INFLUENCE OF MAIZE STORAGE MANAGEMENT AMONG SMALL SCALE FARMERS ON THE LEVEL OF MAIZE QUALITY, TURBO DIVISION, UASIN GISHU COUNTY - KENYA

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2014
DECLARATION

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

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L50/71756/2014

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I dedicate this work to my father and mother for having introduced me to my education and paid my fees during my initial stages of education and my wife offered me moral support as I wrote these project. I also dedicate this work to my children, Ivy Jepkorir, Eugine Kimutai and Faith Jebet.
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### LIST OF ABBREVIATION AND ACRONYMS

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>DANIDA:</td>
<td>Danish International Development Authority</td>
</tr>
<tr>
<td>FAO:</td>
<td>Food Agricultural Organization</td>
</tr>
<tr>
<td>JAICA:</td>
<td>Japanese International Corporation Authority</td>
</tr>
<tr>
<td>NGO:</td>
<td>Non Governmental Organization</td>
</tr>
<tr>
<td>USAID:</td>
<td>United States of America International Development</td>
</tr>
<tr>
<td>V.H.F:</td>
<td>Viral Hemorrhagic Fever</td>
</tr>
<tr>
<td>W.F.P:</td>
<td>World Food Programme</td>
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Maize storage management plays a great role in controlling shortage of maize grains. Maize being a stable food is depended by two thirds of the Kenyan population. This study covers the influence of maize storage management among small scale farmers on the level of maize quality. Level of maize quality means maize shortage in the study, while maize storage management means storage methods for maize grains. The study was carried out in Turbo division, Uasin Gishu County in Kenya. The study was guided by the following objectives: To establish the influence of moisture content on levels of maize quality among small scale farmers in Turbo, to establish the influence of rodents on levels of maize quality among small scale farmers in Turbo, to determine the influence of insect pest on levels of maize quality among small scale farmers in Turbo division and to establish the influence of maize storage management on levels of maize quality in Turbo division. The study adopted a descriptive survey design which uses words to describe the population by giving complete and detailed information of the phenomena being studied. The target population in this study was 1000 small scale farmers in Turbo division who was stratified into three locations which are Kamagut, Sugoi, and Tapsagoi. The sample size selected from the target population was 300 small scale farmers. The researcher employed simple random sampling technique to select sample size. The research used research questionnaires and interview schedule to collect data from the respondents. Data collected was analyzed using statistical package for social sciences version 18. Correlation table was drawn to show relationship between maize storage management and levels of maize quality. The findings showed that majority of the respondents 88% were of the opinion that poorly aerated storage bags influences moisture content in stored grains, 86% of them and similar percentage said that high moisture content agitates mould growth in maize grain and causes aflatoxin and mycotoxin contamination. The findings further indicated that 94% of the respondents were of the opinion that rodents reduce the quantity and quality of maize grains. Also a majority of the respondents 94% agreed with the fact that larger grain borer and weevils reduce quality and quantity of maize grain, 92% of them were of the opinion that lack of storage technology among small scale farmers lead to high insect pest infestation in maize grain. Finally, the findings on the influence of storage method on maize production among small scale farmers showed that good storage practices limit maize shortage as represented by 90% of respondents who were in agreement. Based on these findings, the study concluded that: poorly aerated storage bags influences moisture content in stored grains, rodents reduce the quantity and quality of maize grains. It is also conclusive that larger grain borer and weevils reduce quality and quantity of maize grain. The study concludes further that good storage practices limit maize shortage. The researcher made the following recommendations: The farmers in Turbo division need to adopt proper and modernized aerated storage bags on their grains to minimize the changes of grains being damage due to dampness as high moisture content in maize influence the development of microorganisms which eventually cause maize losses and contaminations, the farmers also need to developed proper ways of keeping away rodents in the stores as rodents are known to be the greatest destructors of the stored grains, larger insects which also damage the grains in store should be eliminated as much as possible. The study also recommends that modern and sophisticated storage methods such as use of Storage cribs purposefully designed and properly positioned to help in drying of grains in the store. The study successfully met its objectives and it was also found out that there is significant relationship between maize storage and food security.
CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

In global perspective, Shepherd (1993), while carrying out research on the impact of storage management on maize production in developed countries stated that maize storage management and level of maize quality has become an issue of concern for many nations, International Institutions such as World Food Programme (WFP) and Food and Agricultural organizations (FAO) among many others. Shepherd (1993), further established that about one third of the maize produced in the world for human consumption every year approximately 1.3 billion tones get lost or wasted in store due to high moisture content, rodent destruction, insect pest such as weevil and other causes hence jeopardizing the quality necessary for consumption. In developed countries such as USA, Britain, Germany, Australia and others, maize losses in store amount to about 222 million tones. FAO (2008) indicated that maize storage losses occurred throughout the supply chain. Europe and North America loss maize through consumer waste amounting to 95-115kg per year.

In Africa particularly sub-Saharan Africa countries, FAO (2008) report confirmed that these countries losses maize food amounting to 6-11 kg per year: In addition, FAO (2008) further established that the African and Asian countries are known to loss storage maize more compared to USA and European countries. This significant loss of maize in store is due to lack of storage facilities, low level of technology and low investment in maize grain fumigation in store. Level of maize quality means losses that occur on maize grains while in store, during processing or package. While maize storage management means methods used to store maize grain by small scale farmers (Food steering group, 2008). Food security, in particular maize grain availability is crucial for every country in the world. FAO, (2008) defines food security as a situation in which all people at all
times have physical, social and economic access to sufficient, safe and nutritious food which means that dietary needs and food preferences for an active and healthy life.

In Kenya, maize production ranges from 2.2 to 2.7 million tonnes. Agricultural sector is the mainstay of the Kenya’s economy which contributes 24% of Gross domestic product (GDP) and the 27% of Gross domestic product indirectly through linkages with manufacturing, distributions and other services. The maize as one of the commodities contributes a significant part. Maize is a major staple food in Kenya. It is estimated that about 30% of maize production in Kenya is lost due to post harvest losses such as weight loss, rodent and pest destruction while in the store. Other contributors are poor technology to control moisture content and ignorance of farmers on post harvest losses.

Post harvest losses of maize have contributed to levels of maize quality in Kenya. Since 2008, Kenya has been facing a severe food shortage problem in particularly maize which is a staple food as stated above. These are depicted by high proportion of population having no access to maize product in the right amounts and quality officials estimates indicate over 10million. Kenyan are maize insecure with majority of them living on food relief from internal and external well wishers such as world food programme, red cross, USAID, JAICA, DANIDA, Companies and individuals. The achievement of the national food security has been the key objective of the Agricultural sector. There are many factors which have contributed to levels of maize quality and the Ministry of Agriculture in Kenya is coming up with strategies to limit it in Kenya.

1.2 Statement of the Problem

The levels of maize quality (maize shortage) has been a centre of focus by the Kenyan government since independence in 1963. In recent years and especially starting from 2008, Kenya has been facing severe maize shortage problems. These are depicted by high proportion of population having no access to
maize grains in the right amounts and quality. Official estimates indicate over 10 million people are facing levels of maize quality with majority of them living on food relief (Agricultural Research Institute Report, 2008). Maize being stable food due to the food preferences is in short supply and most household have limited choices of other food stuff.

The current food insecurity of maize is attributed to several factors including the frequent droughts in most parts of the country, high cost of domestic maize production due to high cost of inputs especially fertilizers, internal displacement of farmers in Rift Valley in 2008. Following post election violence, high global maize prices, low purchasing power for large proportion due to high level of poverty and to a large extent of maize shortage losses. It is upon this statement that researcher will zero into influence of maize storage management among small scale farmers on levels of maize quality in Turbo Division, Uasin Gishu county in Kenya.

1.3 Purpose of the Study

The purpose of the study was to investigate the influence of maize storage management among small scale farmers on the level of quality in Turbo Division, Uasin Gishu County in Kenya. The study was also to determine if there is significant relationship between maize storage and food security.

1.4 Objectives of the Study

This study sought to achieve the following objectives:
1. To establish the influence of moisture content on levels of maize quality among small scale farmers in Turbo Division.
2. To establish the influence of rodents on levels of maize quality among small scale farmers in Turbo Division.
3. To determine the influence of insect pest on levels of quality among small scale farmers in Turbo division.
4. To establish influence of maize storage management among small scale farmers on levels of maize quality in Turbo division.
1.5 Research Questions

1. How does moisture content influence levels of maize quality among small scale farmers in Turbo Division?
2. To what extent do rodents influence levels of maize quality among small scale farmers in Turbo Division?
3. What is the influence of insect pest on levels of maize quality among small scale farmers in Turbo Division?
4. In what extent does maize storage management influence levels of maize quality among small scale farmers in Turbo Division?

1.6 Significance of the Study

The Government of Kenya and Ministry of Agriculture is very concerned with the levels of maize quality in the country. The result from this study will be helpful in policy development stage and will be used to curb the problem in the country. The results will be particularly useful to farmers to gain knowledge in preventing maize shortage. The research will benefit the future researchers to gain insight of maize losses in store. Researchers will use the same towards betterment of research in the field of agriculture.

1.7 Limitation of the Study

The researcher was limited to the language of the catchment area because he comes from the area of study. The study also limited itself to all small scale farmers without preference to specific group of farmers.

1.8 Delimitation of the Study

The study confined itself to the influence of maize storage management among small scale farmers on maize shortage in Turbo division, Uasin Gishu County in Kenya. The time span for the study was limited to three months April to June 2014. The study delimited its findings to the responses from small scale farmers in Turbo division. The study also delimited itself to extraneous variables which were beyond the researchers’ control such as respondents’ honesty personal
barriers and uncontrollable setting of the study. The study delimited itself further to target population of 1000 small scale farmers while sample size was 300 small scale farmers calculated using 30% of total target population.

1.9 Assumptions of the Study

The following assumptions will guide the study: The study assumes the respondent will return all the expected questionnaires. The study will expect the respondents to provide sincere and honest reliable information. The findings of this study will be expected to benefit small scale farmers on storage of maize grain to control maize shortage. It is also assumed that recommendation of the study will be accepted by implementing authority.

1.10 Definition of Significant Terms

**Food losses:** This is a significant reduction of food materials due to weight loss pest destruction, excess preparation of food diet, wastage during processing and packing of food.

**Food stuff:** products edible by human beings which include cereals (maize, wheat, rice) legumes (beans, groundnuts, soya beans) and vegetables and fruits such as kales, cabbage, mangoes, oranges among others.

**Insect pest:** is any organism that causes annoyance or injury to human beings, human possessions, or human interests.

**Levels of maize quality:** Level of maize quality means losses that occur on maize grains while in store, during processing or package.

**Maize storage management:** safe and convenient ways of storing maize grains either in small scale or large scale.

**Moisture content:** is a measure of the amount of water found within a material at any given time

**Rodents:** gnawing mammals of an order that includes rats, mice etc that destroy maize grains in store such as weevils.

**Small scale farmers:** maize farmers who practice subsistence farming.
**Staple food**: Chief or prominent food among food products used by a given group of people in a given place (online encyclopedia, 2013).

