SOCIO-CULTURAL AND ECONOMIC FACTORS INFLUENCING HOUSEHOLD POST-HARVEST CEREAL LOSS IN WIKILILYE LOCATION, KITUI COUNTY, KENYA

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DECLARATION

I understand that plagiarism is an offence and therefore declare that this thesis is my original work and has not been presented to any other institution for any other award.

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DEDICATION

I dedicate this work to my son Ian Kinyanjui for being a source of motivation and encouragement. It is also dedicated to my mother Monica Wanjiku, for emotional support and untiring prayers and finally to my family my brother Isaac Kinyanjui and uncle John Wainaina for moral and financial support.

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ABBREVIATION AND ACRONYMS

ACP	African, Caribbean and Pacific
APHLIS	African post-harvest losses information system
ASCU	Agriculture Sector Coordination Unit
CGA	Cereal Growers Association
CIMMYT	The International Maize and Wheat Improvement Center
FAO	Food and Agriculture Organization
FLW	Food Loss and Waste
FFS	Farmers Field Schools
FGD	Focus Group Discussion
FSC	Food Supply Chain
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
KARI	Kenya Agricultural Research Institute
KDC	Kitui Development Center
KNBS	Kenya National Bureau of Statistics
LDCs	Less Developed Countries
MoA	Ministry of Agriculture
NASEP	National Agricultural Sector Extension Policy
PHLs	Post-harvest Losses

PICS	Purdue Improved Crop Storage
PPS	Population Proportional to Size
SDGs	Sustainable Development Goals
SPSS	Statistical Package for Social Scientists
SSA	Sub- Saharan Africa

OPERATIONAL DEFINITION OF TERMS

Bodaboda: A motorcycle taxi

Cereal: Any edible components of the grain of cultivated grass. Cereal grains are grown in greater quantities and provide more food energy worldwide than any other type of crop. For the study the focus was on maize.

Cereal loss: Refers to the decrease in edible food mass available to households for consumption throughout the different segments of the supply chain. In addition to quantitative loss, food products can also face a deterioration of quality, leading to a loss of economic and nutritional value.

Food waste: Refers to food losses resulting from household decisions to discard food that still has value. Food waste is most often associated with the behavior of the retailers of the food service sector and of the consumers, but food waste and losses take place all along food supply chains.

Myethya: Women groups

Post- harvest cereal losses: Quantitative and qualitative unintended loss in maize which makes it unavailable or unfit for human consumption, occurring during any of the various phases of post- harvest marketing and storage. In this context we specifically refer to the time frame from harvest until marketing or consumption. This includes food lost due to insects, rodents or microbial growth during storage.

***Utaa*:** A type of cereal (maize storage) constructed above the firewood fire place used for storage and for preservation by smoking.

ABSTRACT

Food security in food-deficit countries in sub-Saharan Africa remains a big challenge. Yet, a large volume of food, valued in excess of USD 4 billion (grain alone), is harvested each year. The United Nations predicts that 1.3 billion tons of food produced is lost globally. This happens during post-harvest operations every year in a world where over 870 million people go hungry. In Kenya, 30-40% of the total cereals produced yearly are lost due to post-harvest handling inefficiencies, which impact negatively on farmer's food security. Despite the recorded continued post-harvest cereal loss (PHL), which is an important and complementary factor to food security, hunger and malnutrition, it has not received the required attention. Specifically, in Wikililye Location factors influencing households post-harvest cereal loss are not documented. Studies done have concentrated on the effect of aflatoxins on maize. Therefore, this study sought to determine the socio-economic, perceptions on environmental influence and post-harvest management strategies (storage) factors influencing household post-harvest cereal loss in the study area. The specific objectives of this study were: describe the socio-economic factors influencing household post-harvest cereal loss; examine the influence of the farmers' perception of environmental factors on household post-harvest cereal loss; and influence of post-harvest management strategies on post-harvest cereal loss. The study was guided by the Adoption Theory. The study used a cross-sectional descriptive research design. The study focused on households in Wikililye location. The target population was 3,149 households. Consequently, a sample size of 343 was determined using the Raosoft software. A mixed method approach was employed, which allowed the use of various complementary methods to collect both qualitative and quantitative data. A semi-structured questionnaire was administered to 343 households that were systematically sampled; four key informants' interviews and four focus group discussions were conducted with informants who were purposively selected. In addition, direct observations were made on the household cereal storage facilities. Statistical Packages for Social Science (SPSS) version 24 was used to analyze quantitative data. Descriptive statistics were generated and data are presented in tables as frequencies and percentages. Qualitative data were analyzed thematically and are presented in form of narratives and verbatim quotations. Findings of the study revealed that 63% of the households in the study area experienced cereal loss. The main social economic factors that influence post-harvest cereal loss include gender, age, level of education, marketing of cereals and alternative source of income. Factors like land size and source of livelihood also influenced household post-harvest cereal loss. The results reveal that only a small number of informants 4% perceive environmental issues as significant factors impacting on household post-harvest cereal loss. The study recommends that socio-economic issues need to be addressed if post-harvest cereal loss in Wikililye is to be reduced. Specifically, equal training opportunities should be availed to both men and women to allow them to gain knowledge on effective post-harvest loss mitigation practices. Finally, the dormant storage facilities for the communal storage system should be revived because they will contribute in reducing post-harvest loss.

CHAPTER ONE

1.0 INTRODUCTION

The chapter discusses the universal understanding of post-harvest cereal loss. It presents the relationship between different variables and post-harvest cereal loss. The chapter examines how household's characteristics influence post-harvest loss of cereals. Further, the chapter covers the statement of the problem, objectives, research questions, scope and significance of the study.

1.1 Background of the Study

The main challenge for many governments, development agencies and policy formulators is how to feed over 9.1billion people with safe food by the year 2050 (Parfitt, Barthel, and Macnaughton, 2010). This is because about 70% extra food production will be required to feed them (Godfray et al., 2010; Hodges, Buzby, and Bennett, 2011; Parfitt et al., 2010). Developing countries are considered to be where most of this population will be, several of which are already facing crisis of food insecurity and hunger. Food production is currently being challenged by limited land, increased subdivision due to population pressure, increasing urbanization, water and increased weather variability due to climate change, and land use for non-food crop production such as housing (Parfitt et al., 2010).

These intensify the concerns of the increasing food demands. In the last few decades, most of the countries have focused on improving their agricultural production, land use and population control as their policies to cope with this increasing food demand. Empirical data indicating that 50-70% of the attention has been directed toward increasing agricultural production (Hodges, Buzby, and Bennett, 2011). However, post-harvest loss (PHL), an important and complementary factor, has not received the required attention. Available evidence indicates that over the years only a small percentage of

funding is allocated to research for post-harvest loss (Bourne, 1977; Bourne, 2017; Kitinoja, Saran, Roy, and Kader, 2011). This has contributed to an ongoing debate among scientists, development agencies and policy formulators about the advantages of agricultural intensification for higher production. The question is whether it will improve or worsen food security and poverty of the households that lack the capacity to preserve their excess production (Greeley, 1986). It is partly because of this reason that Abass et al., (2014) emphasize the need for research aimed at establishing the extent and causes as well as the factors contributing to cereal loss of smallholder farmers.

Post-harvest loss accounts for direct physical and quality losses that reduce the economic value of a crop, or make it unsuitable for human consumption. According to Fox and Fimeche (2013), the losses in severe cases can be up to 80% of the total production. The United Nations predicts that 1.3 billion tons of food produced is lost globally, during post-harvest operations every year, in a world where over 870 million people go hungry (FAO-World bank, 2010; Gustavsson, Cederberg, Sonesson, Van Otterdijk, and Meybeck, 2011; Prusky, 2011). According to various studies (see, for example Kang'ethe, 2011 and IFAD, 2013) food losses still persist, while the number of food insecure population remains unacceptably high. Food loss is a large and increasingly urgent problem and is particularly acute in developing countries (Gustavsson et al., 2011). This is where food loss reduces income by at least 15% for 470 million smallholder farmers and downstream value chain actors. Most of them are a part of the 1.2 billion people who are food insecure. Food loss, therefore, gives rise to food insecurity. Empirical data by Gustavsson et al., (2011) estimated cereal losses in the Middle East and North Africa especially the regions of North Africa, West and Central Asia during the post-harvest period to be 14-19%. Kader et al., (2012) indicates that reducing these losses in order to increase food availability and food security for the Middle East and North Africa population is much less costly than increasing production by expanding production area and/or productivity per hectare and/or by increasing their

imports. According to Food Corporation of India in Asia alone, losses for cereals and oil seeds range between 10-12%.

In India, a report from the World Bank estimated 7%-10% of cereal loss at post-harvest operation for the year 1999 (Basavaraja, Mahajanashetti, and Udagatti, 2007; Shah, 2013). The estimates further indicate that up to between 12 and 16 million metric tons of cereals is wasted each year and could meet the food demand of about one-third of India's poor population (Nagpal and Kumar, 2012). In African countries, the losses have been estimated to range between 20% and 40%, which is considerably significant considering the low agricultural activity in several regions of Africa (Abass et al., 2014). FAO (2013) further indicates that the total food losses in many African countries are estimated to be worth $4 billion per year, an amount which can feed 48 million people. A post-harvest loss on cereals is estimated to be high and account for about 25% of the total crop harvested Voices Newsletter (2006).

In a recent report by World Bank (2011) and the Food and Agriculture Organization (FAO) of the United Nations; their data revealed that each year, significant volumes of food are lost after harvest in sub-Saharan Africa. FAO (2011b) termed it as "missing food" in which they estimated that currently, in every 5kilos of cereals produced, 1kilo is lost to pest and decay in sub-Saharan Africa. A recent report by Stathers, Lamboll, and Mvumi (2015) shows that post-harvest loss in Sub-Saharan Africa is extremely devastating. Twenty four percent of the total population in this region suffers from undernourishment, and this population is expected to double over the next 35years. Losses per year in this region are equal to about $4billion USD, which is 13.5% of the total cereals produced, or enough food to adequately feed 48 million people for a year. According to Kimatu, McConchie, Xie, and Nguluu (2012), in Sub-saharan region, due to poor post-harvest management strategies, there has been a repeated cycle of food production and post-harvest losses, which have systematically depleted the mineral quality of the farms exposing the region to substantial food insecurity.

A report of a joint FAO/World Bank Zorya et al. (2011) indicates that post-harvest loss of cereal in Southern and Eastern Africa accounts for over 40 % of the total post-harvest loss in Sub Saharan Africa countries. This represents losses of about $1.6 billion in value yearly. According to FAO (2013) such losses are equal to the annual calories needed for at least 20 million people or more than half of the value of total received food aid by SSA in a decade (Zorya et al., 2011a). In Ethiopia, a study by Dereje (2000) shows that the magnitude of post-harvest loss is tremendous and ranges between 5% to 26% for different crops. In Uganda, (Africa Post-harvest Loss Information System [APHLIS], 2012) indicated that post-harvest losses of maize to be at average of 17.58%, which translates to an annual volume loss of 215,243.13 metric tons.

In Kenya, according to Cereal Growers Association 30-40% of the total cereal production in Kenya is lost due to post-harvest handling inefficiencies. This impact negatively on farmers income, market supply, cereal prices and food security. A study done by Wambugu, Mathenge, Auma, and Van Rheenen (2009) in Siaya and Busia western Kenya reports a loss of cereals of 80-100% due to pest infestation and this has led to serious food insecurity and poverty in the area. Population increase has also contributed to this state of affair. In semi-arid eastern regions of Kenya, studies done by Bett and Nguyo (2007) estimated an annual maize loss of 5 to 17%, which translates in monetary terms to 1.8 million 90 kilogram bags valued at KSh 8.1 billion. In Eastern Kenya studies done by Recha, Kinyangi, and Omondi (2012), show that 50% of grain losses has been experienced in the past 3 years due to invasion by aflatoxin producing fungi that affect all types of grains produced. The reviewed literature, therefore, reveals the urgency in making known the factors influencing post-harvest cereal loss that could aid in mitigating the food insecurity, curb hunger, and increase income to the farmers.

1.1.1 Socio-economic Factors and Household Post-harvest Cereal Loss

The causes and the prevention of post-harvest cereal losses necessarily involves more than technical issues such as technology of food processing and storage, knowledge of pests and pests control, deterioration of cereals. Social, economic and cultural factors strongly affect the nature and magnitude of post-harvest cereal loss (Development, 1978). Grethe, Dembélé, and Duman (2011) observe that the factors contributing to post-harvest cereal losses can be analyzed from the perspective of social and economic development. They noted that socio-economic factors and agricultural technology were the main causes of cereal post-harvest losses especially in developing countries. This study aims at understanding how these factors influence post-harvest cereal loss. Gender is a social factor that has an effect on agriculture generally and influence post-harvest cereal loss in particular. According to Bala, Haque, Hossain, and Majumdar (2010) majority of the worlds agricultural producers are women: they produce more than 50% of the food that is grown worldwide. Women are usually responsible for food processing and make a major contribution to food storage, which has greater impact on post-harvest cereal loss. However, Team and Doss (2011) holds a different stance. According to them agricultural sector is underperforming, including post-harvest loss in part, because women, who represent an important resource in agriculture and the rural economy through their role as farmers, labourers and entrepreneurs, almost in every place encounter more severe constraints than men in access to productive resources. This indicates that it is not clear on whether women contribute to post-harvest cereal loss or not.

In Asia and African regions, women play a vital role in agricultural labour force and agricultural activities as a whole. They make up about 50 percent of the labour force in sub-Saharan Africa. In southern Africa, 40 percent and 50 percent in Eastern Africa of labor force is made of women (Team and Doss, 2011). For instance in Kenya women contribute to 75% of labour force in agriculture (Kimani-Murage et al., 2011). This indicates that women play an imperative role in agriculture and agricultural activities. However, despite being central to agricultural systems around the developing world, poor

women face barriers to preventing post-harvest cereal loss. They lack the knowledge about cereal standards so their produce is discarded at market, they have limited access to tools for efficient post-harvesting management or to a larger extent they are excluded from producer associations through which products can be sold (Tielens and Candel, 2014).

Gender influence on post-harvest loss of cereals has been viewed from different perspectives. According to various studies (see for example Bayard, Jolly, and Shannon, 2007; Dolisca, Carter, McDaniel, Shannon, and Jolly, 2006; Mzoughi, 2011; Newmark, Leonard, Sariko, and Gamassa, 1993), female farmers have been found to be more likely to embrace and adopt to changes, which can improve their livelihoods. This is due to their tendency to dedicate most of their income to household food and the general wellbeing of the household (Hoddinott and Haddad, 1995; Hopkins, Levin, and Haddad, 1994) and, therefore, play a significant role in reducing any possible loss. However, other authors hold a different view. For example Kereth, Lyimo, Mbwana, Mongi, and Ruhembe (2013) and Rugumamu (2012) observe that women contribute to cereal losses, as farmers and crop handlers, because they do not have adequate information on proper crop harvesting and handling techniques resulting in significant damage by insect pests during storage and marketing. This shows that there is no consensus on the influence of gender on post-harvest cereal loss.

In their study in Tanzania, Creighton and Omari (2000) argue that in smallholder crop production, women are especially more likely than men to be socially and economically involved in post-harvest activities. This concurs with Zorya et al. (2011a) who found out that in SSA, Kenya included, women play a significant role in post-harvest handling, processing, marketing, and household food security, and this enables them to take measures of ensuring the losses are minimized. However, in terms of production which has a bearing on post-harvest loss of cereals, Team and Doss (2011) observe that women

output is naturally small. Female headed households have smaller farms and use fewer purchased inputs, which further effect post-harvest cereal loss.

