has led to 80.6% of the farmers selling their produce at low prices .During harvesting the supply of maize grain is higher than its demand, and this lowers the selling price

.19.4% of the farmers experience food shortage as a result of poor marketing. Lack of Market leads to selling of maize at low prices and food shortages with an influence of Cramer's  $p=0.302$ . From the findings, market challenges has influenced production where 38.6% of famers experiences low prices as their major challenge for maize marketing ,20.6 of farmers lacks ready market for their produce,13.4% claimed that the prices are not steady, they keep fluctuating,11.4% of farmers face competitions from other cereals like rice, wheat, sorghum and millet,6.0% of farmers indicated that they do have poor infrastructure that affects transportation of their produce to the market and 5.1% of farmer stated that the imported maize from other countries challenges them in that they end up losing market, this s because the imported maize s sold at a cheap price. Market challenges has an influence on maize production with Cramer's  $p=0.347$  in that it delays the preparation of planting and the purchase of inputs as many farmers depend on sold maize as source of income. Competition from imported maize has made some farmers to reduce acreage under maize and opt for other enterprises.

#### **5.4 Conclusion of the study**

There is need for proper management practices on maize crop in order to realize high production of maize grain. Early acquisition of inputs enable the farmers to plant on time, it is of the utmost importance that the farmers carry out soil testing to ascertain the nutrient content of the soil and soil Ph therefore the farmers should use correct soil sampling methods when submitting samples for laboratory analysis. Soil testing will help to inform the choice of the farmers with regard to the type of fertilizer to use during planting and top dressing their maize crop. The appropriate time for farmer to begin preparation for planting should be between November and February to allow the field to rest enough, for organic matter to fully decompose, allow for proper aeration of the soil and also to prevent the spread of maize lethal Necrosis disease which is currently on threat to the maize crop.

Proper weed control ensures that the maize crop grows in a weed free environment in order to maximize growth. With maize drying being a critical step in the control of aflatoxin and weevil attack, adequate strategies should be developed to ensure that maize is properly dried before and during storage. With the current vagaries of weather there is need of proper management practices of the grains at this stage to ensure food security. Modern stores raised from the ground and fitted with metal deflectors should be used to store the grains in order to reduce losses due to

rodent destruction. Maize marketing system should be improved as it determines the state of food security. In the recent years especially after liberalization of the sector in 1995 there are many actors in the chain which eliminates monopolistic tendencies and brings about competition. This is very vital particularly in the input and output markets, (WHO, 2013). Good road network system is important to ensure that the farmers take their produce to the nearest NCPB depots to avoid exploitation by middlemen.

Post-harvest management is a crucial component of food production in developed countries. However, it is still neglected in the developing countries where large losses from farm to plate have been attributed to poor handling, distribution, storage, and purchase/consumption behavior. Although the main investment in addressing global hunger has been on increasing food production, it needs to be complemented with comprehensive programs which address the huge postharvest losses especially in the famine prone Sub-Saharan countries, (WHO, 2011). Recent studies have shown that this is surely one of the most sustainable alternatives to increasing food security. The highlight of this review, which links food security, farm management, Aflatoxin mitigation, agribusiness and crop diversification to post-harvest management, justifies an investment in reducing post harvest losses in any country, (ARC, 2012).

## **5.5 Recommendations**

### **1. Agricultural advice to farmers in relation to maize production in Moiben sub-county**

To carry soil analysis by taking the soil sample for analysis to either University of Eldoret, KARI Kitale or Egerton university Njoro . This will ensure that the farmers use the right fertilizer and quantity for his or her farm .Practice soil conservation measure e.g. terracing of farmer field.

Good farm management –farm planning and layout leads to early land preparation ,early planting, purchasing of farm inputs in time and rotational programme for his/her crops ,weed control and pest control practice. Practice minimum tillage so that he/she purchase enough fertilizer for the maize crop using the money which would have been used in ploughing or harrowing. Use of certified seeds of high yielding qualities and disease resistance.

**2. Farmers should be supported by the government in ensuring food security by provision of subsidized fertilizers at strategic points of the sub-county through the national cereals and**

produce board .This enables farmers to apply their crop with the correct quantities of fertilizer raising the crop yield in the end. Construction of dryers and silos/stores within the sub-county to help the farmers to dry and store their produce. Provision of mobile driers by the County government. The national Government should legitimize the introduction of genetically modified maize in order to increase production and make the country food secure.

3. Farmer should form co-operative societies to help them market their produce. Tuiyotich farmer's co-operative society in sergoit location is the only active society that helps its members in marketing their product.

### **5.6 Suggestions for further research**

1. An investigation on proper timing of planting maize should be done.
2. To assess the role of extension officers in maize production and food security.
3. To establish reason why there is wide gap of maize production from farmer to farmer.
4. To investigate on the effects of land subdivision and farm succession on maize production.
5. To investigate the influence of genetically modified maize on food production.

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**Appendix i**  
**Letter of transmittal**

TECLA JERONO BIWOTT,

PO BOX 1190,

ELDORET.

DEAR RESPONDENT,

I am a student at the University of Nairobi pursuing a Master of Arts degree in project planning and management.