1.11 **Organization of the Study**

The study was organized into five chapters. Chapter one consists of the background of the study, statement of the problem purpose of the study, objectives of the study, research questions, significance of the study, limitation of the study, delimitation of the study, definition of key operational terms and the organization of the study. Chapter two; reviews of the previous studies in the related field and it is organized into brief introduction of the chapter, a review of concept of level of maize quality, moisture content and level of maize quality, rodents and level of maize quality, insect pest and level of maize quality and maize storage management and levels of maize quality, theoretical framework, conceptual framework, summary of literature, review and research gaps to be identified. Chapter three contains research design used, target population of the study, the sampling design and sample size, data collection instruments, validity and reliability of the study, data procedures and data analysis method. Chapter four comprise analysis the responses from the respondents as per the objectives of the study, presents the results in tabular and graphical forms and interprets the results from the findings. Discussions are also formed to help assess the contribution of the data collected to the body of knowledge. Chapter five gives the summary of the findings, the conclusions and the recommendations of the study.
CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

This chapter describes the literature on maize storage on shortage. It provides literature on the influence of moisture content, Rodents, pest insects on maize shortage and also maize storage methods that limits maize shortage. The literature will be sourced from textbooks, referred journal, unpublished articles, internet and unpublished articles.

2.1 Concept of Levels of Maize Quality

Levels of maize quality are the disparity between the amount of maize demanded and the amount supplied to the market. This occurs when there is excess demand than the amount of maize supplied by farmers. It affects both consumers and processors. Maize grain is stored by almost every human society. Storing maize grain has several main purposes such as enable consistent supply through out the year, preparedness for catastrophes, emergencies and periods of maize scarcity or famine and protection from destruction or theft. Safe storage of maize management grain by small scale farmers should be adhered to by following laid down guidelines by warehouse licensing board. Guidelines have been thoroughly researched by scientist to determine the best methods for reducing the real threat of food poisoning from unsafe food storage. It is also proper to maintain storage hygiene, to reduce risk of bacteria or virus growth on maize grain.

2.2 Moisture content on levels of maize quality

Moisture content is the amount of water present in moist maize. Moisture content in maize influence the development of microorganisms in stored maize, which eventually cause maize losses and contaminations (Weinberger et al., 2008; Murdolelono and Hosang, 2009). Contamination of food products by mycotoxins
have been reported in America, Britain and Germany (Wild and Gong, 2010), and over 300 types of mycotoxins have been identified, out of which 20 types have been found to occur naturally in foods and feeds [Institute of Food Science and Technology (IFST), 2009]. *Fusarium*, *Aspergillus* and *Penicillium* species have been identified as the most important types of fungi that infest stored maize and produce mycotoxins which are harmful to both human beings and animals (Sweeney *et al.*, 2000; Bennet and Klich, 2003; Ngoko *et al.*, 2008; Wild and Gong 2010). Mycotoxins that are produced by the indicated fungal species include fumonisins and T-2 toxins which are mainly produced by *Fusarium* species (Atkins and Norman, 1998, Akande *et al.*, 2006), aflatoxins which are produced by *Aspergillus* species (D’Mello and Macdonald, 1997; Cousin *et al.*, 2005; Perduri and Gobba, 2009) and ochratoxins which are mainly produced by *Penicillium* and some *Aspergillus* species such as *Aspergillus niger* (Cousin *et al.*, 2005, Magalhãesa and Bernado, 2010).

While contaminations of cereal products have been reported in South America and Australia (Wild and Gong, 2010), alarming concentrations of mycotoxins in maize have been reported in developing countries (IFST, 2009). In South Africa, Malawi, Congo, Mali and Zimbabwe, outbreaks of diseases and deaths associated with the ingestion of foods and feeds that are made from maize that is contaminated with mycotoxins have been reported (Wild and Gong, 2010). Consumption of maize which is contaminated by the mycotoxins may lead to diseases such as cancer and kidney problems (Hayes, 2000; Munkvold *et al.*, 2009). Other diseases that mycotoxins cause include suppression of the immune system, interference with neurone function and protein synthesis, and retarded growth (Hayes, 2000; Munkvold *et al.*, 2009). Death may also occur as a result of chronic exposure to high levels of mycotoxins (Hayes, 2000; Munkvold *et al.*, 2009). In 2004 death of more than 100 people in Eastern Kenya was associated with consumption of maize meals that had high levels of aflatoxins. Outbreaks of illnesses caused by consumptions of high levels of mycotoxins were also reported.
in 2005 and 2006 in Kenya (Muthoni et al., 2009). Much of the contamination of commodities by mycotoxins has been associated with inadequate storage technologies and climatic conditions such as high humidity, dampness and temperatures (World Health Organization (WHO), 2006; Williams, 2004; Gourama and Bullerman, 1995; Tachin, 2008). This shows that storage technologies play a major role in determining the quality of maize. Thus, ensuring maximum efficiency of the storage technologies is crucial to the safety of stored maize and health of the consumers.

Maize is deficient in the essential amino acids lysine and tryptophan, thus, the protein which is found in maize is of low quality (Friedman, 1996; Escobedo, 2010). This, together with its deficiency in minerals and vitamins, means that maize may subject the consumers to poor nutrition especially in places where it is the staple food crop. This robs the consumers of nutrition security and subjects them to food insecurity. The nutrient deficiency of maize is being addressed through breeding and molecular technologies that aim at not only improving maize yield, but also improving and enhancing its nutrient content (Ortiz-Monasterio et al., 2007). However, in Tanzania and Kenya breeding technologies are focused on improving maize seeds for high yield. The susceptibility of maize seed to attack by pests, together with the use of inefficient storage technologies especially among small scale farmers in Kenya are still hindering achieve and maintenance of the highest quality of maize (Adda et al., 2002).

2.3 Rodents and levels of Maize quality

In America and Britain, rodents have a serious impact on people’s lives. They nest in the roofs of households, relying on food and human drinking water stored inside the home and causing serious losses to these stores. They also damage crops, personal possessions and buildings, and transmit dreaded diseases such as the bubonic plague. Three types of rodents: black rats, brown rats and house mice scientifically known as Rattus rattus, Rattus norvegicus and Mus musculus species, respectively, are significant contributing factors to crop
loss worldwide (De Groote, 1996; Kgware et al., 2008). Rodents multiply fast and may consume considerable produce per day depending on their species. It is estimated that 15 % of maize produced in Africa is lost to rodents alone each year (Stenseth et al., 2003). Likewise, in Tanzania outbursts of pre-harvest and post-harvest rodents infestations of maize are common, causing an estimated loss of 15 % of maize per annum (Makundi et al., 2005; Mulungu et al., 2010). Rodents make holes in storage containers, and through this they create moisture problems in the stored products (The Somali Agricultural Technical Group (SATG), 2009); while they also contaminate food grains with their excretions and hair (Cao et al., 2002).

Rodents can transmit about 60 types of diseases to humans, and are carriers of diseases that affect both humans and domestic livestock (Parshad, 1999). Black rats are associated with transmission of bubonic plague, whereas brown rats are associated with spreading the weil’s disease, cryptosporidiosis, viral hemorrhagic fever (VHF), Q fever and hantavirus pulmonary syndrome (Public Health of Canada, 2008; Mills and Childs, 2001). House mice are notorious for transmitting lyme disease, an infection caused by the bacterium *Borrelia burgdorferi* of which house mice are hosts (Noble Pest Management, 1994; Public Health of Canada, 2008). House mice also transmit the lymphocytic choriomeningitis arenavirus (Mills and Childs, 2001), which cause aseptic meningitis (Roebroek, 1994.). In the light of the above literature review, storage pests do not only reduce the amount of food that can be available to the consumers, but they also cause health problems through contaminations and reduce the nutritional content of the infested foods. Rodents prefer foods that are rich in vitamins and protein. The rodents are likely to consume the most nutritious parts of the maize grain thus, causing reduction in the vitamin and protein content of the grain. In Kenya the storage methods that allow the infestation of stored maize by rodents to take place, impact negatively on the quantity and quality of the maize grain.
2.4 Insect pest and levels of Maize quality

In sub-Saharan Africa, the larger grain borer, *Prostephanus truncatus* (Horn) (Coleoptera: Bostrichidae), was identified as the most damaging storage pest that causes great losses of maize (Lamboni and Hell, 2009). It was estimated that in Africa, *P. truncatus* causes up to 40% of maize loss within six moths of storage (Lamboni and Hell, 2009), whereas an estimate of 34% of maize loss due to *P. truncatus* after 3-6 months of storage were reported in East Africa (Hodges, 1998). *Sitophilus zeamais* (Motschulsky) (Coleoptera: Curculionidae), was named as the next most important insect pest of stored maize in Africa, followed by *Tribolium* spp (Coleoptera: Tenebrionidae), *Cathartus quadricollis* (Gue´rin) (Coleoptera: Silvanidae), *Rhyzopertha dominica* (Fabricius) (Coleoptera: Bostrichidae), *Oryzaephilus* spp (Coleoptera:Cucujidae), *Gnatocerus* spp (Coleoptera Tenebrionidae) *Palorus* spp (Coleoptera Tenebrionidae), *Cryptoles tes ferrugineus* (Stephens) (Coleoptera: Laemophloeidae) (Lamboni and Hell, 2009).

However, recently moths, particularly *Sitotroga cerealella* (Adda et al., 2002) and *Plodia interpunctella* (Mohandass et al., 2007) have been identified as important insect pests next to *Sitophilus zeamais* in the order of importance. While up to 12% of maize loss due to maize weevils alone has been reported in the tropics (Pingali and Pandey, 2001), *Sitophilus zeamais* has been reported to be responsible for 10-20% of maize losses after three months of storage (Boxall, 2002, as cites by Tefera et al., 2011). Thus, due to inefficient storage technologies millions of tonnes of maize are lost to insect pests in the world each year. In Tanzania losses of up to 34% of maize due to insect pests have been reported (CIMMYT and Dubin, 2010). However, the authors have neither indicated what methodologies they used to estimate these losses nor stated whether they took into consideration the consumption patterns of the people studied, thus, the accuracy of the estimations is not guaranteed.
In Kenya, insect pests impact negatively on maize in the following ways: insects’ activities in stored maize damage maize kernels by making holes in them, which make the maize kernels susceptible to infestation by moulds (Sallam, 1999). Insects further spread moulds in storage facilities through moving from one place to another (Lamboni and Hell, 2009). In fact, moulds in maize have been found to intensify with the intensification of insect pests (Wright, 2011). Insect pests may also affect the quality of maize by contaminating the stored maize with wastes, which may further lead to interference with the odour, colour and taste of the maize. In addition, insect pests would reduce the nutritional value of stored maize (Lamboni and Hell, 2009), possibly through feeding on the nutrient rich germ and the outer layer of the maize kernels, which in turn leads to significant reduction in the kernels’ nutrient content. Humidity and temperature in the storage facilities, moisture content of maize grain prior to storage, materials from which storage facilities are made, damage of maize grain prior to storage and length of time during which maize is stored are the main factors that influence development of pests in stored maize. Issues raised in this paragraph are further reviewed in the sections that follow.

2.5 Maize storage management and levels of Maize quality

The poor status of small scale farmers leads them to select maize storage management which is cheap to construct regardless of their inadequacy, consequently, most of the grain losses occur during storage (Obetta and Daniel, 2007). This necessitates improvement of the storage technologies. Factors that usually affect the farmers’ choice of the storage methods include the cost of building and running the storage method, availability of the materials and expertise for building the storage facility, climatic conditions of the area and the types of pest problems in the area (FAO, 1985). Other factors include the amounts of crops that are to be stored and the expected quality of the stored crops (FAO, 1985) in Europe and America, advance storage methods are used to store maize.
Sack storage: In Africa, storage sacks are made of different materials such as sisal natural fibres such as jute and synthetic fibers, and they can store up to 100 kg of grain each (Lindblad and Druben, 1976). To prevent the storage sacks from absorbing moisture from the floor, the sacks need to be stacked on platforms raised off the floor with space between them to allow air to flow under the sacks and between them. This cools the stored crops from the heat that results from respiration of the grain. Regular inspection of crops stored in sacks is necessary for keeping the grains safe from attacks by pests (De Groote, 2004). The weakness of sack storage is that sacks do not last long (FAO, 1994). New storage sacks are likely to be needed after every harvest, which makes this storage method expensive. Sack storage methods require that the storage sacks be treated with pesticides prior to storage to reduce chances of infestation (FAO, 1994).