Studies conducted by World Bank (2011) in Kenya show that majority of Kenyan women (9 out of 10) live in rural areas. They play important and comprehensive roles in the rural sector as smallholder farmers, income earners and family caretakers. More and more rural families are likely to be headed by women as men migrate to the cities in search of employment. As such, women's time commitments and responsibilities in agricultural activities are increasing and are involved in mitigation to losses of production. Although a complex analogy, gender of the household head does affect the rate of post-harvest cereal loss. Thus there is no consensus in the available literature on the role of gender in post-harvest cereal loss. This study, therefore, sought to examine whether the gender of a household respondent impacts on post-harvest cereal loss in Wikililye location.

Age is a social factor whose influence on agricultural activities has been widely reviewed. Numerous researchers have differing views. Some studies found that age has no influence on agricultural activities such as the adoption of new technologies or decisions concerning management activities (Anim, 1999; Bekele and Drake, 2003; Thacher, Lee, and Schelhas, 1996; Zhang and Flick, 2001). Others found that age is significantly and negatively related to farmers choice of agricultural activities, for example, the choice to adopt new technologies aimed at improving post-harvest management activities to reduce cereal loss (Anley, Bogale, and Haile-Gabriel, 2007; Dolisca et al., 2006; Featherstone and Goodwin, 1993; Gould, Saupe, and Klemme, 1989; Lapar and Pandey, 1999a; Mzoughi, 2011; Nyangena, 2008)

According to Matsumoto, Obara, and Luh (1983) age is an important variable in post-harvest handling of maize as it influences agronomic practices adopted by the farmers. This influence may be either positive or negative. El-Osta and Morehart (1999) and Lapar and Pandey (1999b) reported that age may positively or negatively influence adoption of

agricultural technologies. In Burkina Faso, studies by Savadogo, Reardon, and Pietola (1998) have found age to influence agricultural activities especially when it involves embracing new technologies, which are meant to reduce loss of cereals and improve agriculture as a whole to deal with hunger and food insecurity. This is because the old, due to their conservative nature and the tendency to evade risks, are postulated to be reluctant to try out new technologies and innovations and stick to the traditional ones, which contribute to the amount of cereal loss. The young on the other hand are receptive to new ideas and are energetic and ready to adapt to modern methods of farming and technologies to reduce loss of cereals. Thus, there is no agreement on the kind of influence age has on cereal loss and food insecurity and the study aims at determining this.

The level of education is a socio cultural factor that has an influence on post-harvest cereal loss. Ani (2007) indicates that education is a continuous issue and a lifelong process. It is a powerful tool for shaping peoples life and making a meaningful life, even at an adult age. This is the reason there exist a positive correlation between education and human survival. Increased agricultural productivity as well as reducing post-harvest losses depends primarily on the education of the rural farmers to understand and accept the complex and innovative changes which, according to Odia (2017) are difficult for the rural farmer without formal education to understand.

Different scholars have divergent views on the impact of education in relation to post-harvest cereal loss. According to Najafi (2003) the level of formal education of household members could lead to awareness of the possible merits of utilizing modern agricultural technology. This enables them to carry out activities that reduce post-harvest loss of cereals. This is in consonance with El-Osta snd Morehart (1999) and Mann, Hendrickson, and Pandey (2001) who argue that post-harvest loss of cereals will either increase or decrease with a farmer's level of education. According to them increased level of education will result in increased adoption and adherence to the recommended

improved scientific methods because it makes the farmer to make more informed decisions.

According to Kumar and Kalita (2017) in their study in developing countries, lack of knowledge contributes to a significant amount of cereal loss during the post-harvest operations, despite being the region where people try to make the best of the food produced. However, in Mato Grosso Brazil, a study by Martins, Goldsmith, and Moura (2014) on the managerial factors affecting post-harvest losses of cereals, showed that education level did not influence the magnitude of losses, although it was hypothesized that higher education level should lead to lower post-harvest cereal loss.

In Karnataka India, education was positively associated with good post-harvest cereal management, indicating that farmers who had some form of education experienced reduced post-harvest losses (Kumari & Pankaj, 2015). They reported that providing informal training, seminars, workshops and farming techniques to the farmers enabled them to be more receptive to the adoption of appropriate technology and, therefore, curbed the extent of post-harvest cereal loss. Similarly, in Pakistan, Bashir et al. (2012) demonstrate that education enables individuals to have access to information on best management practices, including on post-harvest losses and this enables them to curb losses and make better informed decisions.

In Kitui and Wikililye location in particular, the uptake of farming technologies disseminated by Kitui County Ministry of Agriculture, Water and Technology aimed at improving agricultural productivity and curbing losses to mitigate food insecurity of households, can be affected by education level of household heads (County Government of Kitui, 2016). According to Mwaniki (2006) majority of the population in Wikililye location have lower primary and upper primary level education. However, the influence of the level of education in the study area on household post-harvest cereal loss has not

been documented. This study, therefore, sought to establish the influence of education attainment on household post-harvest cereal loss.

Source and level of income plays a vital role in post-harvest loss of food including cereals. This is evident globally as Parfitt, Barthel, and Macnaughton (2010) outline the factors leading to post-harvest losses in developing countries where production is dominated by small scale farmers with limited or none existent access to financial resources. In these countries, production, harvest and post-harvest techniques and technology are often out-dated. In addition, technical, regulatory, and financial capacities are often inadequate. Buchner et al. (2012) argue that post-harvest cereal losses at the front end of the post-harvest supply chain are significantly higher in developing countries than in developed countries. The main reason is related to the fact that small-scale labour-intensive agricultural production in Africa is inefficient. This is due to the limitation of capital, technology, and management. According to the World Bank, FAO and NRI (2011) the farmer ability to afford and willingness to pay for improved technology to reduce post-harvest loss of cereals rely mainly on their economic power.

In Nigeria, according to a study by Mada, Hussaini, and Adamu (2014), the main causes of grain post-harvest losses and waste in low income countries are connected to financial management and technical limitation. Due to inability to purchase mechanized post-harvest operation machines, post-harvest losses are inevitable. In Tanzania ANSAF (2016) noted that ability to have an alternative source of income and availability of labor beyond production are some of the factors that influence the utilization of improved storage structures. In different agro-ecological zones of Kenya, a study by Affognon, Mutungi, Sanginga, and Borgemeister (2015) showed that farmers lack of economic incentives to store and better protect food contributed a lot to post-harvest losses.

Marketing of cereals especially by small scale holders, subject them to economic post-harvest cereal loss. According to Hodges, Bernard and Rembold (2014) post-harvest

cereal losses may be both physical (weight and quality) experienced during post-harvest handling activities and also loss caused by lack of opportunity as a result of producers inability to access markets or lower market value due to for example sub-standard grain and inadequate market information. Of greater significance are qualitative post-harvest losses that lead to a loss in market opportunity and nutritional value; they contribute to high food prices by removing part of the food supply from the market (Zorya et al., 2011).

In sub-saharan Africa Zorya et al. (2011) discovered that there may be greater absolute post-harvest loss during bumper harvests. This may be brought about by shortage of labour to care for the grain or lack of incentive since larger harvests are associated with a sharper fall in the market prices. In addition, low prices and surplus production may result in a slower flow to the market leading to longer storage periods on the farm contributing to more cereal losses. This may be due to attack by both the normal pest complex and larger grain borer associated with significance increase in storage losses.

In East and Southern African counties studies by Kimenju, De Groote, and Hellin (2009) and Tefera et al. (2011) show that many smallholders sell their produce immediately after harvest because of lack of suitable storage structures for cereal storage and absence of storage management technology. Further, these studies found out that farmers sell at low market prices for any surplus cereals they produce to avoid post-harvest losses caused by pest infestations and pathogens during storage. Specifically, in Ghana, Taiwo and Bart-Plange (2016), identified households bumper harvest to be associated with post-harvest cereal loss.

According to Mutungi and Affognon (2013), majority of the farmers in Kenya face limited storage capacity hence are forced to sell their cereals, especially maize in the early harvesting season when the prices are lower. Tefera et al. (2011), on the other hand observe that traditional storage practices in Kenya cannot guarantee protection against

major storage pests of staple food crops like maize, which contributes to between 20-30% grain losses, particularly due to post-harvest insect pests and grain pathogens. As a result, smallholder farmers end up selling their grain soon after harvest, only to buy it back at an expensive price just a few months after harvest. Thus marketing of cereals has an influence on post-harvest cereal loss. These is especially when farmers sell at lower prices, due to economic needs or to avoid future losses as a result of poor and inadequate storage systems. In Wikililye location, however, there is a dearth information on whether farmers face losses due marketing of cereal produce. This study, therefore, sought to establish whether farmers market their produce and if so the influence marketing has on post-harvest cereal loss.

Socio-economic characteristic have been reported to have different influence on post-harvest loss of cereals in different regions. However, in Kitui and particularly Wikililye location, the area of study, there is no documented information that such a study has been carried out to determine the influence of socio-economic factors on households post-harvest loss of cereals thus necessitating the current study.

1.1.2 Perception on Environmental Factors Contributing to Household Cereal Loss

Environmental factors have been connected to cereal losses. Grolleaud (2002) indicates that climatic conditions, including wind, humidity, rainfall, and temperature influence both the quantity and quality of a harvest thus influencing cereal losses. According to Kumar (2002), of all the various factors influencing the deterioration of stored cereals, moisture plays a major role. If the moisture content is maintained at a sufficiently low level, grains and cereals can be stored for many years with little adverse effect even under conditions that may otherwise be unfavorable.

Kader et al. (2012) identified moisture as a reason for cereal losses in Lower Egypt. In this region, due to moisture content and non-existence of corn dryers, the corn is left to

dry in the open air either shelled or as cobs. Due to microbial spoilage brought about by long drying period losses are incurred in terms of quality and quantity of the cereals. In some parts of Africa according to Hell et al. (2008) one of the factors that has contributed to post-harvest losses is high humidity and moisture content of grains during storage and also climate change which has caused the time of harvest and drying to be largely unpredictable. Most farmers in Africa, both small and large, rely almost exclusively on natural drying of crops from a combination of sunshine and movement of atmospheric air through the product, so damp weather at harvest time can be a serious cause of post-harvest losses. The post-harvest cereal loss substantially varies with regions. For example, in Swaziland the loss was in excess of 16% De Lima (1987) while in Amuria and Katawi districts of Uganda, it was about 20% (CFSAM.2008 cf Rembold, Hodges, Bernard, Knipschild, and Léo, (2011). The major causes of these losses being damp floors, inadequate sunshine and high humidity.

In Eastern Kenya, the period required for full drying of ears and grains depends considerably on weather (Recha et al., 2012). Poorly dried and broken grain becomes more susceptible to insects such as flour beetles and weevils, and vulnerable to molds and rotting during storage. Similarly, excessive rains during harvesting dampen the crop resulting in formation of fungus (*Aspergillus flavus)*. This aflatoxin producing fungi invades all types of grain produce, and has caused over 50% grain loss in Eastern Kenya in the past three years.

Reviewed literature indicates that environmental factors have considerably contributed to cereal loss in many regions of the world. In the study area, the same has been witnessed, but there is little documented evidence on the community perceptions and understanding of the influence of the climatic conditions to household cereal loss. This study, therefore, sought to establish the influence of the farmer's perception on environmental and climatic factors on household post-harvest loss of cereals in Wikililye location.

1.1.3 Post-harvest Management Strategies in Relation to Cereal Loss

According to FAO (2011b) the issue of cereal losses, caused by factors such as poor post-harvest management strategies is of high importance in the efforts to combat hunger, raise income and improve food security in the world's poorest countries. Storage plays a significant role in the food supply chain. Numerous studies indicate that maximum losses happen during this operation (Aulakh, Regmi, Fulton, Alexander, and others, 2013; Bala et al., 2010; Majumder, Bala, Arshad, Haque, and Hossain, 2016). In developing countries, even though people try to make use of cereals produced, a significant amount of cereal is lost due to poor storage facilities (Kumar and Kalita, 2017). Africa, in particular, experiences recurrent heavy post-harvest cereal loss (Hell, Cardwell, Setamou, and Poehling, 2000). Much of these losses are because of poor storage infrastructure, for example, use of traditional wooden cribs, which facilitate the growth of pests including the lesser and larger grain borers. Elsewhere in Asia, mud bins, pots, and plastic containers are common storage structures (Kumar and Kalita, 2017). Thus evidence from developing countries, show that 50%-60% of the grains are stored in the traditional structures at both farm level, for self-consumption and for seed (Grover and Singh, 2013). In most of them, mainly in South Asia and Africa, cereals are stored as bulk or in bags in simple granaries constructed from locally available materials such as bamboo, mud, and bricks.

In sub-Saharan Africa, farmers not only face challenges during production of staple crops, but also face many grain management constrains after harvest. They are not able to take advantage of price increases that occur during production since the storage systems are not effective. They, therefore, weaken their food security as they shift from sellers to buyers of cereals during the storage season (Kadjo, Ricker-Gilbert, Alexander, Tahirou, and others, 2013).

In a study in Togo, Smith, et al. (1994) identified maize as the main cereal grown and is mainly produced by small-scale farmers who suffer substantial losses because of insects and pest due to poor traditional storage methods. In-house smoked storage is a common maize storage method where maize is stored within the dwelling in space between the ceiling and roof over the cooking spot to receive the heat (Pantenius, 1988). Further, studies in Uganda show that indigenous structures for storage are made of locally available materials such as mud, grass, and wood without any scientific design, which cannot guarantee the protection of crops against pests for a long time (Costa, 2014). Losses of as high as nearly 60% in maize grains are experienced after storing them for 90days in this traditional storage structures.

More than 90% of the Kenyan population depends on maize as their staple food (Laboso and Ngeny, 1997). A large part of harvested maize is stored to guarantee supply between harvest seasons. The bulk of storage takes place in on-farm storage systems characterized by traditional storage structures that are prone to invasion by agents of stored food losses including insects and rodents (Nukenine 2010, Lathiya, Ahmed, Pervez, and Rizvi, 2008). These traditional storage practices used by farmers cannot guarantee protection against major storage pests of staple food like maize (Gitonga, De Groote, Kassie, and Tefera, 2013). In the larger Kitui area post-harvest losses in storage vary with crop variety, climatic conditions and storage structures (Recha, Kinyangi, and Omondi, 2013). For example, on farm storage of maize accounts for 80% of all maize harvested, but suffer post-harvest losses during storage of between 20-30% within 6months of harvest. Thus available literature suggests that the type of storage system used has an influence on post-harvest loss of cereals. However, in Wikililye location, the storage facilities utilized and their influence on household post-harvest cereal loss has not been adequately examined. This study, therefore, aimed at establishing the influence of storage system on household cereal loss.

The lack of awareness or poor knowledge of good post-harvest practices and technology by farmers has been identified as one of the challenges to be addressed if a meaningful post-harvest losses of cereals reduction is to be achieved (Abass et al., 2014; Affognon et al., 2015; Kitinoja et al., 2011). However, different studies have differing views on the influence of awareness and knowledge of better storage practices on post-harvest losses. According to Kaminski and Christiaensen (2014) different factors plays a role. These include non-availability of the technologies individuals have knowledge or awareness of, lack of economic incentives to store and better protect food, non-cost effectiveness of technologies or the knowledge and other interventions being too narrow or short-lived to pay off. In different agro-ecological zones of Kenya including eastern region, training on grain storage and protection technologies did not necessarily result in lower post-harvest cereal storage losses as farmers who received training incurred similar magnitude of post-harvest losses as those farmers who did not receive the training (Ognakossan et al., 2016). The study current study aimed at determining whether knowledge of improved storage system influenced post-harvest cereal loss in Wikililye location.