I am conducting an academic research on the effects of the management of maize on food security in Moiben Sub County. This questionnaire has been formulated to help obtain information on maize management as practiced by you as a farmer in the sub county.

Please note that all your responses to the questions will be held with utmost confidentiality. Kindly answer all the questions truthfully and to the best of your knowledge.

Thank you for your cooperation and patience

Yours faithfully

Tecla Jerono Biwott

L50/66386/2013

Email [tjbiwott@gmail.com](mailto:tjbiwott@gmail.com)

Cell no: 0723807006.

## QUESTIONNAIRE FOR FARMERS

### PART A: DEMOGRAPHIC INFORMATION

1. Indicate your gender

a) Male

b) Female

2. Indicate your age bracket

a) 20-30 years

b) 31-40 years

c) 41-50 years

d) Over 50 years

3. Indicate your highest educational level

a) O' level

b) Diploma

c) Degree

d) Master

e) Others (specify).....

4. How long have you been growing maize?

a) 0-5 years

b) 6-10 years

c) Over 10 years

d) Others (specify).....

**PART B: Planning of planting maize on food security.**

5. How many acres of land do use to grow maize?

.....  
.....

6. Which month of the year do you plough your land for maize planting? Tick the appropriate.

January

February

March

April

Others (specify).....

7. When do you buy the seeds for planting?

January

February

March

April

Others (specify).....

8. (a) Which type of fertilizer do you use for planting maize?

DAP

23:23:0(Nitrophos)

(b)When do you buy them?

.....  
.....  
.....

(c)Where do you buy them from?

.....  
.....  
.....

9. What is the appropriate time for planting maize?

January

February

March

April

.....  
.....  
.....

10. What determines the planting time in Moiben sub- County?

a) Availability of rain

b) Availability of seeds

c) Farmers preparedness

d) Others (specify)

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.....

11. What are some of the challenges that you face as you prepare to plant maize?

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.....  
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12. What might be the implication of challenges on planning to plant maize?

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.....  
.....

**SECTION C: Growth control of maize on food security.**

13. At what stage of maize growth do you control weeds?

- a) Before emergence of the crop
- b) After emergence of the crop
- c) At knee high
- d) At tasseling (flowering)
- e) Others (specify)

.....  
.....  
.....  
.....

14. What are the methods that you use to control weeds?

.....  
.....  
.....  
.....

15. Do weed control practices have impact on food security? If yes, what are the effects?



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16. Do you apply topdressing fertilizer to your maize crop? Yes/No,if yes which type of topdressing fertilizers do you use?  
If, no give reasons.

.....  
.....  
.....  
.....

17. How many bags of maize (90kg) do you harvest from an acre of land?

**SECTION D: Maize storage and food security**

18. What effect do the maize storage practices have on food security in Moiben sub-county?

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.....  
.....  
.....

19. Which methods do you use for maize storage?

- a) Traditional stores
- b) Modern stores
- c) Others (specify)

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20. What might be the impact of poor storage of maize to food security?

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**SECTION E: Effects of maize marketing on food security**

21. What are the effects of maize marketing on food security in Moiben sub-county?

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22. What challenges do farmers face during marketing of maize?

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.....

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23. What strategies have you put in place to ensure fair marketing of maize?

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## Appendix ii

### Interview schedule for the agricultural officers

#### Questions:

1. As an agricultural officer, kindly explain to us about your role in relation to production of maize in Moiben sub-county.
2. How does the government support the farmers to ensure that there is food security in the sub-county?
3. According to you when do you think is the appropriate time for farmers to begin preparations for planting?
4. What facilitates or determines the time for preparation or planning for planting?
5. What should be the time span between planning and planting itself?
6. What are some of the management practices required to be carried by farmers to ensure maximum production?
7. How does the government policy affect the management of maize?
8. What are some of the challenges that farmers face in maize management that may lead to food insecurity?
9. What are the efforts put in place to ensure that maize is well managed hence food security?
10. What storage facilities do famers use to store maize?
11. Are there cooperative societies that help maize farmers to market their produce?
12. In your opinion which crop competes with maize for production resources among the farmers in your area of work?

### Appendix iii

#### Morgan and Krejcie, (1970) table

<i>N</i>	<i>S</i>	<i>N</i>	<i>S</i>	<i>N</i>	<i>S</i>
10	10	220	140	1200	291
15	14	230	144	1300	297
20	19	240	148	1400	302
25	24	250	152	1500	306
30	28	260	155	1600	310
35	32	270	159	1700	313
40	6 2	80	162	1800	317
45	40	290	165	1900	320
50	44	300	169	2000	322
55	48	320	175	2200	327
60	52	340	181	2400	331
65	56	360	186	2600	335
70	59	380	191	2800	338
75	63	400	196	3000	341
80	66	420	201	3500	346
85	70	440	205	4000	351
90	73	460	210	4500	354
95	76	480	214	5000	357
100	80	500	217	6000	361
110	86	550	226	7000	364
120	92	600	234	8000	367
130	97	650	242	9000	368
140	103	700	248	10000	370
150	108	750	254	15000	375
160	113	800	260	20000	377

170	118	850	265	30000	379
180	123	900	269	40000	380
190	127	950	274	50000	381
200	132	1000	278	75000	382
210	136	1100	285	1000000	384

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