The advantage of sack storage in Kenya is that it provides the farmer with ease of access to the stored crops because the farmer can choose to store the grain filled sacks at any convenient place in the home. However, sacks can be easily damaged by rodents, which would expose the stored maize to rodents’ infestations. Lastly, although sack storage method is commended for having the capacity to keep stored grain cool, the extent to which sack storage method is efficient for protecting maize from moisture content problems, especially in humid places, has not been given adequate attention. It was hypothesized that because storage sacks allow aeration to take place, they can easily allow moisture to enter, which can lead to moisture content problems and development of fungi in the stored grain especially in humid places.

Storage cribs: Storage cribs can offer stored crops up to six months of storage, they can last more than a year and the amount of crops that they can store would depend on the size of the crib (UNIFEM, 1995). The advantage of storage cribs is that maize stored in them continues to dry through ventilation due to the manner in which the cribs are built. However, the rate at which maize dries in a
crib depends upon the force at which air currents pass through the maize cobs, and this is influenced by the width of a crib (FAO, 1987). Thus, maize would dry faster in a cribs 60 cm wide crib than it would in a crib which is wider than 60 cm (FAO, 1987). Placing the longer side of the crib in line with the orientation of the prevailing wind has also been found to be helpful in allowing as much air current as possible to be blown into the maize cobs in the crib (FAO, 1987). Storage cribs are commonly used by small scale farmers in Kenya.

Thus, purposeful designing and positioning of cribs may be helpful in maize drying. However, it has also been noted that it takes eight to ten days to bring maize in a crib to the right moisture content during the dry season, and 80 days during the wet season (FAO, 1980). Generally, maize with 30 % moisture content at harvest can take about six weeks to be appropriately dried in a crib (Shepherd, 2010). The length of time that it takes for maize in storage cribs to dry is a lot longer than the time recommended by Semple et al., 1989 and Reed et al., 2007) for drying maize which is not dry enough for storage at harvest. As a result development of moulds and insect pests on maize stored in cribs in humid areas is likely to occur. Thus, cribs may not be suitable for use in areas characterized by prolonged seasons of rainfall, coolness and high humidity because they would create conditions that are favourable for the growth of pests.

Storage cribs can be metallic or non-metallic. Walls and floors of non-metallic cribs are made using wood and mud, while roofs are thatched. Rodents can easily make holes through them, while moisture can also penetrate into the cribs and cause moisture content problems in the stored grain. As opposed to non-metallic cribs, metallic ones are made using materials which rodents cannot make holes through such as iron or aluminum sheets, and they can be rodent proofed by fitting into them structures that prevent rodents from getting into the cribs.
Storage baskets: Storage baskets are made of reeds, elephant grass, bamboo, supple sticks or sorghum stalks, and they can be plastered in order to make them somewhat airtight (FAO, 1994).

Furthermore, storage baskets can last relatively longer if they are not exposed to moisture, thus, it is recommended that storage baskets should be raised above the ground in order to prevent them from absorbing moisture (Shepherd, 2010). Storage baskets are cheap to make using local materials, and they can hold up to 100 kg of grain (Lindblad and Druben, 1976), which is relatively small. In addition, storage baskets may be roofed or not roofed (Shepherd, 2010). A storage basket which is not roofed makes it very easy for stored grain to be infested by rodents. Thus, roofing of the storage baskets is recommended for more efficiency. However, like non-metallic cribs, in general, the materials from which storage baskets are made, make it easy for rodents to make holes through them, whereas absorption of moist air by the storage baskets is also possible. This can lead to development of insect pests and moulds in the storage facilities. Therefore, storage baskets may subject stored maize to rodents, insect pests, and possible contaminations especially in humid environments. Consequently, the quality of stored maize in relation to its nutritive value would be impacted upon negatively.

Mud block silos: Mud block silos are made using compacted soil (Lindblad and Druben, 1976). Compact soil is naturally a poor conductor of heat and has high thermal inertia (Darlington, 2007) because heat does not flow through it easily. Thus, when exposed to heat a brick silo would build up heat on the surface while the inner parts of the bricks remain cool. This helps to keep crops stored in the brick silo cool, leading to longer storage (UNIFEM, 1995). Other advantages of mud brick silos include that the bricks can be made locally and that the farmers can choose to make a silo of the desired size and that they are cheap to build (UNIFEM, 1995).

Also, a slanted floor and a grain chute make it easy for the farmers to reach the grain when necessary without opening the top of the silo (Lindblad and
Druben, 1976). However, due to the nature of the material used to make the mud brick silos, moisture can easily get into the storage facilities and cause moisture problems and damage to the storage facilities. The ease with which mud block silos break renders them expensive since new ones will have to be built after every breakage (Coulter and Schneider, 2004). Also rodents can easily make holes through the mud bricks, which, apart from damaging the storage facilities under discussion in this section, leads to infestation of the stored grain and subsequent problems such as loss of grain to the rodents and moisture content problems. Proper handling and protection can ensure 6-8 years of use of mud brick silos; whereas burnt mud brick silos can be used for 20 years or more (Coulter and Schneider, 2004). Thus, it is recommended that mud bricks be burnt to increase their durability.

Metal silos: It is a common method of storage in Europe and America. Metal silos can hold up to 4000 tonnes of grain depending on the sizes of the silos (Ikisan, 2000). Due to the fact that they are metallic, rodents cannot make holes through them. Furthermore, metal silos can be made airtight by lining the inner walls with air proof plastic materials, and they can easily be fumigated. Thus, metallic silos have the capacity to protect stored grain from rodents and insect pests. However, metals are good conductors of heat (Stoker, 2010), thus, heat flows through them easily. Therefore, unlike brick silos, build-up of heat inside the metallic silos can occur when they are exposed to heat (Villiers et al., 2006). Condensation can also occur when temperatures drop, which leads to moisture content problems and creates favourable conditions for infestations (Villiers et al., 2006). Other disadvantages of metal silos include that they are expensive to construct (Lindblad and Druben, 1976). Thus, poor farmers in Africa may not be able to afford them. They may also be subject to corrosion in moist environments (Villers et al., 2006). The latter shortens the metallic silos’ lifespan and makes them unsuitable for use in humid places.
Roof storage: In Kenya, most cases, farm households hang maize cobs on beams below the roof of the kitchen so that smoke and heat from the fireplace can dry and protect stored maize from insect pests (UNIFEM, 1995). However, due to the limited size of the area below the roof, farm households can store relatively small amounts of maize using this type of roof storage method. Furthermore, this type of storage is mostly used for storing seeds for planting.

For prolonged storage, maize cobs are piled on planks spaced in the roof space of a building. Using roof storage, farmers may store maize for up to one year. Roof storage provides the farmer with a facility that can last for as long as the roof lasts, and the farmer can also store as much harvest as possible depending on the size of the roof. Heat and smoke from the fire are used to keep the stored crops dry and to protect them from infestations by insects. Nevertheless, maize which has high moisture content at storage may take a long time to dry in the roof storage facilities since it is piled up. This may lead to development of fungi and possible mycotoxin contamination of the stored grain. The roof storage method may easily expose stored crops to attack by rodents and moisture from the surrounding areas.

2.6 Theoretical Framework

This study is based on the Marxist theory of food security and drying theory of equilibrium moisture content. The Marxist theory of food security is an approach of assessing food security by identifying food shortage in particularly staple food such as maize, rice, banana among others. On the other hand drying theory seek to establish the levels of moisture content in the grains such as maize, wheat, rice, beans, peas and other crops. Moisture contents plays a great role as far as storage of food stuff is concern. High moisture content facilitates microbial development of aflotoxin.

The two theories are relevant to this study which intends to find out the influence of maize storage management among small scale farmers on levels of maize quality. The theory of Marxist and dry theory are considered appropriate for
the purpose of this study which ultimately aimed at improving level of maize quality through proper maize management. These two approaches will be applicable and it has been applied before in Europe and America with good results (Kerr, 2004).

2.7 Conceptual Framework

In the study the conceptual framework to be adopted is where maize storage management is the independent variable and level of maize quality as shown in figure 1.

<table>
<thead>
<tr>
<th>Independent variable</th>
<th>Dependent variable</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Maize storage management</strong></td>
<td><strong>Levels of quality</strong></td>
</tr>
<tr>
<td>Moisture content</td>
<td>- Number of maize bags in tonnage per population</td>
</tr>
<tr>
<td>- Level of humidity</td>
<td></td>
</tr>
<tr>
<td>- Range of temperature</td>
<td></td>
</tr>
<tr>
<td>Rodents</td>
<td></td>
</tr>
<tr>
<td>- Types of rats</td>
<td></td>
</tr>
<tr>
<td>- Number of mice</td>
<td></td>
</tr>
<tr>
<td>Insect pest</td>
<td></td>
</tr>
<tr>
<td>- Number of grain borer</td>
<td></td>
</tr>
<tr>
<td>Methods of Storage</td>
<td></td>
</tr>
<tr>
<td>- Types of sacks</td>
<td></td>
</tr>
<tr>
<td>- Size of silos</td>
<td></td>
</tr>
<tr>
<td><strong>Weather</strong></td>
<td></td>
</tr>
<tr>
<td>- Frequent of weather changes</td>
<td></td>
</tr>
</tbody>
</table>

**Figure 1: Conceptual framework**

Source: Authors own compilation (2014)

Without appropriate stored-food protection measures, farmers are often left with no alternative but to sell their produce soon after harvest, even though it may
not be possible to secure attractive prices on the market. Integrated stored-food protection enables farmers to extend the storage period without having to take the risk of increased losses.

However, maize in store can be decreased both in quantity and quality by the following factors, high moisture content due to dampness in store or improper drying, damage by rodents and storage pests as a result of poor storage practices, and generally poor management practices. The most important point in both short-term and long-term storage is the application of proven hygiene measures, which include thorough cleaning of the store and its surroundings. Remove all material remaining from the last harvest. If possible, treat the empty store with an insecticide to expel or destroy any concealed pests. Repair any damage to the roof before further storage. With clay stores, seal any cracks. Stores standing on posts can be protected against intrusion by rodents with simple barriers.

Insect pest populations in stored maize are influenced by availability of food, relative humidity, temperature and moisture content of the grains. Temperatures of 27°C to 31°C are optimal for development of pests of stored maize grains. At temperatures below 14°C and above 42°C development generally does not take place. Most storage pests die at temperatures below 5°C and above 45°C. The optimum relative humidity for most storage maize pests lies at around 70%, the minimum being 25-40% and the maximum 80-100%. Very few species are able to survive in extremely dry conditions.

Storage pests for maize grains are not able to develop quickly or breed successfully in very dry conditions. Their rates of development below 11.5% moisture content are distinctly slower, and at moisture contents below 8% many fail to breed at all. Moisture contents of 12-18% favour rapid increase especially in suitable temperature and relative humidity conditions. Moisture contents of maize in store should be below 13.5%. With insufficient drying, the grain is usually extremely satisfactory for insect breeding.
Storage management practices also influence on the quality of maize productivity. For farmers with a small crop, there is a reduced risk of having to purchase expensive additional food at the end of the storage season. The presented package thus helps secure income in rural areas. This is most effective where there is a lack of capital for investment. The storage management practices described here have the particular advantage of using materials which are available everywhere, and of being based essentially on traditional practices.