Adoption of new technologies to prevent post-harvest losses has been a policy to curb losses. Training in improved handling and storage practices to the use of hermetically sealed bags and households metallic silos are seen as promising practices in the reduction of post-harvest cereal loss (World Bank, FAO, and NRI, 2011). However the choice of technology package depends on several factors, such as the amount of production, crop type, prevailing climatic conditions, and the farmer affordability and willingness to pay which are linked to social, cultural and economic implications of adoption.

Multidisciplinary approaches and several technologies have been developed to lessen PHL in developing countries. However according to Shafiee-Jood and Cai (2016), the potential gain from adopting these technologies have been faced with challenges particularly in the rural areas and specifically among small scale farmers. This is despite modern methods such as hermetic bags being easy to install, elimination of pesticide use,

favorable costs, and modest infrastructure requirements being some of the additional advantages that make them attractive et al., (2014).

According to Kiaya (2014) post-harvest technologies can contribute to food security in multiple of ways. They can reduce post-harvest loss, thereby increasing the amount of food available for consumption by farmers and poor rural and urban households. In a number of African countries Goletti (2002) reported that the control of large grain borer (LGB) through improved technologies greatly reduced the loss of maize in on-farm storage among smallholders' farmers thus improving their food security. In Nigeria factors such as socio-economic status, education background, economic motivation and training received have a positive correlation with the technology utilized (Atibioke et al., 2012). In Tanzania prohibitive acquisition costs such as in the case of metal silos contributes to the low uptake of modern technology of storage (ANSAF, 2016) .

Even though the adoption of improved storage system is seen as a way of reducing post-harvest losses the underlying factors such as availability and affordability hinders this. Despite farmers who have already adopted improved storage systems reporting decreased losses, there are others facing challenges in the process of adoption. Thus the current study aimed to explore the situation in Kitui County, specifically, Wikililye location since documented information regarding improved storage system is scanty.

1.2 Statement of the Problem

Post-harvest cereal loss is influenced by a multiplicity of factors. These factors affect the extent to which households experience losses. Some studies show that socio-economic factors such as gender, age of household head, and education impact post-harvest cereal loss in households (Grethe, Dembélé, and Duman 2011, Odia 2017), while other studies reveal that environmental factors (Kumar 2002, Recha et al., 2012) have a major influence on post-harvest cereal loss. However, even within socio-economic factors, there is no agreement on how these factors influence post-harvest cereal loss. For

example, from the reviewed literature gender of the household respondent may have either positive or negative influence. Similarly, age and education are important variable in understanding post-harvest cereal loss particularly in the adoption of new technologies and generally embracing change. However, different groups may differently adopt new technologies aimed at reducing post-harvest cereal loss as the available literature suggests. Thus, it is not clear, what is the contribution of socio-economic factors in preventing, and/or exacerbating post-harvest cereal loss in the study area. Studies that have focused on environmental factors in relation to post-harvest cereal loss have largely dealt with humidity and moisture content and rainy periods during post-harvest season, which interfere with the drying activities. For example, scientific data show that presence of moisture in the cereals results in increased level of aflatoxin, which increases post-harvest losses. However, community knowledge and perceptions about the role of environmental factors in post-harvest cereal loss in Wikililye is not well documented.

Other studies have focused on post-harvest management strategies mainly storage including storage facilities and system used, knowledge of improved storage system and use of innovative technologies as the main factors influencing post-harvest cereal loss (Costa 2014, Majumder et al., 2016). More specifically, some researchers has examined awareness or knowledge of good post-harvest practices and technologies employed by farmers as important factors in addressing or reducing post-harvest losses of cereals. These studies, however, have differing views on the influence of availability, awareness, and knowledge of better storage practices on post-harvest cereal losses. In Wikililye location there is little information on the available post-harvest management strategies and practices including knowledge of technologies and the actual adoption of improved storage systems and their impact on cereal loss, food availability and food security hence the current study.

Marketing of cereals is a factor that has an impact on post-harvest cereal loss. This is particularly so when those involved are smallholder farmers who are likely to sell their

produce due to economic and social needs. Research suggests that small scale farmers face economic loss due to exploitation by buyers who buy at throw away prices; which pushes the farmers to more poverty and hunger when they have to buy back food at very high prices. However, marketing of cereals and its influence on post-harvest cereal loss in Wikililye location has not been adequately examined. Similarly, information on who is involved in the marketing of cereals and how this impacts household post-harvest cereal loss in the study area is scanty. Thus the current study aimed at exploring not just marketing strategies but also those involved in the marketing in relation to cereal loss

1.3 Justification

This study was prompted by the fact that food insecurity, hunger and malnutrition are global concerns. Studies have been carried out on how to curb food insecurity and hunger. However, in order to be able to deal with them, all factors at all levels need to be considered and put into perspective. Post-harvest loss of food and especially maize, a staple crop in Kenya is a matter of great concern. Studies and resources have been directed towards increasing productivity. This study aims at determining the factors influencing post-harvest maize cereal loss. Specifically in Kitui county and Wikililye location no such study has been done. Also the increase in population which needs to be fed and the massive losses being experienced also prompted this study.

The study contributes to the realization of Sustainable Development Goals (SDG) goal number 1of zero hunger by reducing food losses and waste by 2030. In Kenya, the importance of food security is given attention in a number of policy papers including *Sesional Paper No.1 of 1994,* on National Food Policy. The Government of Kenya hopes to eradicsate poverty by ensuring food security both at the national and household levels. The Agriculture Sector Coordination Unit (ASCU) formed in 2002 has been involved in the formulation of policies favoring smallholder agriculture such as the National Agricultural Sector Extension Policy (NASEP), which liberalized service delivery to farmers and enabled the emergence of farmers associations like the Cereal Growers

Association (CGA) that provides a voice for cereals farmers. The findings of this study inform National Food Policy in Kenya, the National Agricultural Sector Extension Policy (NASEP). Government, policies makers, donors and non-governmental organizations may find the information useful and help in initiating suitable intervention programs in order to reduce cereal losses as well as improve food security and curb hunger through policy and practical interventions.

At the theoretical level, this study contributed to the current debate on post-harvest cereal loss. It contributes to knowledge by making reference materials available to students from diverse fields of study agriculture, health sciences, nutrition and social sciences among others.

1.4 Objectives of the Study

1.4.1 Overall Objective

The overall objective of this study was to assess the socio-cultural and economic factors influencing households post-harvest cereal loss in Wikililye location Kitui County.

1.4.2 Specific Objectives

The specific objectives of this study are to:

i) Describe the socio-cultural and economic factors influencing households post-harvest cereal loss in Wikililye location of Kitui County.

ii) Explore the perceptions on environmental factors influencing households post-harvest cereal loss in the study area.

iii) Examine the post-harvest management strategies influencing post-harvest cereal loss in Wikililye location of Kitui County.

1.5 Research Questions

i) What are the socio-cultural and economic factors influencing households post-harvest cereal loss in Wikililye location of Kitui County?

ii) What knowledge and perceptions on environmental factors influence households post-harvest cereal loss in Wikililye location of Kitui County?

iii) What are the post-harvest management strategies influencing households post-harvest cereal loss in the study area?

1.7 Scope of the Study

The current study was carried out in Wikililye location of Kitui County. Firstly, while many factors ranging from physical, biological, mechanical are known to influence post-harvest loss of cereals, this study did not deal with those factors. The study focused on socio-economic, perceptions on environmental factors and post-harvest management strategies mainly storage as factors influencing post-harvest cereal loss. Secondly, maize being Kenya's main staple crop produced by over 90 percent of the rural households, the study focused on maize as the main cereal. The unit of analysis was the individual respondent in a household in the study area sampled on the basis of a well defined criterion. These are the informants who provided data of this study.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Introduction

In this chapter, pertinent literature is reviewed including the socio-economic, perception on environmental factors and post-harvest management strategies (storage) that impact on post-harvest cereal loss. The chapter highlights the key themes and issues pursued in the study. The chapter also presents the theoretical framework used in this study.

2.2 Socio-economic Factors to Household Post-harvest Cereal Loss

Cereal loss refers to any change that reduces its value to humans and can be either quantitatively or qualitatively measured (Cheshire, 1978; Savary, Teng, Willocquet, and Nutter Jr, 2006). The former includes loss of dry matter indicated by reduction in weight or volume while the latter covers loss of important qualities like germinating ability and nutritional contents. Cereal losses may be caused by pest infestations, infections by pathogens and poor or inappropriate handling technologies (FAO, 1996).

Post-harvest losses according to Zorya et al. (2011) are classified into three main categories; quantitative loss, qualitative loss, and economic or commercial loss. Others classify as direct and indirect losses. Quantitative loss indicates the reduction in physical weight, and can be readily quantified and valued, for example, a portion of grain damage by pests or lost during transportation. A qualitative loss is contamination of grain by molds and includes loss in nutritional quality, edibility, consumer acceptability of the products and the caloric value (Zorya et al., 2011). Economic loss is the reduction in monetary value of the product due to a reduction in quality and or/ quantity of food (Tefera et al., 2011).

The past experience with reforms in the agricultural sector has revealed that programs need to be sensitive to the social economic, cultural and political characteristic of a

society and that the technical and scientific components of change cannot be divorced from the social context within which they are applied (Development, 1978). The peoples way of life, be it social, cultural or economic influence how they carry out their activities and this impact all other aspects. All post-harvest cereal and food losses occur at a particular cultural and socio-economic environment which has an influence on its magnitude. In order to reduce this losses measures and techniques adopted must consider both social and economic factors (Kiaya, 2014) for a successful implementation.

2.2.1 The Role of Gender in Household Post-harvest Cereal Loss

Gender is a social factor that affects agricultural activities. It refers to a socially constructed involvement of men and women, which is fundamental to the organization of farm work and to decision-making concerning the farm (Riley, 2009). This entails a gender role that defines who does what. For example men carry out tilling of the land, weeding etc while women do harvesting, drying and storage. This may influence post-harvest cereal loss and different levels among the gender. According to Zorya et al. (2011) all aspects relating to post-harvest issues can be "gendered" (for example their impact on men and women). Thus in the agricultural management of crop, understanding gender relation is important.

Various studies have indicated that gender is an important variable affecting agricultural activities, which have a bearing on post-harvest cereal loss. Female farmers have been found to be more likely to embrace and adapt to changes, which can improve their livelihoods (Newmark et al., 1993; Dolisca et al., 2006; Bayard et al., 2007; Mzoughi, 2011). However, despite women ease of adopting changes and access to new agricultural technologies being crucial, gender gaps leads to gender inequalities in access, adoption and usage of these technologies (Staudt, 1977). This may influence female farmer's ability to protect their produce despite being more likely to adapt to changes aimed to reduce losses and improve food security.

The role of women in agricultural sector shows that women account for more than half of the labor needed to produce the food consumed in the developing countries and three quarters of the food consumed in Sub Saharan Africa (Hopkins et al., 1994). In Africa, as in many other regions throughout the developing world, women play crucial roles in agriculture as producers and providers of food. As farmers, traders, income earners, mothers and family caretakers, women are a critical link in achieving food security through the reduction of post-harvest losses (World Bank, 2011). Morris and Doss (1999) observed that women have active and continuous interaction with the environment as producers of food. However, regarding their technological knowledge on pest control measures, harvest, storage and preservation technologies, women are hardly included in policy making and implementation. Njiro (2003) in a study in Eastern Kenya noted that these omissions of the knowledge systems of an important proportion of agricultural producers make it difficult to come up with relevant techniques for rural household farmers in the effort to mitigate post-harvest loss.

Despite their key role in food production, women face many other challenges, which include unequal access to land, agricultural inputs, and access to technology, extension support and to finances for production (Quisumbing et al., 1995; FAO, 2011a). Evidence from Ghana indicates that gender-linked differences in the adoption of modern methods to promote production and curb post-harvest losses are attributable not to inherent characteristics of the technologies themselves but instead to results from gender linked differences in access to key inputs (Morris and Doss, 1999). The study suggests that adoption of new technologies is associated with resources because wealthier farmers can bear the risk and are thus likely to try new technologies. At the same time women are faced with more challenges than men since they experience more challenges in accessing resources aimed at reducing post-harvest loss.

In the same region of Ghana, although based on tomato production, studies showed that gender had an influence on post-harvest loss (Aidoo, Danfoku, and Mensah, 2014). Female farmers were found to be more prone to high levels of losses than their male counterparts. According to the study male-headed households tend to have many man-hours available and more time for harvesting and other farm activities compared to their female counterparts who have household/family responsibilities to attend to.

In Kenya Staudt (1977) in a paper titled "inequalities in the delivery of services to a female clientele" observed that, in societies where agricultural production is the mainstay of economic production, men and women carry out different activities. They also have access to different resources and benefits, and carry out different gender roles in the production and post-harvest cycle. She also noted that decision making process in the households, whether inter or intra regarding the allocation and use of technological resources aimed at reducing post-harvest loss are influenced by gender. Due to this, female farmers tend to experience high levels of cereal post-harvest loss compared to their counterparts. The current study aimed to determine whether gender contributes to post-harvest cereal losses.

In Africa, a study in Machakos county, eastern Kenya by Njiro (2003), technological development is modeled and implemented everywhere. This occurs irrespective of their appropriateness to factors such as environment, cultural and economic context. Lack of thorough considerations on the impact of these factors on technology implementation makes it fail. From several studies it is revealed that women opinions and perspectives are rarely taken into consideration when these technologies are being developed. Despite the main challenges faced by women farmers, empirical study in East Africa particularly in Malawi, Uganda and Tanzania by Kaminski and Christiaensen (2014) found the effect of gender on households post-harvest cereal loss was substantial. The findings indicated that it is especially female-headed households that experienced lower rates of post-harvest cereal (maize) losses. These show that women levels of post-harvest cereal loss is

minimal regardless of the challenges their face. The influence of gender on post-harvest cereal loss seems to have divergent views. Reviewed literature is not in consensus on whether or how gender influences post-harvest cereal loss. The current study aimed at determining gender influence on post-harvest cereal loss particularly in Wikililye location, Kitui County, since there is no documented literature on the same.

2.2.2 Age and Household Post-harvest Cereal Loss

Age is an important variable in agricultural activities because there is a universal increase in the proportion of older people and a decline in the proportion of younger people living in rural areas and engaging in agriculture (Sif Heide-Ottosen, 2014). Literature on the influence of the older population on agricultural activities mainly production has largely been documented. In a study in Canada Tang and MacLeod (2006) suggested that older farmers are on average less productive than younger workers and that labor force aging has a modest negative direct impact on productivity. The study however did not determine the influence of age on post-harvest activities and specifically losses. The current study diverted from influence of age on productivity and determined whether age influences post-harvest cereal losses.

Li and Sicular (2013), in a study in China found out that agricultural work force exhibited an “aging” phenomenon and that agricultural labor force “aging” is not conducive to the overall development of agricultural production. However, these studies did not indicate the influence of age on post-harvest activities that may create losses. In Jamaica where agriculture occupies an important place in the life course of many elderly people Woodsong (1994) reported that the rural concentration of elderly population has negative consequences for agricultural production and post-harvest losses. Specifically, age exerts adverse effect on the employment, not only in agriculture, but also in other areas such as

manufacturing, construction mining and quarrying industries (Siliverstovs, Kholodilin, & Thiessen, 2011).

Agricultural activities; including those that reduce post-harvest losses requires not only labor input, but also technological development. However, aging has an influence on adoption of technologies and innovations, which influence post-harvest cereal loss. According to Bokusheva et al. (2012) in central American countries, the probability of adoption of improved storage systems and other innovations to improve production and curb post-harvest losses declines with the age of the household head. This is consistent with findings of other studies in both developing and developed countries (Barham, Foltz, Jackson-Smith, and Moon, 2004; Ersado, Amacher, and Alwang, 2004), which show that older individuals are more reserved and rigid regarding the introduction and acceptance of innovations due to declining cognitive and learning abilities and thus influence their agricultural activities as well as post-harvest loss of cereals.

However, Guo, Wen, and Zhu (2015) hold a different view. Agricultural knowledge and skills in agriculture, such as production, operation, and management, increase with age. The accumulated knowledge and skills help farmers to maximize the efficient use of agricultural input, such as pesticides and fertilizers, as well as labor input and overall reduced post-harvest loss. Due to the accumulated knowledge, older farmers are able to deal with post-harvest challenges that may lead to post-harvest losses. Zorya et al. (2011a) note that in addition to gender, communities can be disaggregated by age, wealth, household composition, and health status, among other. This diversity is important. HIV/AIDs, increasing migration due to population growth, decreasing land sizes, and high fertility levels, climate change, urbanization, and associated employment opportunities mean that in rural sub-Saharan there are rapidly growing numbers of child-headed households, female-headed households, widows/widowers, and elderly relative looking after grand children Zorya et al. (2011). High fertility and consequence rapid

population growth in many sub-saharan countries means that youth now make up the majority of most of the population.

Thus from the foregoing, the influence of age on agricultural activities and mainly production in developing countries have shown varying and sometimes contradicting views on the role of age on agriculture. There is no consensus on the contribution of age to agriculture and majority of the studies done are directed on production. The current study focused on the influence of age on post-harvest cereal loss.

2.2.3 Education and Household Post-harvest Cereal Loss

Influence of education on agriculture and mainly production has received a lot of attention (e.g. Appleton and Balihuta, 1996; Jamison and Moock, 1984; Moock, 1981). One of the reasons that education may influence agricultural activities according to Appleton and Balihuta (1996) is that education enables individual farmers to follow written instructions such as calculating and applying correct dosages. This contributes to increased productivity and also reduced post-harvest losses.

Both formal education and other forms of education influence agricultural activities. They positively impact agriculture from production to reduction of post-harvest losses. Davis et al. (2012) discuss Farmers Field Schools (FFS) in Tanzania, Uganda, and Kenya which are aimed at improving knowledge and skills of adult farmers. Through experiential learning, farmers learn new techniques, ways of solving problems, and are also assisted with major decision making. Farmers Field Schools were found to improve farmer's agricultural production and reduced post-harvest losses.

Education influences the farmers' likelihood to adapt to new technologies, which further influences the level of post-harvest cereal losses. Reviewed literature indicates that educated farmers adapt to new technologies compared to their non educated counterparts.

For example, Adegbola and Gardebroek (2007) indicate that farmers who are educated are better to process information, allocate inputs more efficiently and assess the profitability of new or improved and easily adapt to changes as compared to farmers who lack education. This indicates that through the adaption to changes, and the advantages of being educated, reduces post-harvest cereal loss. Elsewhere Ali and Byerlee, (1991) and Schultz (1975) found out that education plays a greater role in modernizing agriculture. This is because education helps farmers to deal with challenges brought about by technological changes in agriculture. The better educated farmers were found to adjust more successfully to technological changes than the less educated farmers. In Nigeria Olayemi et al. (2012) found that lack of education hindered farmers acceptance of improved storage technologies. In other words education facilitates farmer's adoption of innovations. This lowers the rate of post-harvest losses among the educated farmers.

In Odisha India Das and Sahoo (2012) found out that there is a positive, continuous, and significant relationship between level of farmers education and the level of productivity. They also found that education positively influenced the use of other agricultural inputs. Thus education has positive impact on cereal production and reduction of post-harvest loss of smallholder farmers (Asadullah and Rahman, 2009; Kaminski and Christiaensen, 2014). In Mozambique in a study by Saha and Stroud (1994), reported that most households heads were illiterate and had attended school for only few years. However, the study indicated that the level of education attained by households head is positively related with households adoption behaviors. They revealed that education positively influenced households to quickly respond to their current low productivity by adopting improved storage that reduced post-harvest losses, increased household income and their standard of living.

Asadullah and Rahman (2009) estimated the effect of schooling and education on cereal production and reduction of post-harvest loss. They found a positive effect of household

respondents' level of education on productivity. However, literature on the influence of the level of education on post-harvest cereal loss is scanty, hence the current study.

2.2.4 Alternative Sources of Income and Household Post-harvest Cereal Loss

The influence of alternative source of income on post-harvest cereal loss has been reviewed by a number of authors. In Ghana adoption of new technologies aimed at increasing productivity and reducing post-harvest losses of households farmers was associated with resources (Morris & Doss, 1999). The wealthier farmers are better able to bear risks and thus, are more likely to try new technology. This is in consensus with a study in Zambia by Simatele (2006) which indicated that alternative source of income in a household can be invested in agriculture, thereby allowing the farmer to tend to the production needs and measures to curb losses. This leads to increased yields and food availability within the households.

In Ethiopia, livestock ownership, which is an alternative source of income has influence on cereal productivity and post-harvest cereal loss (Heshmati, 2017). In this study, farmers with more livestock, which could be readily converted to money, were able to buy modern farm inputs to prevent loss than those who owned fewer livestock units. Similarly, in Uganda, smallholder farmers with cash savings at the beginning of harvesting and post-harvest periods had a longer storage period (Omotilewa, Ricker-Gilbert, Ainembabazi, & Shively, 2016).

In an impact analysis study, Gitonga et al. (2013) found major differences in socio-economic and other baseline characteristics between adopters and non-adopters of metal silos in Kenya and they found out that these technologies are still only within reach of the relatively more affluent or productive farming households.

2.2.5 Marketing of Cereals and Household Post-harvest Cereal Loss

Influence of marketing of cereal produce especially in developing has a bearing on post-harvest cereals loss. In most developing countries unlike in the developed countries where farmers are assumed to store produce only for price increase, smallholder farm households have limited market access and store cereals for household food security or a small number for arbitrage reasons (Renkow, 1990; Saha and Stroud, 1994). This is the reason why suitable market institutions need to be developed and promoted to enable marketing groups and individuals to best respond to market demand (Coulter and Shepherd, 1995). Collective marketing can take various forms and for grains may include inventory credit schemes and Warehouse Receipt Systems to accelerate the efficient removal of the crop from the farmer into safe centralized storage in order to reduce post-harvest cereal loss.

A common scenario in African counties is the tendency of the majority of the few who market their produce to do so immediately after harvest. In Uganda, only about 17% of the households stored maize to sell in the lean period; the rest store for consumption and for seeds (Kadjo et al., 2013; Stephens and Barrett, 2011). Smallholder households market their maize soon after harvest due to urgent need for cash. Others sell due to concerns about their storage losses. These households later repurchase maize at higher prices. This situation of sell low, buy high, affects households income and also food access (Kadjo et al., 2013). In Dadoma, Tanzania, farmers sell more than 60% of the produce within the same month of harvesting (Tefera and Abass, 2012). This is a major factor that contributes to food insecurity situation of farmers.

In sub-saharan Africa empirical studies by Kaminski and Christiaensen (2014) in east Africa Malawi Uganda and Tanzania found out that when it comes to households marketing their maize versus the households who auto-consume, losses appear higher when a larger share of the maize harvest is marketed. These losses are reinforced by the high number of sales by households, hinting that the self-reported post-harvest losses

estimates included some of the losses incurred during the marketing process by the farmers.

In Kenya, more than 75% of maize area is cultivated by more than 3.5 million small scale farmers (owning less than 5 acres), who produce more than 65 percent of the maize consumed in the country (Dennis, 2017). Despite this, small scale farmers are net buyers of maize. This is because they produce little, sell it all to the market when the prices are low and eventually buy it from the market at high prices (Otieno, 2017). Mutungi and Affognon (2013a) observes that maize is Kenya‘s main staple food crop and over 90% of rural households produce maize for food and economic gain. Small-scale farmers contribute 70% whereas medium- and large-scale farmers contribute 30% of total maize production. Household consumption accounts for 30–50%, whereas, 50–70% of the maize produced is marketed either to millers, large traders, small assemblers, the National Cereals and Produce Board or to neighboring households. Thus maize is produced for both consumption and market (Mutungi and Affognon 2013). This indicates that despite marketing being done immediately after harvesting at lower prices, most produce is marketed.

2.3 Perception of Environmental Influence on Household Post-harvest Cereal Loss

Cereals such as maize are one of the major staple food crops in sub-Saharan Africa, including Kenya. However, climate and other conditions attract a huge number of factors, which influence post-harvest loss since they contribute to the destruction of crops (Jones, Duncan, and Hamilton, 1981).

Contamination by molds is mainly determined by the temperature of the grain and the availability of water and oxygen. Molds can grow over a wide range of temperatures, but the rate of growth is lower with lower temperature and less water availability. The interaction between moisture and temperature is vital. Maize, for example, can be stored for a period of one year at a moisture level of 15% and a temperature of 15 °C. However,

the same maize stored at 30 °C will be substantially damaged by moulds within three months of storage (Proctor, 1994).

Humidity as a factor influencing post-harvest cereal losses was studied by Pessu, Agoda, Isong, Ikotun, and others (2011). According to them there is movement of water vapor between stored food and its surrounding atmosphere until equilibrium of water activity in the food and the atmosphere. A moist food will give up moisture to the air while a dry food will absorb moisture from the air. Dried or dehydrated products need to be stored under conditions of low relative humidity in order to avoid adsorbing moisture to the point where mold growth occurs (Pessu et al., 2011).

Rainfall influences both the quantity and the quality of cereal produce leading to post-harvest cereal loss as (Grolleaud, 2002) observe. According to Hodges, Buzby, and Bennett (2011) pre-harvest rainfall patterns help to proximate the total harvested quantities and humidity conditions. Rainfall during and after the harvest, has an influence on post-harvest loss of cereal at the harvesting and drying stages. They further foster early pest infestation and affect the dry matter content before storage, there increasing post-harvest cereal loss when post-harvest rainfall is higher (Hodges et al., 2011). The condition is inevitable in sub-Saharan Africa where both small and large scale farmers rely almost exclusively on natural sun-drying process. Therefore, any rainfall or damp weather during pre-harvest, harvest and post-harvest periods can be a serious cause of post-harvest cereal losses (Zorya et al., 2011). This is was earlier observed by De Lima (1987) in a study is Swaziland where rainfall being high during harvesting or close to harvesting leads to a lot of maize not properly dried and therefore rotting.

A study in east Africa, particularly in Malawi, Uganda, and Tanzania by Kaminski and Christiaensen (2014) found out that post-harvest loss of cereals particularly maize increases with humidity and temperature. Hotter and more humid environment foster

pest infestations and rotting. A study in Eastern, Kenya by Recha et al. (2012) identified weather changes as a factor contributing to post-harvest losses especially during storage. These losses impact on food security, since quantity is reduced and quality, which is poor makes it unfit for consumption. The study identified poor drying of grain and excessive rains during harvesting, which dampen the crop resulting in formation of fungus and high temperatures, and high humidity during drying that further favors development of fungus. This aflatoxin producing fungi invades all types of grain and, in eastern Kenya, 50% of grain is lost due to this. The study focused on the weather changes and their influence on post-harvest loss. The current study focused on the perception of farmers on the influence of these factors to post-harvest cereal loss.

2.4 Post-harvest Management Strategies and Households Post-harvest Cereal Loss

2.4.1 Storage system used and post-harvest cereal loss

Storage is of imperative in agriculture mainly because production is seasonal while demands for agricultural commodities are spread through the year. Food insecurity in Africa, which is a major problem is caused by post-harvest losses incurred mainly during the storage period according to the African Ministerial Council of Science and Technology (AMCOST, 2006). The type of storage used plays a vital role in post-harvest loss of cereals or lack of it. Numerous studies indicate that maximum losses happen during the storage periods. This is the situation in developing countries and especially in Africa including Kenya (Hell et al., 2000).

Storage is particularly crucial in agriculture because agricultural production is seasonal while the need for agricultural produce is spread all through the year. Climate change experienced in the recent years has added up to the problem. For example, in semi-arid Eastern Kenya, in the 1970s, there used to be planting and harvesting twice a year since both long and long rains were reliable. However, from the 1980s, rain has become unreliable, leaving the community with one dependable annual harvest (Recha et al.,

2012). Therefore, small scale farmers require storing for long and mitigation of loss during storage would curb hunger and food insecurity. According to Adejumo and Raji (2007) in terms of marketing, storage is an imperative activity. It enhances marketing efficiency by providing utility. It is particularly important in agriculture because agricultural commodities are not spread throughout the year. Therefore, there is need to meet average demand by storing excess supply during the harvesting and post-harvest season for gradual release to the market during off season periods. In the process, stabilization of seasonal prices can be attained.

Reviewed literature shows that in East Africa, majority of farmers rely on traditional storage systems, which are not effective leading to post-harvest losses. In Nigeria, farmers use the traditional methods of storage like storing maize over the fire places, sacks and tins, which are not effective leading to post-harvest loss of agricultural produce (Olayemi et al., 2012). In Ghana, farmers experience very high storage losses with estimates ranging between 30-40 percent. This is due to poor storage methods resulting to invasion of the cereals by destructive pest of stored maize. They include larger and smaller grain borer which turns maize into powder, causing high losses to farmers and threatening their food supply and income (Boxall, 2002). Similar occurrence is observed in Togo by P. Smith et al. (1994) where the main cereal grown is maize 95 percent of which is produced by small scale farmers who suffer substantial post-harvest losses because of insects and mildew due to poor traditional storage methods.

In Ethiopia, farmers use various methods and types of facilities to store their crops (Gabriel and Hundie, 2006). This includes traditional grain stores such as grain pits, bags (made of polyethylene, sisal or goat skin), earthen pots and some others. Indeed more than 70% use polyethylene bags and sacks made of sisal, which increased the rate of cereal loss. In Uganda, the predominant storage technologies utilized by households are polypropylene bags (71%), heaped-in-house, where maize is left in the cob (11%), with

traditional and improved granaries utilized by only (8%) and private off-farm facilities (2%) (Omotilewa, Ricker-Gilbert, Ainembabazi, and Shively, 2016). In their sample only 1% of the respondents used the hermetic (airtight) technologies. The literature indicates that majority of small scale farmers rely on traditional methods of storage. These methods contributed to the increased rate of post-harvest cereal losses.