2.8 Summary of the Literature review and Research

Extensive research has been done on the concept of maize storage management but little research has been done on influence of maize storage management on levels of maize quality among small scale farmers. The researcher dwells on food shortages in general but did not specifically break the maize shortage into influence of moisture content, rodent infestation and insect pest infestation. This study therefore will bridge this gap in literature.

2.9 Knowledge gap

<table>
<thead>
<tr>
<th>Variable</th>
<th>Source</th>
<th>Finding</th>
<th>Gap</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture content</td>
<td>Wild and Gong (2010)</td>
<td>Moisture content influences the development of micro-organism in stored maize.</td>
<td>The past literature fails to show how moisture caused by poorly aerated storage bags influences level of quality.</td>
</tr>
<tr>
<td>Rodents infestation</td>
<td>Degroote (1996)</td>
<td>Rodents influence maize shortage by destroying grain and spreading diseases.</td>
<td>The past study fails to show that rodents reduce the quality of maize and how rodents’ faeces contaminate stored grains.</td>
</tr>
<tr>
<td>Insect pest infestation</td>
<td>Lamboni and Hell (2009)</td>
<td>Insect pest influence maize shortage by</td>
<td>This study does not specify exact time to treat maize</td>
</tr>
</tbody>
</table>
Methods of storage management  | Obetta and Daniel (2007)  
---|---
Maize storage management influence | boring the grains paving way for mould infestation.
levels of maize quality | grains so as to prevent insect pest infestation.
depending on the quality of the store. | The past study did not specify appropriate maize management for small scale farmers.
CHAPTER THREE

RESEARCH METHODOLOGY

3.0 Introduction

In this chapter the researcher focuses on the research design used, target population of the study, the sampling design and sample size, data collection instrument, validity and reliability of the study, data procedures and data analysis.

3.1 Research Design

Best and Khan (1993) defines a research design as a blue print for fulfilling objectives and answers to research questions. He emphasizes that a research design is a plan and structure of investigation conceived so as to obtain answers to research questions. The research design expresses both the structure of research problem and the plan for investigation used to obtain empirical evidence on the relations of the research problem. The current study was conducted within the confines of a descriptive survey design. This design uses words to describe the population by giving complete and detailed information of phenomena. Descriptive survey involves data analysis with aims of coding, categorizing comparing views, opinions and attitudes (Koul, 1992). The descriptive survey design was chosen because it allows the study to collect in depth data from the respondents using research instruments such as questionnaires and interview schedules which gave a detailed account of the state of maize storage and maize shortages among small scale farmers in Turbo Division.

3.2 Target Population

Target population study is a study of a group of individuals taken from the general population who share a common characteristic such as age, sex, or health condition. This group may be studied for different reasons such as their response to a situation carried out to find out certain information. Target population about which information is desired for the study population (Borg and Hall, 2009). The
target population in this study consisted of the small scale farmers in Turbo division. The targeted population was 1000 small scale farmers. They are earmarked because they are the one facing maize shortage due to maize storage management influence as a result of moisture content, rodents, and insect pest. The target population was stratified into three location as shown on table below.

### Table 3.1 Target Population

<table>
<thead>
<tr>
<th>Location</th>
<th>Total target population</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kamagut</td>
<td>320</td>
</tr>
<tr>
<td>Sugoï</td>
<td>280</td>
</tr>
<tr>
<td>Tapsangoi</td>
<td>400</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1000</strong></td>
</tr>
</tbody>
</table>

Source: Researcher’s source

#### 3.5 Sample size and sampling procedures

Sampling is that part of statistical practice which concerns the selection of individual observations intended to yield some knowledge about a population of concern especially for the purposes of statistical inferences (Ghoshi, 2002). Sampling frame which has the property that study can identify every single element and include any in the sample. The most straight forward type of frame is a list of elements of the population preferably the entire population. The sampling frame must be a representative of the population and this is a question outside the scope of statistical theory demanding the judgement of experts in the particular subject matter being studied (Kothari, 2006).

The researcher used a sample size of 30% from the selected respondents selected from the target population as recommended by OSO and Onen (2005) who recommends at last 30% of the target population to be used for purposes of the research. In this study the sample size selected was 300 respondents which represent 30% of the target population. Sample size calculation is shown on table 3.2 below:
Table 3.2 Sample Size

<table>
<thead>
<tr>
<th>Location</th>
<th>Target population</th>
<th>Procedure (30%)</th>
<th>Sample size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kamagut</td>
<td>320</td>
<td>96</td>
<td>96</td>
</tr>
<tr>
<td>Sugoi</td>
<td>400</td>
<td>120</td>
<td>120</td>
</tr>
<tr>
<td>Tapsagoi</td>
<td>280</td>
<td>84</td>
<td>84</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1000</strong></td>
<td><strong>300</strong></td>
<td><strong>300</strong></td>
</tr>
</tbody>
</table>

Source: Researcher’s source

Sampling technique is the procedure a researcher uses to gather people, places or things to study (Kombo, and Tromp, 2006). The researcher purposely targets a group of people believed to be reliable for the study. The study employed simple random sampling technique. Random sampling technique was used to select small scale farmers from Turbo division.

3.5 Research Instrument

The researcher used the questionnaires and interview schedule to collect data. Kothari (2008) defines questionnaires as the consisting of a number of questions printed or typed in a define order on a form. The researcher constructed open ended questionnaires which were administered to small scale farmers in Turbo division. The researcher used questionnaires because it is of low cost (Kothari, 2008). Questionnaires are commonly used to obtain data about population since each item is developed to address a specific objective research questions or hypothesis of the study (Mugenda and Mugenda, 2003). This method is quite popular especially when survey is used as the researcher is interested in finding out the views, opinion and attitudes of the respondents regarding influence of maize storage on maize shortage among small scale farmers in Turbo division.

3.6 Reliability of Research Instruments

The questionnaires used in this study were pre-tested through a pilot study before actual data collection. This enabled a revision of the questionnaires before
actual data collection. The pilot study was done to determine reliability. It was done in Turbo division.

A reliable criterion is stable or reproductive. Reliability is a measure of how consistent the results from a test are (Kombo, 2006). The study involved test retest method. This is whereby the study involved the administration of questionnaires to two different respondents at different times. The outcome of the two tests was correlated and variation detected if any. This ensures that questionnaires measure what they were supposed to measure.

3.7 Validity of Research Instruments

According to Yi (2004), the validity of research is concerned with the extent to which that data measures what they are suppose to measure. In this study the opinion of the content experts which in this case comprised of the supervisor and college lecturers played a significant role in determining the validity of the research instruments. Validity index of 0.70 was used to determine its validity.

3.8 Data Collection Procedure

The researcher acquired a permit from the district agricultural officer and division Agricultural officer to conduct the study. The researcher distributed questionnaires to the respondents with an assistance of a person whom the researcher briefed him before using him in distribution of questionnaires and collection of questionnaires after being filled by the respondents.

3.9 Data Analysis

The study adopted both quantitative and qualitative analysis in order to achieve the objective of the study. The influence of maize storage on maize shortage among small scale farmers was analyzed based on the data collected using questionnaires. The data was analyzed by use of SPSS version 18. Correlation table on the same was drawn to demonstrate the relationship between maize storage management levels of maize quality.
### 3.10 Operationalization of Variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>Measurement category</th>
<th>Scale of measurement</th>
<th>Analysis test</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Independent</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Level of humidity</td>
<td>Always</td>
<td>Ordinal</td>
<td>Percentage</td>
</tr>
<tr>
<td>Range of temperature</td>
<td>Occasionally</td>
<td>Ordinal</td>
<td></td>
</tr>
<tr>
<td><strong>Rodents</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Types of rats</td>
<td>Always</td>
<td>Nominal</td>
<td>Percentage</td>
</tr>
<tr>
<td>Number of mice</td>
<td>Always</td>
<td></td>
<td>and</td>
</tr>
<tr>
<td><strong>Insect pest</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of grain borers</td>
<td>Always</td>
<td>Nominal</td>
<td>Percentage</td>
</tr>
<tr>
<td>Number of weevils</td>
<td>Always</td>
<td></td>
<td>and</td>
</tr>
<tr>
<td><strong>Methods of storage</strong></td>
<td>Occasionally</td>
<td>Ordinal</td>
<td>Percentage</td>
</tr>
<tr>
<td>Types of sacks</td>
<td>Occasionally</td>
<td></td>
<td>and</td>
</tr>
<tr>
<td>Size of silos</td>
<td>Occasionally</td>
<td></td>
<td>frequency</td>
</tr>
<tr>
<td>Size of cribs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Dependent</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maize shortage</td>
<td>Occasionally</td>
<td>Nominal</td>
<td>Percentage</td>
</tr>
<tr>
<td>Number of maize tonnage per population</td>
<td>Occasionally</td>
<td>Nominal</td>
<td>and</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>frequency</td>
</tr>
</tbody>
</table>
3.11 Ethical Consideration

The researcher agreed to comply with the following principles which were meant for protecting the dignity and privacy of every individual who in the course of research work carried out under the project, requested to provide personal or commercially valuable information about him/her self or others (hereinafter referred to as a subject of research). The respondents were notified on aims, methods, anticipated benefits and potential hazards of the research his/her rights to withdraw from participation in the research. The information gathered from the respondents was kept confidential and it was never revealed at all.
CHAPTER FOUR

DATA ANALYSIS AND INTERPRETATION

4.1 Introduction

This chapter gives the analysis of the findings, and its interpretation. The analysis has been summarised in table and interpreted in each table according to the findings. The purpose of the study was to establish the influence of maize storage management among small scale farmers on the level of maize quality in Turbo division Uasin Gishu County. Descriptive survey research design was adopted for the study. The study sought to establish the influence of moisture content on levels of maize quality among small scale farmers in Turbo Division, the influence of rodents on levels of maize quality among small scale farmers, the influence of insect pest on levels of quality among small scale and the influence of maize storage management among small scale farmers on levels of maize quality. A total of 300 farmers in Turbo division were involved in filling the questionnaires.

4.1.1 Response Rate per Location

The researcher sought to find out the response rate of the respondents as per the location. However, the study findings in figure 4.1 revealed that in Kamagut location, the response rate was 99% since out of the 96 questionnaires that were given out, 95 (99%) were filled and returned. In Sugoi location, the response rate was found to be 85% since out of the 120 questionnaires that were administered, 102 (85%) were filled and returned. Finally in Tapsagoi location the response rate were 100%. These response rates can be considered good. Although the response rates were good in every location, the number of distributed questionnaires may have had implications on the validity of the statistical analysis.
4.2 Demographic information of the respondents

The study sought to establish the background information of respondents. Table 4.1 demonstrates the distribution of respondents as per the location in which they come from.

<table>
<thead>
<tr>
<th>Locations</th>
<th>Frequency</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kamagut</td>
<td>95</td>
<td>33.6</td>
</tr>
<tr>
<td>Sugoi</td>
<td>102</td>
<td>36.0</td>
</tr>
<tr>
<td>Tapsagoi</td>
<td>86</td>
<td>30.4</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>283</strong></td>
<td><strong>100.0</strong></td>
</tr>
</tbody>
</table>

The study results showed that out of 283 (100%) respondents, 102 (36%) were from Sugoi location, 95 (33.6%) were from Kamagut location and 86 (30.4%) were from Tapsagoi location.