In tanzania, Sweeney, White, and Dobson (2000) carried out a study on the quality of maize. The interest was to determine the elements which affected stored maize; however it did not consider the storage facilities and their influence on post-harvest cereal loss. Findings indicated susceptibility of maize to fungal infection which was influenced by conditions such as high humidity, poor storage facilities, non-improved storage technologies which lead to insect activity in maize. In Kenya, maize is the most important cereal and staple food for over 90% of the population. Maize accounts for more than 20% of all agricultural production and 25% of agricultural employment in Kenya (Republic of Kenya, 2007). However, grain losses contribute to food insecurity and low farm incomes. According to Odendo, De Groote, & Odongo (2001), on farm maize yield and later losses due poor storage facilities leads to low food available to keep up with the rate of population growth. These lead to serious food insecurity and poverty. In Eastern Kenya, Recha et al. (2012) reported that at least 95% of small scale farmers rely on traditional storage facilities such as baskets, cribs and gunny bags that do not guarantee protection against the larger grain borer, which causes over 30% of the losses in the area. Maize loss due to poor storage poses a recurrent problem in the country, which is most acute among poor farmers. This creates the necessity to address the issue.

2.4.2 Knowledge and awareness of improved storage systems

In developing countries, imperative information dissemination through different media, practical hands-on experience, better direction and awareness are lacking most of the times in the agricultural and food sector where farming is highly concentrated among rural farmers (Sokoya, Alabi, and Fagbola, 2014). The farmers lack necessary awareness

on modern strategies that can improve farming method, marketing and food storage. Clear information flow among the farmers to create awareness is likely to improve productivity making and abundance of farm produce available all year round. The current study aimed at determining the level of awareness of improved storage systems and whether it has an influence on post-harvest cereal loss.

In Nigeria, Olowu (2008) reported that majority of the country population 68% are illiterate and living in rural areas engaging in agriculture. The farmers rely on old traditional ways of farming, their information needs are not met and lack relevant strategies and tools for improved and modern storage systems. Adomi, Ogbomo, and Inoni (2003) observed that this category of farmers lack necessary information and awareness for better storage facilities and implementation strategies that can help in providing food all year round. In addition, Onemolease (2005) reported that lack of awareness of the improved storage methods lead to corn farmers in Nigeria to experience serious post-harvest losses particularly due to grain rot. Majority of the farmers claimed not to be aware of improved storages.

In a study in Tanzania, Tefera and Abass (2012) noted that awareness creation plays a vital role in the implementation of improved technologies. This is because availability of improved technologies alone may not be effective unless communities are sensitized and level of awareness enhanced, which in turn affects adoption and thus reduction of post-harvest cereal loss. The study emphasized that promotion of technology should be accompanied with awareness creation at different strata: community, private sector, extension officers, local authorities and media. Farmers require to be made aware and advantages outlined to increase productivity and reduce post-harvest cereal losses.

Better knowledge and awareness have considerable implication on farmer's wellbeing from production, through to post-harvest activities that impact post-harvest cereal losses. There is need for knowledge and awareness through good information flow and sharing

among agricultural stakeholders for better management of post-harvest losses, which according to Sam (2011) can involve researchers, policy makers, and the farmers. This is to enhance agricultural production, and improve food storage. The present study, therefore, explores how farmer's awareness and knowledge of improved storage facilities influence post-harvest cereal loss and food security.

2.4.3 Adoption to Improved Storage System

Adoption of improved storage systems has numerous number of advantages in the effort to reduce post-harvest loss of cereals. Based on the literature, the most utilized intervention strategy in terms of improved storage to reduce post-harvest cereal loss is the use of especially, but not limited "hermetic" technologies. Those that stabilize oxygen levels and provide tight seals to inhibit the reproduction and life cycle of insects and other pests or pathogens that destroy stored food, especially grains and cereals (Murdock, Margam, Baoua, Balfe, and Shade, 2012). According to Tefera et al. (2011) improved technology such as metal silo has proved to be effective in protecting harvested cereals from attack and destruction, not only from storage insects, but also from rodents, pests, birds, insects and fungal (molds) invasion.

Adopting improved storage systems, for example, metal silos means better storage capacity that hinder post-harvest loss, which enables the users to have continuous source of food thereby improving their wellbeing (Coulter, Brussel, and Wright, 1995; Gladstone, Astuias, and Hruska, 2002; Hermann, 1991). In West Africa, the Purdue Improved Crop Storage (PICS) bags prevent losses with maize, sorghum, wheat, rice, peanuts, among others (Jones, Alexander, and Lowenberg-DeBoer, 2011). In Uganda and Burkina Faso World Food Program (WFP) reported a high reduction in losses and increased household incomes with the introduction of improved technologies hermetic crop bags, plastic silos, and metal silos (Costa, 2014). In Mbeere Districts , Eastern Kenya, farmers have reported a reduced amount of post-harvest losses after adopting improved storage technologies such as metal silos (Abraham W. Ali, 2010). Thus

improved technologies are more effective in the control of post-harvest losses than the traditional storage methods such as granaries, plastic and metal barrels, sacks and barns (Coulter et al., 1995; Gladstone et al., 2002; Hermann, 1991).

In Togo, in an effort to reduce post-harvest maize loss farmers were advised to take efforts to make a little extra cost of adopting improved storage facilities without major changes to their usual storage methods. These simple adopted improved systems increased the harvest and improved the quality of maize, with farmers reporting losses of 9 percent as compared to between 15-50 percent using the ordinary traditional methods (L. C. Smith, El Obeid, and Jensen, 2000). According to FAO (2011b) some of the benefits that occur to farmers from utilizing improved agricultural storage technologies include reduced pest and disease infestation this leading to increased harvest index. In Tanzania, studies by Mwanga (2002), found out that the use of recommended improved storage methods is linked to both productivity of crops and reduced post-harvest losses.

Gitonga et al. (2013) in a study to analyze the difference in adopters and non-adopters of metal silos in Kenya, found out a number of advantages the adopters had. Adopters experienced almost the complete elimination of losses caused by insects and pests. Adopters had an increase of 150-198kg/household of available maize grain, and an increase in home-based maize consumption by 1.8-2.4 months, thus a decrease in market reliance. The adopters had an increase in wait time before selling grains on market (thus economic gain from higher prices received from sales) and finally a reduction of time associated with food insecurity by one month.

De Groote et al. (2013) studied the effectiveness of hermetic bags for maize storage in Kenya and Baoua, Amadou, and Murdock (2013) studied the hermetic effectiveness on cowpea in Niger. Both studies found out that there was considerable loss prevention. However, Affognon et al. (2015) critiqued their findings. According to them, many, although not all, of the studies draw conclusion about the effectiveness of the hermetic

technologies based on controlled laboratory settings, but not the actual and often imperfect use by farmers under their varied constraints and operating environments. The current study focused on the influence of adoption of improved storage on post-harvest cereal loss and further aims at dealing with the critique by involving the farmers' view of the utilization and effectiveness of the improved storage if any.

2.6 Theoretical Framework

2.6.1 The Diffusion of Innovation Theory

This study was guided by the Diffusion of innovations Theory, which was developed by (Rogers Everett M., 1976). The study of diffusion of innovation took off the subfield of rural sociology in the mid western United States of America in the 1920s and 1930s due to the rapid advancement of agricultural technology, researchers started to examine how independent farmers were adopting to hybrid seeds, equipment, and techniques (Valente and Rogers, 1995). The diffusion of innovation theory is concerned with the manner in which a new technological idea, artifact or technique or a new use of an old one, migrates from creation to use (Arnie, 2012). According to the theory, technological innovation is communicated through particular channels overtime and among the members of a social system, which defines diffusion (Apperson & Wikstrom, 1997). The main concept is diffusion of innovation and has got four main elements: Innovation: Is an idea, practice or object that is perceived as new by an individual or group [or organization), Communication: The process by which participants create and share information to one another in order to reach a mutual understanding, Time: Time involved in the innovation-decision process, the time taken to adopt an innovation by the adopter and the adoption rate across the social system, Social system: Are a set of interrelated social units (e.g. individuals, informal groups, organizations) that are engaged in problem solving to achieve a common goal.

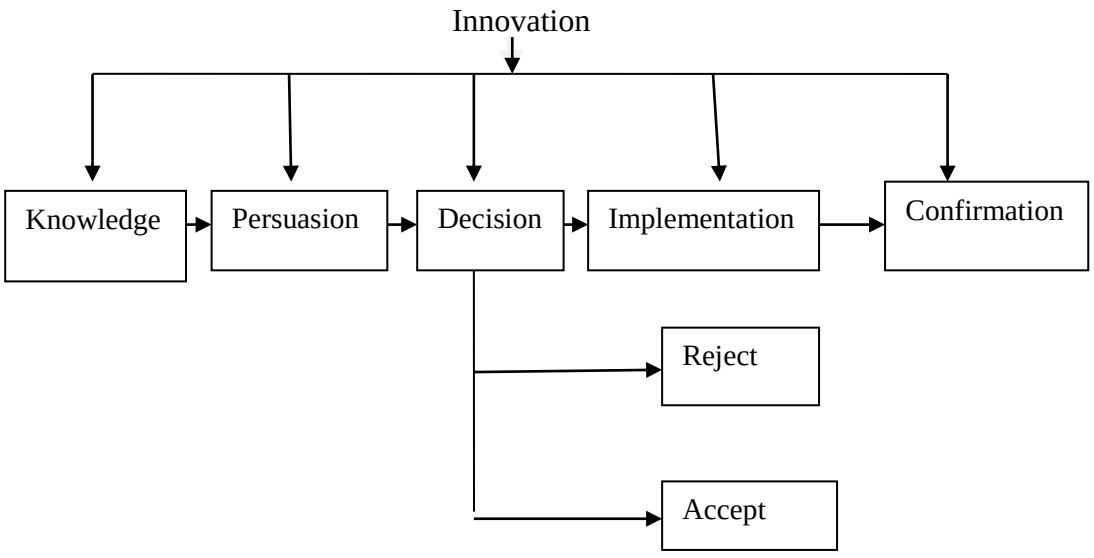
Diffusion of innovation theory purports to describe the patterns of adoption, explain the mechanism, and assist in predicting whether and how a new invention will be successful

(Mahajan, Muller, & Srivastava, 1990). Rogers (2005) in his book, *Diffusion of Innovations*, points out that diffusion is not a single, all encompassing theory but it has several theoretical perspectives that relate to the overall concept of diffusion; it is a meta-theory. This theory concerns the spread of innovation, ideas, and technology through a culture or cultures. Diffusion theory states that there are many qualities in different people that cause them to accept or not to accept an innovation.

Further Rogers developed adopter categories which is classification of individuals within a social system on the basis of innovativeness. Rogers suggests a total of five categories of adopters. The adoption of an innovation follows an S curve when plotted over a length of time (Fisher & Pry, 1971). The categories of adopters are: innovators, early adopters, early majority, late majority and laggards (Rogers, 1976, pp. 150). Innovators are characterized by willingness to take risks, have the highest social status, have financial ability, are social and have closest contact to scientific sources and interaction with other innovators. Innovators risk tolerance allows them to adopt technologies that may eventually fail. Financial resources and ability help the adopters to absorb these failures (Rogers, 1976, pp. 282). Early adopters are individuals who have the highest degree of opinion leadership among the adopter categories. Early adopters have a higher social status, financial ability, higher education and are more socially advanced than late adopters. They are more cautious in adoption choices than innovators. They use judicious choice of adoption to help them maintain a central communication position. Early majority: They adopt an innovation after a varying degree of time that is longer than the innovators and early adopters. Early Majority have above average social status, contact with early adopters and rarely hold positions of opinion leadership in a system. Late majority: They adopt an innovation after the average person. These individuals approach an innovation with a high degree of skepticism and after the majority of society has adopted the innovation. They are cautious about change and have a questioning attitude towards innovations. They are also characterized by below average social status, little financial liquidity, in contact with others in late majority and early majority and

little opinion leadership. Laggards adopt an innovation after the average participant. These individuals approach an innovation with a high degree of skepticism and after the majority of society has adopted the innovation. Late Majority are typically skeptical about an innovation, have below average social status, little financial ability, in contact with others in late majority and early majority, and little opinion leadership.

Rogers further identified five stages to the process of decision to adopting an innovation. The first stage is knowledge, in which an individual becomes aware of an innovation, but has no information about it. Next is persuasion, in which the individual becomes actively interested in seeking knowledge about the innovation. The third stage is of decision making where the individual weighs the advantages and disadvantages of the innovation and decides whether or not to adopt it. After the decision is implementation, in which the individual actually does adopt and use the innovation. Confirmation is the final stage. After adopting the innovation, the individual makes a final decision about whether or not to continue using it based on his own personal experience with it. These same stages apply, to varying degrees, to groups of people or as individual.



Adapted from Rodgers (2005)

The theory first received criticism in the 1970s in the context of international development projects (Rogers, 2003). The main criticism was that innovations were being targeted to the "Innovators" and "Early Adopters" considered the more 'progressive' farmers, with the expectation that innovative practices would trickle down to the majority of farmers. However, the reality was that the application of the theory was viewed as a source of inequity, dividing rural communities and not benefitting/assisting those in most need. Particularly this was noticeable when the diffusion of innovations process benefited larger farmers by increasing their production but decreasing the market prices/farm gate returns received by all farmers in the region including the non-adopters (Schonherr & Mbugua, 1974). Secondly, the theory is critiqued by Van den Ban (1998) who noted that the theory tends to assume innovations originate at research institutes/central agency rather than farmers themselves. It further assumes that there is enough research information available to the extension/change agent and does not tend to see knowledge as a combination of research outputs plus the farmer's knowledge, experience and interpretation of the problem.

In relation to this study, several factors and characteristics have been identified as influencing the loss of cereals after harvest. Farmers' adoption of new knowledge and innovation on cereal loss will be increased if they perceive that the better practice has an advantage over previous methods. This can be promoted through educating, training and sensitizing farmers on the factors that lead to cereal loss. Farmers with adequate knowledge are more likely to make decisions which enhance food security adoption. Through education, farmers develop positive attitude which often encourage them to learn skills necessary for implementation and not be reluctant in adoption due to cultural beliefs and norms of society. Education is also important for the confirmation stage to help a farmer decide whether to accept and utilize improved methods that reduces cereal losses. In Kenya, this theoretical framework was utilized by Schonherr and Mbugua

(1974) in the aim of developing more efficient methods for stimulating diffusion of agricultural innovations and at the same time reducing the dualistic pattern of rural development.

Thus I find this theory relevant for my study since it will inform on knowledge, persuasion, decision making, implementation and confirmation of better practices in relation to the factors that influence post-harvest loss of cereal, which will be beneficial to the people of wilikilye location.

CHAPTER THREE

3.0 RESEARCH METHODOLOGY

3.1 Introduction

This chapter describes how the study was carried out. It discusses the design that was utilized to conduct the study, describes the study site including, the study population, techniques used to derive the study sample, and the data collection methods, research instruments, data analysis and presentation techniques. Ethical considerations are also presented in this chapter.

3.2 Research Design

The study adopted cross sectional descriptive research design. Cross sectional design was appropriate for this study because it enabled the collection and analysis of both the qualitative and quantitative data in a short period of time. A mixed method approach was employed. Mixed methods refers to all procedures involving collecting and analyzing both quantitative and qualitative data in a single study context (Teddlie & Tashakkori, 2003). A sequential approach was adopted in the data collection, firstly, quantitative data followed by the qualitative materials. Quantitative data were collected using questionnaire, which provided information on the socio-economic and environmental factors influencing post-harvest loss of cereals produced in households as well as post-harvest management strategies in Wikililye location. The qualitative data were collected using focus group discussions, and key informant interviews on a variety of parameters on post-harvest management strategies as they relate to post-harvest loss of grains/cereals. Observation was used concurrently with other methods to also collect qualitative data.