The study further sought to demonstrate the background information of the respondents according to different locations in which the respondents reside. The findings from each location (Kamagut, Sugoi and Tapsagoi) were as presented in table 4.2, table 4.3 and table 4.4 respectively. The background information was significant to the study as it helped to understand the rationality of the background aspects of the various respondents and how it contributes to the level of maize quality.
Table 4.2 Background Information of Respondents from Kamagut location

<table>
<thead>
<tr>
<th>Background information</th>
<th>Frequency</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>50</td>
<td>52.6</td>
</tr>
<tr>
<td>Female</td>
<td>45</td>
<td>47.4</td>
</tr>
<tr>
<td>Age Range</td>
<td></td>
<td></td>
</tr>
<tr>
<td>21-30 years</td>
<td>28</td>
<td>29.5</td>
</tr>
<tr>
<td>31-40 years</td>
<td>26</td>
<td>27.4</td>
</tr>
<tr>
<td>41-50 years</td>
<td>19</td>
<td>20.0</td>
</tr>
<tr>
<td>Over 50 years</td>
<td>22</td>
<td>23.1</td>
</tr>
<tr>
<td>Level of education</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Primary level</td>
<td>13</td>
<td>13.7</td>
</tr>
<tr>
<td>Secondary level</td>
<td>45</td>
<td>47.4</td>
</tr>
<tr>
<td>Post secondary</td>
<td>37</td>
<td>38.9</td>
</tr>
<tr>
<td>Farming</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Small scale</td>
<td>87</td>
<td>91.6</td>
</tr>
<tr>
<td>Large scale</td>
<td>8</td>
<td>8.4</td>
</tr>
<tr>
<td>Experience</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Below 3 years</td>
<td>9</td>
<td>9.5</td>
</tr>
<tr>
<td>4-6 years</td>
<td>23</td>
<td>24.2</td>
</tr>
<tr>
<td>7-9 years</td>
<td>8</td>
<td>8.4</td>
</tr>
<tr>
<td>Over 10 years</td>
<td>55</td>
<td>57.9</td>
</tr>
</tbody>
</table>

In Kamagut location, out of 95 (100%), 50 (52.6%) were male farmers while 45 (47.4%). This represented a near equitable distribution in terms of gender for the respondents therefore the data collected gave balanced views in terms of gender differences. Accordingly, the study results showed that majority of respondents 28 (29.5%) in this location were aged between 21-30 years while the least 19 (20%) were aged between 41-50 years. In regards to education level, a
majority 45 (47.4%) had secondary level of education followed by 37 (38.9%) who had post secondary level and the remaining 13 (13.7%) had primary level of education. However, it was observed through study findings on figure 4.2 that majority of the respondents 87 (91.6%) were small scale farmers while 8 (8.4%) were large scale farmers. Based on the experience of farming, majority of them 55 (57.9%) were found to have over ten years of farming experience while the rests 40 (42.1%) had less than ten years of experience in farming.

The information obtained from agricultural officers through interview schedule confirmed that in Kamagut location, there is high number of male farmers than female farmers. This could be likely due to the virtue of male dominance in terms of farming practices as they are the heads of the households as well as the owners of the farms. The findings also showed that majority of the farmers in the location have acquired formal education which has helped them increase level of maize quality.
The findings in Sugoi location indicated that majority of the respondents were male population representing 61.8% of the total population while the female represented only 38.2% of the total population of respondents. Accordingly the results showed that majority of the respondents (32.4%) were between the ages 31-40 years and the least number of respondents came from the ages 41-50 years.
indicating that there was no a clear relationship between the number of respondents participating in farming and their age. In reference to their level of education most respondents were found to have post secondary (46.1%) and secondary (43.1%) level education with very few respondents (10.8%) having primary level of education. The findings also showed that majority of the respondents (93.1%) were small scale farmers while (6.9%) were large scale farmers. This can be attributed to lack of enough land to practice farming. Based on experience the findings indicated that majority of the farmers (58.8%) had practiced farming for more than 10 years and the least percentage of farmers (6.9%) had an experience of less than 3 years. This can be attributed to the fact that the region has good weather patterns favourable for farming hence practice has been going on for many years.
Table 4.4 Background Information of Respondents from Tapsagoi Location

<table>
<thead>
<tr>
<th>Background information</th>
<th>Frequency</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gender</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>52</td>
<td>60.5</td>
</tr>
<tr>
<td>Female</td>
<td>34</td>
<td>39.5</td>
</tr>
<tr>
<td><strong>Age Range</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>21-30 years</td>
<td>19</td>
<td>22.1</td>
</tr>
<tr>
<td>31-40 years</td>
<td>26</td>
<td>30.2</td>
</tr>
<tr>
<td>41-50 years</td>
<td>16</td>
<td>18.6</td>
</tr>
<tr>
<td>Over 50 years</td>
<td>25</td>
<td>29.1</td>
</tr>
<tr>
<td><strong>Level of education</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Primary level</td>
<td>11</td>
<td>12.8</td>
</tr>
<tr>
<td>Secondary level</td>
<td>37</td>
<td>43.0</td>
</tr>
<tr>
<td>Post secondary</td>
<td>38</td>
<td>44.2</td>
</tr>
<tr>
<td><strong>Farming</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Small scale</td>
<td>83</td>
<td>96.5</td>
</tr>
<tr>
<td>Large scale</td>
<td>3</td>
<td>3.5</td>
</tr>
<tr>
<td><strong>Experience</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Below 3 years</td>
<td>6</td>
<td>7.0</td>
</tr>
<tr>
<td>4-6 years</td>
<td>16</td>
<td>18.6</td>
</tr>
<tr>
<td>7-9 years</td>
<td>8</td>
<td>9.3</td>
</tr>
<tr>
<td>Over 10 years</td>
<td>56</td>
<td>65.1</td>
</tr>
</tbody>
</table>

In Tapsagoi location, out of 86 (100%), 52(60.5%) were male farmers while 34(39.5%) were female farmers. This represented a disparity in terms of gender for the respondents therefore the data collected gave imbalanced views in terms of gender differences. However, the researcher was able to collect data from respondents of both genders. Accordingly, the study results showed that majority of respondents 26(30.2%) in this location were aged between 31-40 years,
25(29.1%) were of over 50 years, 16(18.6%) were aged between 41-50 years while the least 19(22.1%) were below 30 years. The information was therefore obtained from respondents of diverse age range.

In regards to education level, a majority 38(44.2%) had post secondary level of education followed by 37(38.9%) who had secondary level and the remaining 11 (12.8%) had primary level of education. However, it was observed through study findings on table 4.4 that majority of the respondents 83(96.5%) were small scale farmers while 3(3.5%) were large scale farmers. Based on the experience of farming, majority of them 56(65.1%) were found to have over ten years of farming experience while the rests 30 (34.9%) had less than ten years of experience in farming.

The information obtained from agricultural officers through interview schedule confirmed that in Tapsagoi location, most of people in that location practiced small scale farming and that majority of these farmers are male farmers. This shows that there is need to encourage female farmers to participate more on farming as well. The findings also showed that majority of the farmers in the location have acquired formal education which has helped them increase level of maize quality.

4.3 Specific Information based on the objective of the study

This section seeks to establish the opinions of the respondents as to according to the specified objectives and has been summarized and presented in tabular form in each category

4.3.1 The influence of moisture content on levels of maize quality

The study was guided by the first objective which sought to find out the influence of moisture content on the levels of maize quality. The findings were summarized and presented as in table 4.5
Table 4.5 The influence of moisture content on levels of maize quality

KEY: SA- strongly Agree, A-agree, U-Undecided, D-Disagree, SD- Strongly Disagree, T –Total, M-Mean

<table>
<thead>
<tr>
<th></th>
<th>SA</th>
<th>A</th>
<th>U</th>
<th>D</th>
<th>SD</th>
<th>T</th>
<th>MEA</th>
</tr>
</thead>
<tbody>
<tr>
<td>High moisture content agitates</td>
<td>F159</td>
<td>84</td>
<td>13</td>
<td>27</td>
<td>0</td>
<td>283</td>
<td>4.3</td>
</tr>
<tr>
<td>mould growth in maize grain.</td>
<td>%56.2</td>
<td>29.7</td>
<td>4.6</td>
<td>9.5</td>
<td>0</td>
<td>100</td>
<td>86%</td>
</tr>
<tr>
<td>Moisture content in maize grain</td>
<td>F135</td>
<td>113</td>
<td>25</td>
<td>10</td>
<td>0</td>
<td>283</td>
<td>4.3</td>
</tr>
<tr>
<td>causes aflotoxin and mycotoxin</td>
<td>%47.7</td>
<td>39.9</td>
<td>8.8</td>
<td>3.5</td>
<td>0</td>
<td>100</td>
<td>86%</td>
</tr>
<tr>
<td>contamination</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High moisture content in maize grain</td>
<td>F144</td>
<td>102</td>
<td>17</td>
<td>12</td>
<td>8</td>
<td>283</td>
<td>4.2</td>
</tr>
<tr>
<td>leads to high colourization of grain</td>
<td>%50.9</td>
<td>36</td>
<td>6</td>
<td>4.2</td>
<td>2.8</td>
<td>100</td>
<td>84%</td>
</tr>
<tr>
<td>Poorly aerated storage bags</td>
<td>F148</td>
<td>116</td>
<td>15</td>
<td>4</td>
<td>0</td>
<td>283</td>
<td>4.4</td>
</tr>
<tr>
<td>influences moisture content in</td>
<td>%52.3</td>
<td>41</td>
<td>5.3</td>
<td>1.4</td>
<td>0</td>
<td>283</td>
<td>88%</td>
</tr>
<tr>
<td>stored grains.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mycotoxin in poorly stored maize</td>
<td>F139</td>
<td>69</td>
<td>52</td>
<td>23</td>
<td>0</td>
<td>283</td>
<td>4.1</td>
</tr>
<tr>
<td>grain may cause cancer</td>
<td>%49.1</td>
<td>24.4</td>
<td>18.4</td>
<td>8.1</td>
<td>0</td>
<td>100</td>
<td>82%</td>
</tr>
<tr>
<td>and kidney problems</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The findings showed that majority of the respondents 88% were of the opinion that poorly aerated storage bags influences moisture content in stored grains, 86% of them and similar percentage said that high moisture content agitates mould growth in maize grain and causes aflotoxin and mycotoxin contamination while 84% of them agreed with the fact that high moisture content in maize grain leads to high colourization of grain. In addition, 82% of the farmers who responded were of the opinion that Mycotoxin in poorly stored maize grain may cause cancer and kidney problems.

The findings on table 4.5 clearly shows that a majority of the respondents were however of the opinion that poorly aerated storage bags influences moisture content in stored grains. This could be as a result of lack of availability of
knowledge on storage measures by majority of the farmers in the region. This means therefore that farmers need to be acquainted with skills and knowledge of storing farm produce.

4.3.2 The influence of rodents on level of maize production among small scale farmers

The study’s second objective sought to establish the influence of rodents on level of production among small scale farmers in Turbo division. The findings were as presented on table 4.6

Table 4.6 The influence of rodents on maize production among small scale farmers

<table>
<thead>
<tr>
<th></th>
<th>SA</th>
<th>A</th>
<th>U</th>
<th>D</th>
<th>SD</th>
<th>T</th>
<th>MEAN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rodents physically damage the maize grain both in the store and while still in the field</td>
<td>F</td>
<td>157</td>
<td>116</td>
<td>7</td>
<td>4</td>
<td>0</td>
<td>283</td>
</tr>
<tr>
<td></td>
<td>%</td>
<td>55.1</td>
<td>41</td>
<td>2.5</td>
<td>1.4</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td></td>
<td>90%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rodents influence mould colonization as carriers of mould spores</td>
<td>F</td>
<td>92</td>
<td>111</td>
<td>45</td>
<td>17</td>
<td>18</td>
<td>283</td>
</tr>
<tr>
<td></td>
<td>%</td>
<td>32.5</td>
<td>39.2</td>
<td>15.9</td>
<td>6.0</td>
<td>6.4</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td></td>
<td>78%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rodents reduce nutritional value of the maize grain.</td>
<td>F</td>
<td>136</td>
<td>104</td>
<td>6</td>
<td>21</td>
<td>16</td>
<td>283</td>
</tr>
<tr>
<td></td>
<td>%</td>
<td>48.1</td>
<td>36.7</td>
<td>2.1</td>
<td>7.4</td>
<td>5.7</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td></td>
<td>82%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rodents reduce the quantity and quality of maize grains</td>
<td>F</td>
<td>194</td>
<td>85</td>
<td>0</td>
<td>4</td>
<td>0</td>
<td>283</td>
</tr>
<tr>
<td></td>
<td>%</td>
<td>68.6</td>
<td>30</td>
<td>0</td>
<td>1.4</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td></td>
<td>94%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rodents can transmit diseases to human beings such as lyme disease; plague etc.</td>
<td>F</td>
<td>152</td>
<td>122</td>
<td>9</td>
<td>0</td>
<td>0</td>
<td>283</td>
</tr>
<tr>
<td></td>
<td>%</td>
<td>53.7</td>
<td>43.1</td>
<td>3.2</td>
<td>0</td>
<td>0</td>
<td>100</td>
</tr>
</tbody>
</table>

The findings indicated that 94% of the respondents were of the opinion that rodents reduce the quantity and quality of maize grains, 90% of them and similar percentage stated that rodents physically damage the maize grain both in
the store and while still in the field and as a result can transmit diseases to human beings such as Lyme disease; plague etc. in regards to whether rodents reduce nutritional value of the maize grain, 82% of the respondents who responded agreed with that opinion. Finally the study found out further that 78% of the respondents were of the opinion rodents influence mould colonization as carriers of mould spores.

It is clear from the study findings (see table 4.6) that majority of the respondents 94% agreed with the facts rodents reduce the quantity and quality of maize grains. This is due to the reason that rodents eat the maize grains thus reducing the quantity as well as the quality as they destroy the qualitative part of the grains leaving behind the grains that are of low quality in terms of nutritive value. However, rodents are known to physically damage the maize grain both in the store and while still in the field and at the same time can transmit diseases to human beings such as lyme disease and plague as evident by the 90% of respondents who were in agreement with that.

4.3.3 The influence of insect pests on maize production

The third objective of the study was to establish the influence of insect pests on level of maize quality among small scale farmers in Turbo division. The findings were as presented on table 4.7
Table 4.7 The influence of insect pests on maize production

<table>
<thead>
<tr>
<th></th>
<th>SA</th>
<th>A</th>
<th>U</th>
<th>D</th>
<th>SD</th>
<th>T</th>
<th>M</th>
</tr>
</thead>
<tbody>
<tr>
<td>Larger grain borer and weevils reduce quality and quantity of maize grain</td>
<td>F</td>
<td>202</td>
<td>68</td>
<td>13</td>
<td>0</td>
<td>0</td>
<td>283</td>
</tr>
<tr>
<td>Fumigation control fully insect pest in maize grain</td>
<td>%</td>
<td>71.4</td>
<td>24</td>
<td>4.6</td>
<td>0</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>Early treatment of maize with pesticide in store prevents insect pest infestation</td>
<td>F</td>
<td>104</td>
<td>120</td>
<td>31</td>
<td>28</td>
<td>0</td>
<td>283</td>
</tr>
<tr>
<td>Maize grain losses due to infestation of weevils occur after a period of three months in store.</td>
<td>%</td>
<td>36.7</td>
<td>42.4</td>
<td>11</td>
<td>9.9</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>Lack of storage technology among small scale farmers lead to high insect pest infestation in maize grain</td>
<td>F</td>
<td>72</td>
<td>152</td>
<td>36</td>
<td>9</td>
<td>14</td>
<td>283</td>
</tr>
<tr>
<td></td>
<td>%</td>
<td>25.4</td>
<td>53.7</td>
<td>12.7</td>
<td>3.2</td>
<td>4.9</td>
<td>100</td>
</tr>
</tbody>
</table>

Table 4.7 reveals that a majority of the respondents 94% agreed with the fact that larger grain borer and weevils reduce quality and quantity of maize grain, 92% of them were of the opinion that lack of storage technology among small scale farmers lead to high insect pest infestation in maize grain, 86% said that early treatment of maize with pesticide in store prevents insect pest infestation while 82% of the respondents agreed with the fact that Fumigation control fully insect pest in maize grain and 78% were of the opinion that maize grain losses due to infestation of weevils occur after a period of three months in store.
Findings on table 4.7 indicated that a majority of the respondents were of the strong opinion that larger grain borer and weevils reduce quality and quantity of maize grain. This is as result that such insects physically damage the grains and also reduce on the quality. The study however showed that lack of storage technology among small scale farmers lead to high insect pest infestation in maize grain and therefore the need for farmers to use modern storage facilities and technologies in order to reduce the amount of damage caused by insects on grains.

### 4.3.4 The influence of storage method on maize production among small scale farmers

The study’s fourth objective sought to establish from the respondents the influence of storage method on level of maize quality among small scale farmers in Turbo division and the findings were tabulated as shown in table 4.8.

#### Table 4.8 The influence of storage method on maize production among small scale farmers

<table>
<thead>
<tr>
<th>Method</th>
<th>F</th>
<th>A</th>
<th>U</th>
<th>D</th>
<th>SD</th>
<th>T</th>
<th>M</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good storage practices limit maize shortage</td>
<td>170</td>
<td>95</td>
<td>7</td>
<td>11</td>
<td>0</td>
<td>283</td>
<td>4.5</td>
</tr>
<tr>
<td>%</td>
<td>60.1</td>
<td>33.6</td>
<td>2.5</td>
<td>3.9</td>
<td>0</td>
<td>100</td>
<td>90%</td>
</tr>
<tr>
<td>Fumigated stores limits maize shortage</td>
<td>91</td>
<td>106</td>
<td>28</td>
<td>46</td>
<td>12</td>
<td>283</td>
<td>3.8</td>
</tr>
<tr>
<td>%</td>
<td>32.2</td>
<td>37.5</td>
<td>9.9</td>
<td>16.4</td>
<td>2.4</td>
<td>100</td>
<td>76%</td>
</tr>
<tr>
<td>Sack storage methods be treated with pesticide prior to storage of maize grains</td>
<td>118</td>
<td>142</td>
<td>14</td>
<td>9</td>
<td>0</td>
<td>283</td>
<td>4.3</td>
</tr>
<tr>
<td>%</td>
<td>41.7</td>
<td>50.2</td>
<td>4.9</td>
<td>3.2</td>
<td>0</td>
<td>100</td>
<td>86%</td>
</tr>
<tr>
<td>Roof storage method stored maize cobs upto one year due to smoke and heat from the fire</td>
<td>113</td>
<td>68</td>
<td>75</td>
<td>24</td>
<td>3</td>
<td>283</td>
<td>3.9</td>
</tr>
<tr>
<td>%</td>
<td>39.9</td>
<td>24</td>
<td>26.5</td>
<td>8.5</td>
<td>1.1</td>
<td>100</td>
<td>78%</td>
</tr>
<tr>
<td>Modern storage methods can store maize grown for over one year e.g. Air tight method</td>
<td>160</td>
<td>82</td>
<td>29</td>
<td>12</td>
<td>0</td>
<td>283</td>
<td>4.4</td>
</tr>
<tr>
<td>%</td>
<td>56.5</td>
<td>29</td>
<td>10.2</td>
<td>4.2</td>
<td>0</td>
<td>100</td>
<td>88%</td>
</tr>
</tbody>
</table>
The findings indicated that good storage practices limit maize shortage as represented by 90% of respondents who were in agreement. Also, the study findings showed that 88% of the respondents were of the opinion that modern storage methods can store maize grown for over one year e.g. Air tight method while 86% of them said that sack storage methods be treated with pesticide prior to storage of maize grains, 78% were of the view that roof storage method stored maize cobs upto one year due to smoke and heat from the fire place and finally some 76% of the respondents agreed with the fact that fumigated stores limits maize shortage.

The findings on table 4.8 indicated that the majority of the respondents supported the statement that good storage practices limit maize shortage. This was interpreted to mean through proper storage practices and management is needed as most of the grain losses which normally occurs during storage is minimized through such measures. The findings also showed that a majority of the respondents 88% agreed with the fact that modern storage methods can store maize grown for over one year e.g. Air tight method. This is due to the reason that modern storage facilities have been design strategically and in a modernized way that helped to minimize waste to grains.

4.4 Influence of maize storage management among small scale farmers on the level of maize quality

The study adopted the regression model to evaluate how each of the identified variables i.e.; moisture content, rodents, insect pest and storage management influenced the level of maize production in Turbo division, Uasin Gishu County, Kenya. The results were illustrated in table 4.9
Table 4.9 Influence of maize storage management among small scale farmers on the level of maize quality (Regression Model)

<table>
<thead>
<tr>
<th>Model Summary</th>
<th>Model</th>
<th>R</th>
<th>R Square</th>
<th>Adjusted R Square</th>
<th>R</th>
<th>Std. Error of the Estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>.612&lt;sup&gt;a&lt;/sup&gt;</td>
<td>.823</td>
<td>.811</td>
<td>.62678</td>
<td></td>
</tr>
</tbody>
</table>

The model summary indicated that about 82.3% of the data could be accounted for in the regression model (R = 0.612).

<table>
<thead>
<tr>
<th>ANOVA&lt;sup&gt;b&lt;/sup&gt;</th>
<th>Model</th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
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<tr>
<td></td>
<td>1</td>
<td>Regression</td>
<td>24</td>
<td>278.668</td>
<td>444.059</td>
<td>.000&lt;sup&gt;a&lt;/sup&gt;</td>
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<tr>
<td></td>
<td></td>
<td>Residual</td>
<td>259</td>
<td>.628</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total</td>
<td>283</td>
<td></td>
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</table>

The regression model also indicated that it was significant (p = 0.00) to mean that it had not been computed by chance. This made the results of the regression model credible and reliable.

---

<sup>a</sup> Predictors: (Constant), d, a, c, b

<sup>b</sup> Dependent Variable: maize production
## Coefficientsa

<table>
<thead>
<tr>
<th>Model</th>
<th>Unstandardized Coefficients</th>
<th>Standardized Coefficients</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B</td>
<td>Std. Error</td>
</tr>
<tr>
<td>1</td>
<td>(Constant)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1.036</td>
<td>.519</td>
</tr>
<tr>
<td>Moisture content</td>
<td>.100</td>
<td>.096</td>
</tr>
<tr>
<td>Rodents</td>
<td>.516</td>
<td>.113</td>
</tr>
<tr>
<td>Insect pest</td>
<td>.483</td>
<td>.176</td>
</tr>
<tr>
<td>Storage management</td>
<td>.394</td>
<td>.820</td>
</tr>
</tbody>
</table>

a. **Dependent Variable: level of maize quality**

The results indicated that there was a significant relationship \( (p = 0.000) \) between moisture content, rodents, insect pest storage management and the level of maize quality. This was interpreted to mean that all these factors affect the level of quality. This shows that there is high disparity between the amount of maize demanded and the amount supplied to the market in Turbo division. This occurs since there is excess demand in the region than the amount of maize supplied by farmers. The amount supplied to the market will only be increased upon addressing the above factors that affect level of quality.