3.3 Study Area

The study took place in Wikililye location in Kitui County. According to national population census (2009) in the KNBS (2010), Wikililye location has a total population of 11,851 persons. It is located in the tropical region between latitudes 0°10' and 3°0' south and longitudes 37°50' and 39°0'east. It is located in the Mulango ward in the Central Division of Kitui County, which covers an area of 809 km^2 and borders the following wards Kisasi to the South, Nzambani to the North East, Mbitini to the East, Kwa Vonza/Yatta to the West and Kyangwithya West to the North West (County Government of Kitui, 2016).

Kitui County has got two climatic zones (Okumu, 2013). The semi-arid zone on the western part and the arid zone on the eastern and southern parts, which have got lower average rainfall and temperatures are 4°C higher than the western (Okumu, 2013). Wikililye location is situated in the western parts of the county, and has high temperatures of 16°C to 34°C through the year. The mean maxima is 28°C and mean minima of 22°C respectively (District Commissioner of Kitui (DCK), 2002). Warmest period occurs between January and February and June and September. The rainfall in the area is not reliable and it is not uncommon for it to fail. The rainfall occurs twice in a year, "long rains" in April-May and "short" rains in October-December. The farmers depend on the rain for agricultural cultivation, with the high areas in the west receiving most rainfall of between 700-1050mm per year and this decline to the south and east up to 500mm per year (District Commissioner of Kitui, 2002). With this type of rainfall which is unreliable, it is important to prevent post-harvest loss since the area sometimes faces prolonged drought and food shortage.

3.4 Local Livelihood Activities

Farming is the main economic activity of the people of Wikililye location. Majority practice subsistence farming and grow crops, maize being the most grown cereal crop. Others include pigeon peas, cowpeas, cassava, beans and green grams. Some residents

own livestock such as cows, goat, sheep, donkeys and poultry. The area is mostly inhabited by the Kamba community. They sell their agricultural produce to meet basic needs while some carry out small businesses such as, motorcycle riding popularly known as *bodaboda*, and artisans.

3.5 Study Population, Sample Size and Sampling Procedures

3.5.1 Study Population

The target population of the study was households resident in wikililye Location. According to KNBS (2010) Wikililye location has a population of 11,851 people with a total of twenty nine villages. In this study, the target population was the accessible adult individuals (respondents) available in the households at the time of the interview in all the villages, key informants and focus group discussants. The total number of households in the location is 3,149. The unit of analysis was household respondents, key informants and focus group discussants.

3.5.2 Sample Size

The sample size was derived using Raosoft$_{(R)}$ software with a 95% confidence level for social sciences and a margin error of 5%. The Raosoft$_{(R)}$ sample calculator is an automated software program that generates the sample size of a research or survey. For the current study the sample size was 343 households. Once the researcher identifies the total population to be studied, the software provides a field where you feed the figures. The software provides a margin error which is the amount of error that you can tolerate. If 90% of respondents answer *yes*, while 10% answer *no*, you may be able to tolerate a larger amount of error than if the respondents are split 50-50 or 45-55. It also provides the confidence level which is the amount of uncertainty can be tolerated. Higher confidence level requires a larger sample size. The sample size is automatically calculated once you input the target population. It thus provides the researcher with the minimum recommended size for the survey (Raosoft$_{(R)}$, 2004). It is from the 343

households sampled that 343 respondents were identified and interviewed. Figure 1 further allaborates on the sample size calculation.

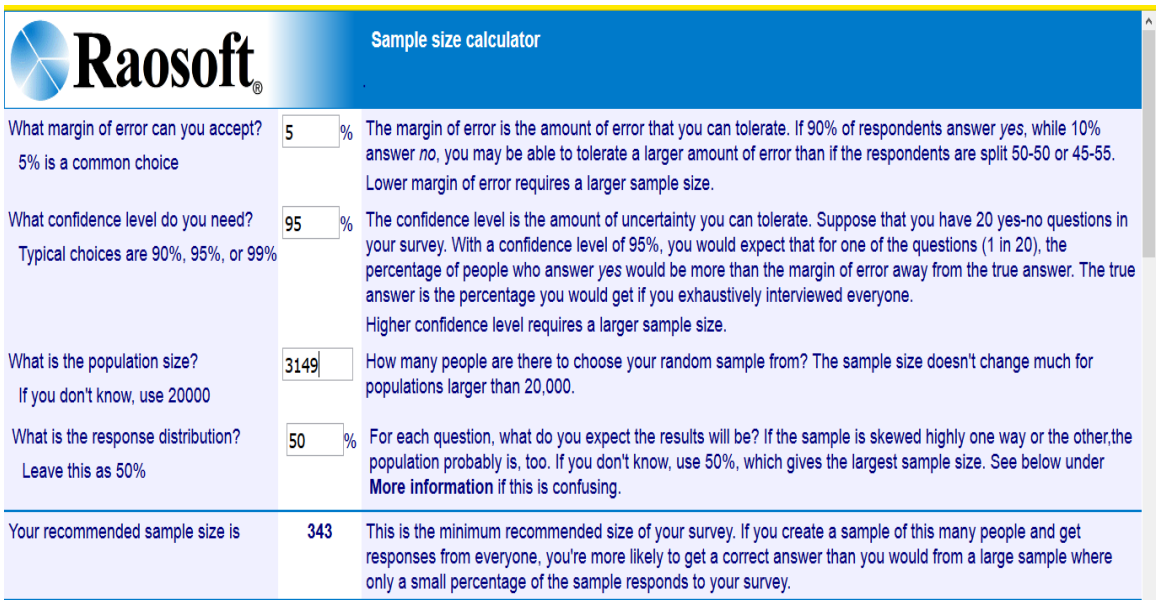


Figure 1: Raosoft sample calculation

3.5.3 Sampling Procedures

All the twenty nine villages in Wikililye Location were targeted and samples were, therefore, selected from each village. In order to obtain the actual households to be interviewed, a sampling frame comprising a complete listing of all the households (study population) in each village was compiled by randomly assigning them numbers. From the sampling frame, in order to identify the exact household respondent, systematic sampling procedure was employed to obtain the K^{th} number, which was calculated by dividing the number of household for each village divided by the sample size obtained for the particular village. The sample obtained for each village was therefore proportional to size of the village meaning that samples were included in the study depending on their numerical strength. The total sample, which provided quantitative data, was 343 from all villages. **Table 1** shows the distribution of the sample.

Table 3.1: Population proportionate to size

S.No	Village	No. of households	Sample size	K^{th} number
1	Silanga	45	4	11^{th}
2	Kangalo	100	10	10^{th}
3	Zambia	49	6	8^{th}
4	Wayani	55	6	9^{th}
5	Kinyakini	69	7	10^{th}
6	Kathukini A	59	6	10^{th}
7	Kathukini B	44	4	11^{th}
8	Katiliku	55	6	9^{th}
9	Tumyaloni	57	6	10^{th}
10	Mulango	69	7	10^{th}
11	Yowani	101	12	8^{th}
12	Kilukiwiya	86	9	10^{th}
13	Musya	68	7	10^{th}
14	Musyau	70	7	10^{th}
15	Kithumulani	54	6	9^{th}
16	Mbathani	77	8	11^{th}
17	Kisekini	150	17	11^{th}
18	Maranatha	112	12	10^{th}
19	Wikililye market	995	110	11^{th}
20	Kavisi west	110	12	11^{th}
21	Yumbisye	224	25	11^{th}
22	Kathuma	61	6	10^{th}
23	Muranga	46	5	11^{th}
24	Kithambangii	109	12	11^{th}
25	Nengya	62	8	13^{th}

26	Kyanzou	65	8	12^{th}
27	Kamale	51	5	10^{th}
28	Kavisi east	55	7	13^{th}
29	Mutungwe	50	5	10^{th}

PPS formula = No. of households in each village × Sample Size

Total number households in the location

K^{th} Number formulae = total households for each village

Determined sample size for each village

The study targeted to interview household heads. Where household heads were absent the person immediately after him/her was interviewed and where none was available, the researcher moved to the next household to cater for the absent one. To cater for gender representation, households heads or person immediately after the household head were interviewed but alternated by gender where applicable in all the villages.

In addition 4 key informants (KIs) from the study area were purposively sampled. They included an agricultural extension officer actively involved in the study area with households agricultural activities, the Director, Kitui Development Center, which is a non-governmental organization in the which has several projects in the study area aimed at improving the overall livelihoods of households through agricultural activities and the administrative offices both the area chief and assistant chief.

Focus Group Discussions whose participants were sampled purposively were carried out. According to Gall, Gall, & Borg (2007) purposive sampling aims at selecting individuals who are well informed about the research topic and interaction among them stimulates feelings, expressions of the phenomenon, knowledge and beliefs which could not be

achieved if interviewed individually. A total of four focus group discussions were carried out. The focus group constituted one group of male discussants, one group of female discussants, one with a combination of both male and females and one with village elders in the location.

3.6 Data Collection Methods

Mixed method approach was employed to collect data for the study. This involved both quantitative and qualitative data collection methods. Quantitative method entailed using structured questionnaires to generate quantitative data from respondents. Qualitative method entailed using Key Informant Interviews with community leaders on factors influencing post-harvest loss of cereals. Focused Group Discussions with community leaders both men and women and government officials to qualitative textual data were carried out. Direct observations by the researcher were also done. The varied methods ensured that the limitations of one type of data collection method were balanced by the strengths of another (Turner III, 2010). The use of multiple methods was also imperative in triangulating data collected. In addition to the primary data, secondary data were collected from existing records and internet materials from other writers on the pertinent issues relating to post-harvest loss of cereals.

The researcher was assisted by three (3) research assistants who were trained on how to collect data. They aided in curbing language barrier and also note taking during focus group discussion. Data was collected in two phases. Phase one (1) took two months and mainly dealt with collecting data using semi-structured questionnaires which were administered by the researcher and 3 research assistants to the sampled respondents in Wikililye Location. Phase two was mainly used to collect data from the sampled key informants and focus group discussants from the location.

3.6.1 Interview Using Questionnaires

The first tool of data collection was personal interviews by use of questionnaires to the 343 household heads to derive quantitative data. The questions were specific and with limited answers to enable generation of quantitative data that is analyzable through statistics as Okeyo (2015) suggests. The questionnaire was organized into different sections; each section of the questionnaire seeking information related to a specific objective. The first section sought to obtain information related to social cultural factors influencing cereal loss of household. This included gender, age, level of education, marketing and alternative source of livelihood. Section two addressed how environmental factors contribute to post-harvest cereal losses in Wikililye location and section three addressed post-harvest management strategies contributing to food loss in Wikililye location. The questionnaire used for data collection is shown in Appendix 1.

3.6.2 Focus Group Discussions (FGDs)

Four Focus Group Discussions made of farmers were conducted with separate groups of males and females, and both male and female village elders. The number of discussant varied from 7-12. The moderator who was the researcher used a Focus Group Discussion guide which was purposively developed in order to gather more in depth understanding about the study. A note taker helped with recording verbatim and non verbatim responses through observations. The FGDs guide for the study is shown in Appendix 2. The purpose of Focus Group Discussion, Key Informant Interviews, and observations was to triangulate data from questionnaire on the factors influencing post-harvest cereal loss.

3.6.3 Key Informant Interviews

The study conducted 4 key informant interviews consisting of the location agricultural extension officer, a non-governmental organization director from the Kitui Development Center and two administrative officers who were the area chief and assistant chief using

key informant interview guide. The aim was to gather more elaborate information about households post-harvest cereal loss its impact on households. This provided more in depth and reliable information that enabled to triangulate data obtained from both the FDGs and survey. The key informant interview schedule that was used to collect data from key informants is presented in Appendix 3

3.6.4 Direct Observation

Direct observation was used to collect non verbal data. This was done during personal interviews with the respondents while administering the questionnaire. Observation checklist enabled the researcher to obtain data on the general information in line with study objectives. This aided in gathering more detailed information which cannot be obtained using the structured questionnaire. This included state and type of storage facilities utilized, state of cereals in the stores, the drying systems used among others. The observations result is presented in form of photos and gives a clear picture.

3.7. Validity and Reliability of Instruments

3.7.1 Validity of Instruments

A research instrument is valid if it actually measures what it is supposed to measure and when the data collected accurately represents the respondents' opinions (Amin, 2005). Validity of the instruments was ascertained by conducting a pilot study to pretest the research instruments. According to Mugenda & Mugenda (2003), a pre-test sample of a tenth of the total sample with homogenous characteristics is appropriate for a pilot study. Therefore, 35 households which is equivalent to 10% of the sample size of respondents, was interviewed, from Kyambiti location a neighboring area that has similar physical, demographic, and socio-cultural characteristics with the main area of study. This ensured that the instructions were clear and all possible responses to a question were captured.

Validity also deals with the question of how the findings of the study adequately represent reality (Orodho, 2009). To ensure validity, therefore, randomization and use of multiple data collection strategies such as semi-structured questionnaires, focus group discussions, key informant interviews, and observations were utilized. Both quantitative and qualitative methods were used for analysis thus triangulation. Cross-sectional descriptive research design which gives the researcher an opportunity to get accurate view of response to issues as well as limited time thus avoiding extraneous factors which can influence the subject was employed (Kothari, 2004).

3.7.2 Reliability of Instruments

Reliability is the extent to which research results are consistent and replicable (Amin, 2005). A test is reliable to the extent that it measures whatever it is measuring consistently (Best & Kahn, 2006). As a quality control measure, the test retest method was applied. This was done by administering the same questionnaire twice to farmers allowing an interval of one week in between. The consistency in the answers provided assurance of reliability of the instrument. The data collection process was done systematically and data were recorded accurately and kept securely as part of an "audit trail" that can enhance reliability of the results of the study (Babbie, 2013). Coding and recording technique was employed in analysing data that could adequately guide a different researcher in carrying out a similar analysis.

3.8 Data Analysis

The data collected for this study were analyzed following mixed method data analysis process including the use of Statistical Package for Social Sciences (SPSS) version 20.0 to run data (Hopkins, 2002). First quantitative data collected through questionnaires was checked for completeness, cleaned, coded, and entered into a computer system before analysis. Analyzed data was presented in frequency tables and percentages, and interpretations and discussions of the findings followed. The study used frequencies and

percentages because of their ability to distribute the respondents according to the various values of the study variables.

Qualitative data analysis seeks to make general statements on how categories or themes of data are related (Nachmias, 2000) thus, qualitative data were analyzed thematically. Qualitative data were analyzed using open coding whereby themes and patterns were identified (Ritchie, Lewis, Nicholls, & Ormston, 2013). Themes and patterns were derived from the responses given by key informants, FGDs and from open- ended responses from the Household Survey Questionnaire. The data was presented using direct quotations and narratives/ verbatim to provide actual feelings and views on the issues under investigation. The researcher personally transcribed the qualitative data from semi- structured questionnaires, oral interviews and focus group discussions.

3.9 Ethical Considerations

Legal and ethical issues were considered and adhered to simultaneously when carrying out this study. Researchers have the responsibility over safeguarding of the rights and safety of the people involved in their studies (White, 2000). This responsibility is clearly articulated in literature as research ethics and includes issues regarding consent, confidentiality and anonymity (Babbie, 2013; White, 2000). Research permit was obtained from South Eastern Kenya University Board of Postgraduate Studies. Permission was also sought from the Wikililye location chief and notice letter was sent to the assistant chiefs in the villages. An agreement was reached on when to collect the data. The researcher explained to the respondent the purpose of the study. The researcher first of all sought respondents' consent to participate in the study while assuring them that their participation was voluntary. Participants were also informed about their right to withdraw consent of participation at any time without a penalty. The respondents were not required to provide their names or any specific form of identification on research instruments. In addition, the participant would not personally experience benefits from participating in the study. However, they could benefit later

from the study findings as farmers and other stakeholders. The participants were assured that all information they provided would be kept confidential and personal interviews also remained confidential. Each farmer who agreed to participate was given a written consent form to sign.