Proper storage of maize in the region is necessary to enable consistent supply throughout the year, preparing for catastrophes, emergencies and periods of maize scarcity or famine and protection from destruction or theft. Safe storage of maize management grain by small scale farmers should be adhered to by following laid down guidelines by warehouse licensing board.

However, these findings are inconsistent with Coyne (2006) who found out that in assessing the regression model for performance as per the indicators in the
study, the study evaluated the standardized coefficients of the study and illustrated the results as indicated in the multiple linear model below:

Performance = 0.100 (moisture content) + 0.516 (rodents) + 0.483 (insect pest) + 0.394 (storage management) + e (Error Margin)

These results thus indicated that rodents and insect pest mostly affect the level of maize quality as they destroy grains both in the field and in the store.
CHAPTER FIVE

SUMMARY OF FINDINGS, DISCUSSION, CONCLUSION AND
RECOMMENDATIONS

5.0 Introduction

This chapter presents the summary of findings, discussion of the findings, conclusions, recommendations and suggestions for further research. This study was carried out with the main purpose of finding out the influence of maize storage management among small scale farmers on the level of quality in Turbo Division, Uasin Gishu County in Kenya. The study also aimed to determine if there is significant relationship between maize storage and food security.

5.1 Summary of the Findings

The findings showed that majority of the respondents 88% were of the opinion that poorly aerated storage bags influences moisture content in stored grains, 86% of them and similar percentage said that high moisture content agitates mould growth in maize grain and causes aflotoxin and mycotoxin contamination while 84% of them agreed with the fact that high moisture content in maize grain leads to high colourization of grain. In addition, 82% of the farmers who responded were of the opinion that Mycotoxin in poorly stored maize grain may cause cancer and kidney problems.

The findings further indicated that 94% of the respondents were of the opinion that rodents reduce the quantity and quality of maize grains, 90% of them and similar percentage stated that rodents physically damage the maize grain both in the store and while still in the field and as a result can transmit diseases to human beings such as lyme disease; plague etc in regards to whether rodents reduce nutritional value of the maize grain, 82% of the respondents who responded agreed with that opinion. In addition, the study found out more that
78% of the respondents were of the opinion rodents influence mould colonization as carriers of mould spores.

The data collected above (table 4.7) to establish the influence of insect pests on maize production reveals that a majority of the respondents 94% agreed with the fact that larger grain borer and weevils reduce quality and quantity of maize grain, 92% of them were of the opinion that lack of storage technology among small scale farmers lead to high insect pest infestation in maize grain, 86% said that early treatment of maize with pesticide in store prevents insect pest infestation while 82% of the respondents agreed with the fact that Fumigation control fully insect pest in maize grain and 78% were of the opinion that maize grain losses due to infestation of weevils occur after a period of three months in store.

Finally, the findings on the influence of storage method on maize production among small scale farmers showed that good storage practices limit maize shortage as represented by 90% of respondents who were in agreement. Also, the study findings showed that 88% of the respondents were of the opinion that modern storage methods can store maize grown for over one year e.g Air tight method while 86% of them said that sack storage methods be treated with pesticide prior to storage of maize grains, 78% were of the view that roof storage method stored maize cobs upto one year due to smoke and heat from the fire place and finally some 76% of the respondents agreed with the fact that fumigated stores limits maize shortage.

5.2 Discussion of the Findings

The issue with maize storage management and level of maize quality has become an issue of concern for governments, NGOs and International Institutions such as World Food Programme (WFP) and Food and Agricultural organizations (FAO) among many others for many decades. However, past studies have established that about one third of the maize produced in the world for human consumption every year approximately 1.3 billion tones get lost or wasted in store due to high moisture content, rodent destruction, insect pest such as weevil and
other causes hence jeopardizing the quality necessary for consumption Shepherd (1993). This therefore calls for proper needs of storage management in order to reduce the wastage that is currently experienced globally.

5.2.1 The influence of moisture content on levels of maize quality

The findings showed that majority of the respondents 88% were of the opinion that poorly aerated storage bags influences moisture content in stored grains. This was interpreted to mean that there is lack of availability of knowledge on storage measures by majority of the farmers in the region. This therefore requires that farmers need to be acquainted with skills and knowledge of storing farm produce.

These outcomes concur with the findings by Weinbergetal (2008) and Murdolelono (2009) which argued that moisture content in maize influence the development of microorganisms in stored maize, which eventually cause maize losses and contamination. In addition, Wild and Gong, (2010), added that contamination of food products by mycotoxins have been reported globally and over 300 types of mycotoxins have been identified, out of which 20 types have been found to occur naturally in foods and feeds as indicated in the report of Institute of Food Science and Technology (IFST), 2009. These mycotoxins are harmful to both human beings and animals. Consumption of maize which is contaminated by the mycotoxins may lead to diseases such as cancer and kidney problems as per the findings of Hayes (2000).

The study findings are also in agreement with the findings by Williams, (2004) Gourama and Bullerman, (1995) who stated that much of the contamination of grains by mycotoxins has been associated with inadequate storage technologies and climatic conditions such as high humidity, dampness and temperatures. This shows that storage technologies play a major role in determining the quality of maize. Thus, ensuring maximum efficiency of the storage technologies is crucial to the safety of stored maize and health of the consumers.
5.2.2 The influence of rodents on maize production among small scale farmers

According to the findings on table 4.6, the findings indicated that 94% of the respondents were of the opinion that rodents reduce the quantity and quality of maize grains and further 90% of them stated that rodents physically damage the maize grain both in the store and while still in the field and as a result can transmit diseases to human beings such as lyme disease; plague etc. This relate to De Groote, (1996) and Kgware (2008) literature which suggest that rodents have a serious impact on people’s lives as they nest in the roofs of households, relying on food and human drinking water stored inside the home and causing serious losses to these stores. They also damage crops both in the field and in store, personal possessions and buildings, and transmit dreaded diseases such as the bubonic plague.

In addition, Roebroek (1994) in his findings on the influence of rodents on production level of maize grains suggested that storage pests do not only reduce the quality and quantity of grains that can be available to the consumers/ farmers, but they also cause health problems through contaminations and reduce the nutritional content of the infested foods. Rodents prefer foods that are rich in vitamins and protein. The rodents are likely to consume the most nutritious parts of the maize grain thus, causing reduction in the vitamin and protein content of the grain. This implies that the storage methods that allow the infestation of stored maize by rodents to take place, impact negatively on the quantity and quality of the maize grain.

5.2.3 The influence of insect pests on maize production

According to the study findings (table 4.7) based on the influence of insects on maize production, the study showed that a majority of the respondents 94% agreed with the fact that larger grain borer and weevils reduce quality and quantity of maize grain and also 92% of them were of the opinion that lack of storage technology among small scale farmers lead to high insect pest infestation in maize grain. This relates to the literature by Lamboni and Hell (2009) which
stated that the larger grain borer, *Prostephanus truncatus* (Horn) (Coleoptera: Bostrichidae) mostly found in Sub-Saharan Africa was identified as the most damaging storage pest that causes great losses of maize.

It is estimated that in Africa, *P. truncatus* causes up to 40% of maize loss within six moths of storage (Lamboni and Hell, 2009), whereas an estimate of 34% of maize loss due to *P. truncatus* after 3-6 months of storage as in accordance with findings by Hodges (1998). This means insects are great damagers and destructors of maize grains and thus need proper storage maintenance practices to effectively control the infestation of insects on grain stores.

Past literature have also shown that while up to 12% of maize loss due to maize weevils alone has been reported in the tropics as per the study of Pingali and Pandey, (2001), *Sitophilus zeamais* has been reported to be responsible for 10-20% of maize losses after three months of storage as indicated by findings of Boxall, (2002). Thus, due to inefficient storage technologies millions of tonnes of maize are lost to insect pests in the world each year. For example, in Tanzania alone losses of up to 34% of maize due to insect pests have been reported CIMMYT and Dubin, (2010). Conversely, however, the authors cited above have neither indicated what methodologies they used to estimate these losses nor stated whether they took into consideration the consumption patterns of the people studied, thus, the accuracy of the estimations is not guaranteed.

It was established further that insect pests impact negatively on maize in the following ways: insects’ activities in stored maize damage maize kernels by making holes in them, which make the maize kernels susceptible to infestation by moulds as indicated in the findings by (Sallam, 1999). Insects further spread moulds in storage facilities through moving from one place to another (Lamboni and Hell, 2009). In fact, moulds in maize have been found to intensify with the intensification of insect pests (Wright, 2011). Lamboni and Hell further stated that insect pests may also affect the quality of maize by contaminating the stored maize with wastes, which may further lead to interference with the Odour, colour and taste of the maize. In addition, insect pests would reduce the nutritional value
of stored maize, possibly through feeding on the nutrient rich germ and the outer layer of the maize kernels, which in turn leads to significant reduction in the kernels’ nutrient content.

Based on these findings, the insect pest in stores results into loss of weight to the grain due to feeding and loss in quality due to: Impurities like droppings, cocoons and parts of insects, which may also lead to microbial infestation as a result of increased temperature and moisture. It also leads to reduction of nutritional value and reduction in germination ability for seeds. Creating localized hot spots within the grain that may initiate wet heating, causing stack collapse due to weakening of bag fibre.

5.2.4 The influence of storage method on maize production among small scale farmers

According to the findings on table 4.9, the findings indicated that good storage practices limit maize shortage as represented by 90% of respondents who were in agreement. Also, the study findings showed that 88% of the respondents were of the opinion that modern storage methods can store maize grown for over one year e.g. Air tight method. This shows that good storage practices and use of modern facilities of storage are required in order to minimize the shortage that are caused due to lack of proper storage practices and facilities. This finding concludes the findings done by Obetta and Daniel (2007) on how storage method influences the production of maize among small scale farmers. Their findings indicated that the poor status of small scale farmers leads them to select maize storage management which are cheap to construct regardless of their inadequacy and it is due to this reason that leads to most of the grain losses to occur during storage.

This necessitates improvement of the storage technologies. Factors that usually affect the farmers’ choice of the storage methods include the cost of building and running the storage method, availability of the materials and expertise for building the storage facility, climatic conditions of the area and the
types of pest problems in the area (FAO, 1985). Other factors include the amounts of crops that are to be stored and the expected quality of the stored crops (FAO, 1985).

Studies by past scholars such as Atkins (1998) have shown that during the first three to four months after storage, as a rule no high losses are caused by insects, and hence no special protective measures are necessary during this period. Maize intended for consumption during this period therefore need not be treated. The farmer should store this maize separately. Only those cobs intended for longer-term storage need to be treated. This should be performed in a separate store or in a suitable storage area. In this way the farmer can save working time and money. This aspect is also of significance to market-oriented farmers.

Therefore the most important point in both short-term and long-term storage is the application of proven hygiene measures, which include thorough cleaning of the store and its surroundings. Remove all material remaining from the last harvest. If possible, treat the empty store with an insecticide to expel or destroy any concealed pests. Repair any damage to the roof before further storage. With clay stores, seal any cracks.

5.2.5 Discussion for the Interview Schedules For local agricultural officers

Majority of the agricultural officers said that high moisture content in maize storage facilities causes fungal diseases that damage maize grains thus leading to the effect of aflatoxin which are harmful to both human beings and livestock. In addition, some of the officers attributed the high loss of the yields right from the farm to the store to high number of rodents’ damage and insect infestation in Turbo area. The common types of rodents and insects described by majority of the officers who were interviewed are rats, moulds, weevils and stalk borers. These rodents and insects are known to reduce yields by about 30-40%.