CHAPTER FOUR

4.0 RESULTS

4.1 Introduction

This chapter presents the findings of the study, which are discussed under thematic subsections in line with the study objectives. The thematic subsections include the socio economic factors influencing household post-harvest cereal loss that include gender, age, level of education, alternative source of income and marketing of cereals, the perception on environmental factors contributing to post-harvest loss of cereals, and finally post-harvest management strategies mainly storage, which contribute to post-harvest loss of grains was also examined.

4.2 Demographic Characteristics of Respondents

The demographic characteristics that were considered in this section included: gender, age, the level of education of the participants, religion and size of land utilized for farming. This gave a deeper insight on understanding the relationship between the variables under study. Table 4.1 summarizes the respondent's demographic profile.

Table 4.1: Demographic characteristics of participants

Category		**Frequency**	**Percent**
Gender	Male	145	42
	Female	198	58
Age group	39 years and below	104	30
	40-59 Years	115	34
	60 years and above	124	36
Religious affiliation	Catholics	38	11
	Protestants	303	88
	Muslims	2	1
Acres of land under cultivation	Below 1	129	37.6
	1 to 3	189	55.1
	3 to 6	16	4.7
	7 and above	9	2.6

Education level of respondents	None	34	10
	Primary level	220	64
	Secondary	64	19
	Tertiary and above	25	7

Source: Field survey data (2017)

A total of 343 respondents participated in this study. Out of 343 respondents interviewed (145) 42% were male while (198) 58% were female. This findings show that majority of the people who participated in the study were females as compared to men. This shows that females engage more in post-harvest activities and farming in Wikililye location. It is also consistent with the current pattern of Kitui County statistics where by females are more available in the homesteads than men. The age of the respondents was also determined. From the findings it is clear that the age was evenly distributed. Most of the respondents were in the age group of 60years and above 36%, respondents 40-49years followed with a percentage of 34 with those 39 years and below constituting 30%. Religion proved of essence to the respondents since none lacked a religious affiliation. The field survey revealed two main religious affiliations, Protestants and Catholics. Majority of the respondents were Protestants 304(89%) and Catholics 37(11%). Only 1% of the respondents were Muslims. On the size of land used for cultivation most of the respondents had below three acres of land. Majority 189(55.1) having less than 3 acres. This is in line with the average landholding among farmers in Kitui according to government of Kenya which ranges from 0-3hectares. Only a few of farmers have a larger land holding. Majority of the respondents had only attained primary level education 220(64%) which indicate that education levels of Wikililye location is generally low.

4.3 Social Economic Factors and Their Influence to Household Post-Harvest Cereal Loss

This sub-section provides the results of the socioeconomic factors that influence post-harvest loss of cereals. First, the sub-section deals with the nature of post-harvest cereal

loss in Wikililye location. It provides the information on whether there is cereal loss or not in the study area. Second, it gives results on the influence of gender, age, level of education, alternative source of income and marketing of cereals and their contributions to post-harvest cereal loss.

4.3.1 Status of Post-harvest Cereal Loss of Wikililye Location

Respondent were first asked whether they experienced any post-harvest cereal loss and the results are displayed in Table 4.2. The table reveals that, majority of the households (63%) experienced some form of post-harvest cereal loss (mainly maize) with 37% reporting that they did not experience any cereal loss. Some experienced loss more than others. While some experienced loss of almost half of their production or incurring economic loss through selling at low prices to cater for other households needs. The mean total loss of households experiencing loss was 25.6kgs.

Table 4.2: Whether experience post-harvest cereal loss

Cereal loss	**Frequency**	**Percentage**
Experience loss	215	63
Don't experience loss	128	37
Total	**343**	**100**

Source: Field survey data (2017)

A respondent provided a sample of her infested maize and reported that this was a recurring problem since the pest seems not to respond to the pesticides she uses. From observations the effect of infestation was immense.

Figure 2: Sample of infested maize

The findings were further confirmed by female discussants who narrated that:

> Our produce especially maize, which almost everyone grows and stores to provide food in the future, is infested by weevils. One of the weevils we call *"Osama"* (to denote how destructive it is) consumes everything and makes maize look like flour. We don't know whether it is the pesticide we buy from the local shops that is expired or what could be the cause.

To further elaborate on the causes of their loss a male FDG participant narrated thus,

> We experience loss both ways. To avoid loss by pest we opt to sell our maize. However, the buyers take advantage of this and lower the prices. They agree with each other and no matter where you go to sell the maize the price is the same. We also sell our maize to cater for our basic needs.

A key informant, an agricultural extension officer in Wikililye Location confirmed the foregoing by observing that majority of the farmers experience loss of cereals maize mainly because of infestation by weevils and pests. This is partly because of the types of storage and the pesticides they buy from local shops, which do not protect their produce. Some of the farmers cannot afford the pesticides and just store their cereal and this aggravates the magnitude of post-harvest cereal loss. Other farmers lack the knowledge on how to apply the pesticides and their cereals end up being infested.

The Director Kitui Development Center, a key informant confirmed the afore mentioned findings by indicating that irrespective of low production due to unfavorable climatic conditions and drought, the small produce the farmers get are lost due to pest infestation and failure to adopt change such as new ways of cereal storage. Thus farmers are forced to sell their cereals when prices are low occasioning economic loss.

4.3.2 Gender and Household Cereal Loss

Agricultural activities characterize Wikililye Location and are carried out by both men and women. Majority (58%) of the household respondents were women while (42%) were men as the finding indicated. This is not unusual given that men travel away from their home whether on short term or long term to find work while women remain behind to look after the home and work in the farm. The study sought to find out the influence of gender of the respondents on post-harvest cereal loss. The results are displayed in Table 4.3. Among households that did not experience post-harvest cereal loss, the percentage of male respondents was lower (34%) compared to that of female respondent at 39%, indicating that males experience lose more than females. The calculated chi-square statistic indicates that there was no significant association between gender and post-harvest cereal loss ($p=0.35$). The results indicate that a higher percentage of males (66%), compared to females (61%) experienced post-harvest cereal loss.

Table 2.3: Gender and household post-harvest cereal loss

Distribution by Gender	Frequency	Percent	Food Loss		No food loss	
			F	%	F	%
Male	145	42	95	66	50	34
Female	198	58	120	61	78	39
Total	**343**	**100**				

P > 0.05

Source: Field survey data (2017)

From Figure 4.3, more males than females in the household experienced post-harvest cereal loss. The findings from the analysis were confirmed by observations. From observation the number of male respondents was smaller because women were more available within the homes. It was also because of gender roles where many women are left at home as their husbands engage in other forms of work such as businesses. A female respondent who is a farmer confirmed the foregoing during a Focus Group;

> Most of our homes are managed by women. We are the ones who take care of our children and our homes. This is because many of our husbands carry out other activities to earn a living such as working in far places especially in towns and if not, they engage in small businesses in the town. Many others prefer casual work such as motorcycle riders or employment in construction sites other than farming.

During the data collection exercise, majority of the men were not present at their homes particularly during weekdays. Many of them were found at the local shopping centers at the *boda boda* sheds, and some were doing small businesses. However, the situation was different on weekends. During the data collection exercise some men would refer the researcher to women for information after explaining to them (men) the research interests. A male respondent during a Focus Group Discussion observed thus:

> Farming cannot provide and maintain our families and with production being interfered with by harsh weather conditions especially the lack of rains, which contribute to repeated massive losses, it makes many of us consider doing businesses and thus we go away from home and come back on weekends to be with our families.

Key Informants including administrative officers both the area chief and assistant chief, lend credence to the above findings when they indicated that women more than the men are involved in the farm and households activities and, therefore, their availability at home was not unexpected.

Despite statistical analysis indicating there was no significant association between gender and postharvest cereal loss, the male respondent households experienced post-harvest cereal loss to a higher extent than female respondent households. This was narrated by a female FGD participant thus,

> Major decisions are made by the male. Some of us even if we have information and knowledge from women groups about the better management and ways of reducing the losses, buying our men into the idea is never easy. Some do not see the need of adopting improved methods, which are expensive since there are cheaper means.

This indicates many respondents were female compared to male, and the rate of cereal losses was higher among the male respondent households. A female discussant had the following to say:

> Women, more than men are involved in agricultural activities including post-harvest management. Since we are left at home as our husbands look for other forms of employment, we have to take care of the little that we produce. Secondly, some of our men prefer staying at home doing nothing and some even steal our cereal and sell without our knowledge.

And a male FGD participant observed thus,

> Some activities such as post-harvest cereal management are considered the work of women. Men prefer tilling the land, planting and maybe weeding. But post-harvest activities' including protecting the cereals from pests and rodents is the work of women.

To further support the foregoing another male Focus Group Discussant narrated:

> Most of the information especially about post-harvest management of cereals and ways of dealing with losses are mostly learned in women associated activities especially in women groups. Very few men get the opportunity to learn about them and this might be the reason for the losses.

This was further confirmed through observations where most of the respondents who knew about improved methods of cereal storage were women compared to men. The women learnt about them in the women groups (*myethya*) where they were also provided with modern storage bags including hermetic bags and some of the women had already adopted use of the bags compared to the men who had little information about the bags and where to find them.

Two of the key informants, the Director of Kitui Development Center, a non-governmental organization dealing with farmers especially on cereal losses and post-harvest management practices and the area Agricultural Extension Officer further confirmed this finding by indicating that one way people deal with post-harvest loss is by use of hermetic bags. However, the chief noted that they conduct training programs especially to women groups where they teach them on the advantages and usage of hermetic bags. Further they buy the hermetic bags at a wholesale price and sell to the group members at a subsidized price. The chief further observed that women are more than men concerned with the food security of their households and so whenever they

organize a seminar to educate the community on agricultural activities, majority of those who attend are women.

4.3.3 Age of Respondents and Household Post-harvest Cereal Loss

The study sought to establish whether age of the respondents had influence on post-harvest loss of cereals. The results are displayed in Table 4.4.

Table 4.4: Age of respondent and household post-harvest cereal loss

Distribution by age	**Frequency**	**Percent**	**cereal Loss**		**No cereal loss**	
			F	**%**	**F**	**%**
Below 39	104	30	42	40	62	60
40-59	115	34	55	48	60	52
60 and above	124	36	73	59	51	41
Total	**343**	**100**				

$P < 0.05$

Source: Field survey data (2017)

Most of the respondents (36%) were of age 60years and above; respondents within the range of 40-59 years constituted 34% while those below 39 years constituted 30%. Results on the distribution of household post-harvest cereal loss by age indicated that respondents aged 60 years and above experienced more post-harvest cereal loss (59%). They were followed by age group 40-59 years at 48% while respondents aged 39 years and below experienced relatively less cereal loss (40%). The calculated chi-square statistics for the association between farmers' age and post-harvest cereal loss was significant ($p=0.02$).

Thus, the findings revealed that a majority of the respondents interviewed were old farmers. Majority of the older people get involved in farming, which is attributed to

many of them having retired from formal jobs and are involved in small scale farming. One 65years old man confirmed this by saying;

> Many of the people in this village are the older ones. Our children no longer live with us since many of them have moved to towns in search of employment. Those who do reside here casually involve themselves with farming, since they prefer other forms of livelihood and many are involved in casual labor such as construction work and *boda boda* riders. I have been involved in farming after retirement from the army.

The young people were also perceived as having negative attitude towards farming as a female discussant in one of the focus group discussion explained it,

> Farming in this area is the work of the poor, old, and uneducated individuals who do not have something else to do. My children believe this is the case and efforts to change their attitude have borne no fruits. I do not know whether its education, which influences them or what. Some of my children instead of farming prefer other forms of labor or leaving it to their wives even though they (my children) did not perform well in their education.

However, the study findings on the influence of age on post-harvest cereal loss indicated that the young experienced less amount of cereal loss compared to other age groups. There was a significant relationship between age and post-harvest cereal loss. The young people who are involved in farming are able to take measures to prevent cereal loss. A focus group discussant elaborated the foregoing,

> The young people are involved in other forms of earning money and therefore are able to purchase pesticides to protect their maize from pests. Majority of them work in towns and their families are here in the villages. Therefore, they buy the required pesticides as they come home on weekends. They also seem to be more informed on the best preventive measures

According to an Agricultural Extension Officer in the area as well as the director of KDC organization who were key informants, there is need to change the negative perceptions and attitudes of the youth towards farming. The young consider farming as work of the older people who are not educated, lack the necessary skills, and are physical laborers' with low economic returns. The negative perception toward persons involved in agriculture especially in the rural communities needs to be addressed so that all segments of the population can actively participate in agricultural activities. Employment, better living, eradication of hunger and poverty will be dealt with if the youth actively involve themselves with agriculture.

This is in line with the director of KDC, a non-governmental organization who observed that many of their projects were hindered by the fact that most of the rural majority were the old. Even though the farmers may have big pieces of land for cultivation, most of them utilize a small portion for growing crops. This is also evident during their training on cereal management practices; the elderly are used to the old methods of storage such as *utaa*, and find it difficult to adopt the new changes.

4.3.4 Education of Respondents and Household Post-harvest Loss of Cereals

The study sought to establish whether academic qualification of respondents had any impact on post-harvest loss of cereals. In view of this, respondents were asked to state their highest level of education. Their responses are shown in Table 4.5

Table 4.5: Post-harvest cereal loss by respondent's level of education

Distribution by level of education	Frequency	Percent	cereal Loss		No cereal loss	
			F	%	F	%
None	34	10	24	71	10	29
Primary	220	64	152	69	68	31
High school	64	19	32	50	32	50
Tertiary and above	25	7	7	28	18	72
Total	**343**	**100**				

P<0.05

Source: Field survey data (2017)

Findings of this study reveal that majority (64%) of the farmers had only attained primary school education, 19% had attained secondary school education while just over 7% had attained tertiary level. Ten percent of the population had not received any education. Field observation confirmed the findings about the low level of education, where many of the farmers could neither read nor write when the questionnaire were provided to them. According to results in Table 4.5, the association between education and post-harvest cereal loss was significant. The findings show that the level of education among respondents in Wikililye location is very low which may contribute to post-harvest cereal losses.

A discussant gave some insights regarding the large number of people with low level education thus,

> Despite education being termed as "key to success", many parents still do not consider it important. Others lack the resources to educate their children while others do not want to struggle paying school fees. More so,

> the majority of those who are educated look for alternative sources of income instead of farming; others migrate to towns. They leave the older farmer's majority of whom are not educated (Male FGD participant).

The study findings indicated that the rate of cereal loss increased with decreased level of education. Majority (72%) of the respondents who had attained tertiary level of education experienced reduced post-harvest cereal loss while those with high school level education had 50% post-harvest cereal loss. Those who had attained primary education or had no education at all experienced high rates of loss at 69% and 71% respectively.

Another male FGD participant gave credence to the foregoing,

> Many of the farmers are older and have little education with some of us having no form of education. The young people who involve themselves in agriculture are those who did not do well in education and have to stay at home, many of whom are young females who are married and left back at home as their husband look for other forms of employment. Individuals who are educated rarely remain here in the village but move to towns in search of formal employment.