The officers suggested that the cost/affordability of modern storage facilities influences choice of Maize storage methods. According to them, most farmers in the region are not stable which leads them to select maize storage management techniques which are cheap to construct regardless of their
inadequacy. This then is what is contributed to high infestation of grain stores by rodents and insects.

The officers further suggested that the use of rat proof stores, properly ventilated stores, and strategic positioning of the stores far from the dump areas will helped to reduce the high of maize grains damage caused by rodents, insects and poor conditions in the stores that leads to contamination of the grains. It was found from the views of the officers that the main types of storage management found in the area of study which limits the levels of maize quality are local stores, in-house stores, open fields where farmers use improvised techniques such as use of polyethene to cover maize grains, granaries etc.

The county officials concluded that the region welcomes new ideas that enhance proper storage management that will helped increase the amount of maize quality in the division as well in the county and the country at large. New ideas will enable the farmers to upgrade storage management to another level and hence the officers welcome the ideas to improve on the farming practices. Consequently, by encouraging farmers to store maize in a healthy and hygienic stores can helped to reduce the chances of grain damage due to dumpiness, infestation by insects or damage by rodents. Farmers need to be educated on proper means of maintaining their stores i.e. farmers should learn to fumigate their stores with chemical after every 3-4 months. The officers also recommended that farmers can apply storage chemicals such sumi combi, scarnor super or actelic super after every six months or twice in a year.

The officers who were interviewed also recommended that farmers should be advised to have well ventilated stores that are also rodent-free by using rat guards. Farmers to form cooperatives or organizations which can be used to mobilize resources to construct good storage facilities. In addition, the officers said that farmers should practices marketing strategies that will enable them to store maize near their locality by using warehouse stores found in their localities.
5.3 Conclusion of the study

The study concludes that poorly aerated storage bags influence moisture content in stored grains. This could be as a result of lack of availability of knowledge on storage measures by majority of the farmers in the region. This means therefore that farmers need to be acquainted with skills and knowledge of storing farm produce.

The study also concludes that rodents reduce the quantity and quality of maize grains. This is due to the reason that rodents eat the maize grains thus reducing the quantity as well as the quality as they destroy the qualitative part of the grains leaving behind the grains that are of low quality in terms of nutritive value. Rodents make holes in storage containers, and through this they create moisture problems in the stored products and they also contaminate food grains with their excretions and hair, thus proper storage methods and maintenance of storage facilities are required to prevent this.

It is also conclusive that larger grain borer and weevils reduce quality and quantity of maize grain. This is as result that such insects physically damage the grains and also reduce on the quality. The study however showed that lack of storage technology among small scale farmers in Turbo division, Uasin Gishu County lead to high insect pest infestation in maize grain and therefore the need for farmers to use modern storage facilities and technologies in order to reduce the amount of damage caused by insects on grains.

The study concludes further that good storage practices limit maize shortage. This was interpreted to mean through proper storage practices and management are needed as most of the grain losses which normally occurs during storage is minimized. Farmers need to be equip with skills on how to properly store their grains. They should be encouraged to adopt the new forms of technology in order to reduce the wastage mostly caused by improper facilities.
5.4 Recommendations

i. The farmers in Turbo division need to adopt proper and modernized aerated storage bags on their grains to minimize the changes of grains being damage due to dampness as high moisture content in maize influence the development of microorganisms which eventually cause maize losses and contaminations.

ii. The farmers also need to developed proper ways of keeping away rodents in the stores as rodents are known to be the greatest destructors of the stored grains. Apart from rodents being damagers of grainers, they can also transmit about 60 types of diseases to humans, and are carriers of diseases that affect both humans and domestic livestock. Therefore the study recommends highly that strict measures such as use chemicals to kill rodents are necessary in order to keep away rodents from the grain stores. There should be stores build in a way that can prevent rodents from entering the stores. To avoid the reduction in stand, farmers usually plant 3-4 plants per hill and thin to 2 seedlings in the third week. This may not be done in the entire field, it could be done for the area notorious for rodent damage e.g. near a bush.

iii. Lager insects which also damage the grains in store should be eliminated as much as possible. This should be done through frequent fumigation of grain stores, ensuring proper and efficient storage technologies. Humidity and temperature in the storage facilities, moisture content of maize grain prior to storage, materials from which storage facilities are made, damage of maize grain prior to storage and length of time during which maize is stored should be always checked and properly implemented to avoid insect infestations in the storage facilities

iv. The study also recommends the use of modern and sophisticated storage methods such as use of Storage cribs purposefully designed and properly positioned to help in drying of grains in the store.
5.5 Suggestions for Further Studies

The study suggested the following areas for further research in relation to influence of maize storage management among farmers on the level of maize quality:

i. Study on other crops apart from maize should be done.

ii. Challenges of storage management should be addressed.

iii. Studies should be done on other forms of pesticides to be used to enhance crop production.
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Friedman, M., (1996). Nutritional Value of Protein from Different Sources. A Review. *Journal of Agricultural Food Chemistry*


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Jones, R., Duncan, H., Hamilton P., (2001). Planting date, harvest date, irrigation effects on infection and aflatoxin production by Aspergillus flavus in field corn. Phytopathology


APPENDICES

Appendix I: Letter of Transmittal

Dear Respondent,

My name is Isaac Too, a master student at University of Nairobi conducting a study on the influence of maize storage management among small-scale farmers on the level of quality in Turbo division, Uasin Gishu County, Kenya. I therefore wish to request you to kindly spare some time and answer the questions below as honestly as possible by ticking or filling in the spaces provided. The information given will be purely for academic purposes and will be treated confidentially. Ultimate, the findings of the study will make suitable recommendations to benefit small scale farmers and the Ministry of Agriculture in general.

Thank you for your cooperation.

Isaac Too
L50/71756/2014
Appendix II: Questionnaire For The Small Scale Farmers

The questionnaire is made up of two sections A and B. Please answer each question by writing on the space provided or tick against the boxes provided. The information provided will be used for the purpose of this research only. Therefore do not write your name anywhere on the answer sheet.

SECTION A: BACKGROUND INFORMATION

1. Gender

   Male [ ]        Female [ ]

2. Age bracket

   26-30 years [ ] 36-40 years [ ] 41-45 years [ ] Over 46 years [ ]

3. What is your education level?

   Primary level [ ] Secondary level [ ] Post secondary level [ ]

4. What kind of farming do you practice?

   Small scale [ ] Large scale [ ]

5. How long have you been a farmer?

   Below 3 years [ ] Between 4-6 years [ ] Between 7-9 years [ ] 10 years and above [ ]

6. Which location do you come from?

   Kamagut [ ] Sugoi [ ] Tapsagoi [ ]
SECTION B: THE INFLUENCE OF MOISTURE CONTENT ON LEVELS OF MAIZE QUALITY

Answer the following by ticking in the correct box as appropriate

6. To what extent do you agree/disagree with the following statements on how do the moisture content influence levels of maize quality among small scale farmers?

Key: S.A; Strongly Agree, A; Agree, UD; Undecided, D; Disagree, SD; Strongly Disagree

<table>
<thead>
<tr>
<th>Statement</th>
<th>SA</th>
<th>A</th>
<th>UD</th>
<th>D</th>
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<tr>
<td>High moisture content agitates mould growth in maize grain.</td>
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<tr>
<td>Moisture content in maize grain causes aflotoxin and mycotoxin contamination</td>
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<tr>
<td>High moisture content in maize grain leads to high colourization of grain</td>
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<tr>
<td>Poorly aerated storage bags influences moisture content in stored grains.</td>
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<tr>
<td>Mycotoxin in poorly stored maize grain may cause cancer and kidney problems.</td>
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</table>

7. How is the level of rain in the region?
   Low [ ] Moderate [ ] High [ ]

8. The level of moisture content in store maize grains should be?
   Below 10% [ ] Between 11-12% [ ] Between 13-14% [ ]

9. High moisture content in maize grains contribute to over three quarters of maize loss.
   Yes [ ] No [ ]
SECTION C: THE INFLUENCE OF REDENTS ON MAIZE PRODUCTION AMONG SMALL SCALE FARMERS

10. In your opinion, what extent do rodents influence levels of maize quality among small scale farmers?

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<tr>
<td>Rodents physically damage the maize grain both in the store and while still in the field</td>
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<td>Rodents influence mould colonization as carriers of mould spores</td>
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<td>Rodents reduce nutritional value of the maize grain.</td>
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<td>Rodents reduce the quantity and quality of maize grains</td>
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<td>Rodents can transmit diseases to human beings such as lyme disease; plague, etc</td>
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11. What methods of pest control do you prefer?
   Biological methods [ ]    Chemical method [ ]

12. Give the possible reason for your answer above.

13. Have you erected a modern grain granary?
   Yes [ ]       No [ ]

14. If No, what are your reasons for not doing so
   ........................................................................................................
   ........................................................................................................
   ........................................................................................................

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SECTION D: THE INFLUENCE OF INSECT PESTS ON MAIZE PRODUCTION AMONG THE SMALL SCALE FARMERS

15. In your opinion, what is the extent in which insect pest influence levels of maize quality among small scale farmers?

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<tr>
<td>Larger grain borer and weevils reduce quality and quantity of</td>
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<td>maize grain</td>
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<td>Fumigation control fully insect pest in maize grain</td>
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<td>Early treatment of maize with pesticide in store prevents</td>
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<td>insect pest infestation.</td>
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<td>Maize grain losses due to infestation of weevils occur after</td>
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<td>a period of three months in store.</td>
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<td>Lack of storage technology among small scale farmers lead to</td>
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<td>high insect pest infestation in maize grain.</td>
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16. Are you aware that storage of maize for over 6 months in the store is likely to be affected by insect pest

Yes [ ]  No [ ]

17. Do you often fumigate your maize grains?

Yes [ ]  No [ ]

18. If No, give a brief answer for your answer.

........................................................................................................................................................................
SECTION E: THE INFLUENCE OF STORAGE METHOD ON MAIZE PRODUCTION AMONG SMALL SCALE FARMERS

19. In your opinion, what storage methods management limits levels of maize quality for small scale farmers?

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<tr>
<td>Good storage practices limit maize shortage</td>
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<tr>
<td>Fumigated stores limits maize shortage</td>
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<tr>
<td>Sack storage methods be treated with pesticide prior to storage of maize grains</td>
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<td>Roof storage method stored maize cobs upto one year due to smoke and heat from the fire place.</td>
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<td>Modern storage methods can store maize grown for over one year e.g Air tight method</td>
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20. Do you agree that modern storage systems are more cost effective than traditional storage methods?
Yes [ ] No [ ]

21. Have you ever visited the agricultural officers for advice on proper storage of maize grains/
Yes [ ] No [ ]

22. If No, give a reason for not having done so

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

Thank you for answering all the questions
Appendix III: Interview Schedule For Locational Agricultural Officers

1. How does moisture content influence the level of maize quality among small scale farmers in Turbo Division?

2. What is the extent in which rodents influence level of maize quality in Turbo Division?

3. Which type of rodents is most effective in destroying maize in stores?

4. What is the extent in which insect pest influence levels of maize quality in Turbo Division?

5. Which are the types of insect pests that destroy maize in stores?

6. Which are the main types of storage management found in your area that limits levels of maize quality?

7. How can stores be used to prevent maize shortages in your area?