A female Focus Group Discussant elaborated more on the academic qualification. According to her most of the farmers were not educated since the educated individuals move to towns for employment. Those who reside in the villages and are educated are the retired or those who combine both farming and working, for example, secondary and primary schools teachers.

The study established that even though people in Wikililye engage in agriculture as a source of livelihood, they lack the knowledge and skills of production as well as post-harvest management. The farmers lack the knowhow, which increases the post-harvest

cereal loss. This was well illustrated by a narrative from a retired government officer who is now a farmer, thus;

> Majority of the farmers in the area are reluctant to adopt change. I know that in order to prevent post-harvest losses of my cereals, I have to take preventive measures which are current since many pests are becoming resistant to pesticides. I utilize the hermetic storage bags which prevent my cereals from being infested and later sell when prices are high.

Conversely, the rate of loss of post-harvest cereals decreased with increased level of education. This was explained by a key informant when he observed,

> The challenge we mostly experience is lack of education by the farmers. Many of farmers are used to old ways of doing things and changing their perception is hard. However, those who are educated are open to new ways and are eager to try and experience other ways. This enables them to preserve their cereals better and avoid loss (Agricultural Extension Officer).

Both the director KDC and extension officer indicated that the farmers who are not educated do not attend *barazas*, seminars and post-harvest training. The less educated are also so dependant and if the seminar does not provide any form of incentive or payment they never attend. However, the members of Focus Group Discussions denied to this by indicating that they do not receive such trainings. Some reported that they do not even know the location extension officers office is, or work station.

Observations in the field revealed that respondents with secondary education and above had well-constructed granaries and a number of the respondents were actually using improved storage methods especially hermetic bags. They had knowledge and understood the post-harvest activities and were able to explain in details how to deal with post-harvest cereal losses.

4.3.5 Marketing of Cereals Influence on Post-harvest Cereal Loss

The influence of marketing of cereals on post-harvest loss was assessed. The results are presented in Table 4.6.

Table 4.6: Marketing of cereals and household cereal loss

Distribution by selling of cereals	**Frequency**	**Percent**	**Cereal Loss**		**No cereal loss**	
			F	**%**	**F**	**%**
Sell	128	37	87	68	41	32
Don't sell	215	63	128	60	87	40
Total	**343**	100				

P<0.05

Source: Field survey data (2017)

The result indicated that majority of the households (63%) do not sell their cereals. This is so because most of them are small scale farmers who produce small amounts on their small farms. However, despite that a number of respondents 37% reported that they do market their cereals for various reasons. A male discussant elaborated this by narrating:

> Many of the farmers here have small farms and even those with large farms utilize a small part for farming. This is because of inadequate rains where we lose our crops before we even harvest. As a result, production is low and nothing is left for the market. However, some of the farmers do sell some of the cereals they produced. This is mainly because of economic and other social needs including payment of school fees.

However, other informants had a different view as to why the farmers sold their cereals.

> Some of the farmers sell their produce even when yields are high. This is because the storage facilities are not sufficient especially in terms of size. Many of the times when we produce more, more cereals tends to be lost due infestation by pest

> which is a challenge to many of us farmers and thus we opt to sell (Female FGD participant).

Results indicate that those who sold their produce experienced more cereal loss (68%), while those who did not market their cereals experiencing less loss (60%). There were a few households who sold their cereal produce but were the most affected by cereal loss. The marketing of cereals of the respondents was cross tabulated. Results reported in Table 4.6 indicate the association between marketing of cereals of the respondents and the extent post-harvest cereal loss. The results confirm a significant association between the two variables of ($p=0.03$). The findings of this study suggest that farmers may sell their cereals to avoid loss through poor storage methods. A focus group participant explained thus,

> Whenever we sell our cereals the prices are very low sometimes as low as 15shillings a kilogram of maize. We then buy later at very high prices. Since we depend on farming, we have no alternative but to sell to cater for our basic needs especially school fees for our children (Male FGD discussant).

A female discussant gave insight into the foregoing,

> The shopkeepers are very hard on us. It is as if they agree with each other on the prices to buy. This is because whenever I want to sell my maize the prices are constant. Even if I travel from my home village to another village town center the prices are fixed. This happens a lot immediately after harvest and since I need the money, I end up selling at throw away prices.

The area administration officer elaborated on the findings. He observed that some of the farmers do sell their cereals mostly during high production and also to meet their social and economic needs. Many of those rely on farming as a source of livelihood and have to cater for their needs including school fees for their children and, therefore, are forced to

sell at low prices. The area agricultural extension officer added that some sells their cereals for entertainment purposes, for example, to buy alcohol.

Some of the key informants noted that the farmers lack collective bargaining power for better prices. To deal with this challenge a collective or communal storage system was built at Kyambiti Location in Mulango Ward, which was aimed at storing produce for farmers. This was intended to give the farmers a collective bargaining power to be able to sell their produce at higher prices. However, the communal storage system was faced with challenges and is no longer in use. The challenges were mainly economic and low production. The director KDC narrated,

> Many of the farmers' yields are low with some of them having nothing to store for long. Secondly, the farmers rely on maize produce for their basic needs such as school fees, and entertainment. Therefore, the farmers cannot store maize when their children are at home due to school fees as well as other needs.

4.3.6: Source of Livelihood and Household Post-harvest Cereal loss

The influence of households' source of livelihood was assessed. Results are presented in table 4.7 and reflect multiple responses. The results show that the main source of livelihood for the majority (70%) of households was farming. A significant number of households (30%) derived their livelihood from combined sources including nonfarm and formal sources together with farming. Majority of the households (65%) obtaining alternative source of livelihood from formal employment and nonfarm activities experienced reduced cereal loss (65%) compared to those who solely depend on farming as a source of livelihood (67%). However, the results of cross tabulation reveal that there is no significant association between alternative source of income and post-harvest cereal loss.

Table 4.7: Sources of livelihood and household post-harvest cereal loss

Distribution by source of income	Frequency	Percent	Cereal Loss		No cereal loss	
			F	%	F	%
Farming	343	70	229	67	114	33
Non-farm and formal sources	150	30	97	65	53	35
Total	**493**	100				

p>0.5

Source: Field survey data (2017)

The results demonstrate that alternative source of livelihood apart from farming influenced post-harvest cereal loss though not in a significant way. The few households who had alternative source of livelihood either formal employment and nonfarm activities experienced reduced post-harvest cereal loss. This was thus explained by a focus group discussant,

> Other sources of livelihood help in dealing with post-harvest cereal loss. The household head can invest in better storage facilities be able to utilize more effective pesticides since he/she can purchase them. But for the majority of us who depend on farming for everything, losses are inevitable (Male FGD discussant).

To further elaborate on this, another discussant had these to say,

> Those with alternative source of livelihood rarely experience the challenges of post-harvest cereal loss. With the ability to effectively store their cereal produce, they are able to sell when the prices are high and thus economic gains. They are also in a position to purchase and cater for their basic needs and are not forced to

sell immediately after harvest a situation most of us who depend only on farming have to endure.

The above observation confirms that majority of the respondents relied on farming for their livelihood. Both the agricultural extension officer and director KDC confirmed the aforementioned by indicating that since the area is rural, majority of the households depend on farming for their livelihood, and since it is not so effective due to other factors, farmers experience post-harvest cereal loss which aggravate the food insecurity situation in the area.

Observations confirmed utilization of improved storage systems especially hermetic bags by the households whose source of livelihood came from both nonfarm activities and formal employment.

4.4: Perception of Environmental Influences on Household Post-harvest Cereal Loss

In order to determine whether environment had an influence on post-harvest loss of cereals respondents were asked whether they experienced any form of environmental change that affected their maize production. This includes changes in the pattern of rain season during harvesting and drying and presence of moisture in the maize, which could favour growth of moulds during storage. To further understand this, farmers were asked whether they had experienced attack of their maize by aflatoxins (*mbuka*). This would provide information on their perception of environmental factors influence on cereal loss. The results are presented in table 4.8. The findings indicated that majority (96%) of the respondents perceived not to experience environmental changes in the area that influenced post-harvest cereal loss while only a few (4%) reported that their cereals were attacked by afflatoxin.

Table 4.8: Environmental influence on household post-harvest cereal loss

Distribution by environmental factor	Frequency	Percent	Cereal Loss		No cereal loss	
			F	%	F	%
Yes	13	4	9	69	4	31
No	330	96	206	62	124	38
Total	**343**	100				

Source: Field survey data (2017)

The study further sought to establish the perception of farmers on influence of the environment on households post-harvest cereal loss. The findings of the study indicated that 38% of the respondents who said they did not experience any environmental change did not experience post-harvest cereal loss. A significant number (31%) of the respondents did not experience cereal loss despite indicating that there were environmental changes that influenced post-harvest activities. This show that majority of the households among those who had observed environmental change were significantly affected by the change since 69% of the respondents said they experienced post-harvest losses.

Overall the findings indicate that only a small percent of the respondents (4%) reported that there were environmental changes, which may have contributed to post-harvest cereal losses. This was narrated by a discussant,

> The environmental changes that affect us are low rainfall and recurrent draught. Post-harvest cereals drying rely on the sun. This area is almost always sunny and thus our activities during post-harvest, in order to avoid *mbuka* are not affected. It may sometimes rain but not for long to a point where we face challenges. Majority of the farmers understand that one has to completely dry the cereals before storing (female FGD discussant).

However, from the findings it is evident that those who reported environmental changes also reported a higher post-harvest cereal loss. The area agricultural extension officer, observed that many farmers do not understand how weather contributes to post-harvest cereal losses. He noted that pests like large grain borer (LGB) thrive in high temperatures. Some farmers also store their produce in polythene bags, which may encourage growth of moulds.

The agricultural extension officer, director KDC and the local administrative officers in collaboration provide extension services, *barazas* (public meetings), and seminars to advise farmers on the best farming and measures to increase production. They also provide guidance on the best post-harvest management strategies in order to reduce post-harvest losses. This would eventually curb hunger and food insecurity.

From direct observation farmers relied on sun drying to dry their cereals as shown in figure 2

Figure 3: Sample of drying cereals by sun

4.5: Influence of Post-harvest Management Strategies on Post-harvest Cereal Loss

To demonstrate the influence of post-harvest management strategies on household post-harvest cereal loss, both type of storage systems currently utilized and awareness of improved storage system were assessed.

4.5.1: Type of Storage Facilities Currently Used and Household Post-harvest Cereal Loss

The researcher was interested in knowing the type of storage facilities the respondents were currently using. In view of this, respondents were asked the type of maize storage facilities that they were currently using. Multiple responses were provided by respondents as illustrated in Table 4.9. The findings indicate that majority (72%) of the respondents utilized gunny bags while a small percentage (15%) used sisal sacks as the form of storage. Respondents who had adopted to improved storage facilities, hermetic bags were few (7%). It was also noted that (6%) of the respondents used other forms of storage mainly *utaa* or never used any form of storage systems because they produced and immediately consumed all the produce through direct consumption and/ or sale. It is evident from the findings of the study that majority of the farmers in Wikililye still use the traditional systems of storing maize.

Table 4.9: Current form of storage and post-harvest cereal loss

Distribution by storage system used	Frequency	Percent	cereal Loss		No cereal loss	
			F	%	F	%
Gunny bags	251	72	166	66	85	34
Sisal sacks	53	15	43	81	10	19
Improved storage bags	25	7	3	12	22	88
Others including *Utaa*	22	6	8	36	14	64
Total	**351**	**100**				

$p<0.05$

Source: Field survey data (2017)

From the findings it is evident that majority of the respondents farmers are still dependent on traditional storage methods. One male FGD participant described this thus,

> We use a section of our house as our stores. Majority of us depend on gunny sacks to store in our produce. This is because we lack resources to purchase other means of storage and we lack space to build granaries and use modern methods of storage. The little we have is for buying local pesticides and the gunny sacks which are more affordable.

In another FGD, a female discussant reported that the amount of production was low thus the reason for the use of the storage method. This shows the amount of cereals produced has a bearing on the type of storage farmer's use. She observed that,

> The amount of produce is not that much. The little we produce is for consumption and we do not store for longer periods, thus no need of big granaries or expensive mode of storage. We just store in gunny bags and *utaani*.

It is evident from the findings that the mode of storage contributes to post-harvest cereal losses. Results from calculated chi-square confirm a significant association between the mode of storage and post-harvest cereal loss. Although the farmers reported using pesticides to protect their maize from infestation, losses were still reported to be a challenge. Those who utilized gunny bags and sisal sacks were more prone to post-harvest cereal losses at 66% and 81% respectively. The other modes of storage mainly *utaa* were also prone to post-harvest losses with 36% of the respondents reporting loss. The households who utilized improved form of storage, majority (88%) experienced no post-harvest cereal losses. This finding was reinforced by the findings from focus group discussions as shown in the excerpt below,

> I have utilized gunny bags, sisal sacks and the hermetic bags. During the period I used gunny bags and sisal sacks my maize was infested a lot by pests even after using the pesticides. However since I started using the hermetic bags my maize is not affected at all and am able to store for longer periods to provide food for my family and also sell at peak periods. Actually buyers look for me to buy (male FGD discussant)

A key informant reported that failure to adopt change and lack of knowledge played a role when forms of storage are put into perspective. She narrated that,

> Poor management practices contribute to loss of cereals. A number of farmers are resistant to change. This is a major challenge especially when the farmers involved are the aged. A case in point is the continued use of outdated mode of storage such as *utaa* which is not always effective. A current emerging issue is where the farmers are building cemented houses and setting aside a place inside the house for storage. This portion does not meet the standard of a good storage facility.

Through observation it was evident that many respondents used a section of their houses to store their cereals. The respondents use gunny sacks to store their produce. Others utilized *utaa*. These forms of storage were not effective enough to protect the farmers maize from post-harvest loss. Figure 3, which depicts gunny bags in the house and *utaa* confirms the foregoing,

Figure 4: Gunny bags in a section of the house and *utaa*

4.5.2 Awareness of the Influence of Improved forms of Storage on Post-harvest Cereal Loss

Knowledge of the improved forms of storage was considered relevant in household post-harvest cereal loss. The results of the influence of knowledge of improved forms of storage are presented in table 4.10. The findings indicate that majority (77%) of the respondents were aware of the modern methods of storing maize especially hermetic bags, in order to avoid post-harvest loss. Only a few (23%) were not aware of the modern methods of cereal storage. The results further show that a significant number (65%) of the households that had knowledge of the improved methods experienced post-

harvest loss, which was a bit higher than those who had no knowledge and experienced post-harvest loss (54%). The results of cross tabulation reveal that there is no significant association between knowledge of improved methods of storage on post-harvest cereal loss (p=0.08)

Table 4.103: Awareness of improved storage system and household post-harvest cereal loss

Distribution by awareness of improved storage system	**Frequency**	**Percent**	**Cereal Loss**		**No cereal loss**	
			F	**%**	**F**	**%**
Yes	264	77	172	65	92	35
No	79	23	43	54	36	46
Total	**343**	**100**				

p>0.05

Source: Field survey data (2017)

The findings are inconsistent with what would be expected for households with knowledge of improved methods of storage since a higher percentage of those aware were found to experience post-harvest cereal loss. Reasons given to explain the lack of positive effect of awareness of better storage practices from FGDs and key informant interviews are inability to purchase hermetic bags low purchasing and lack of availability of these modern forms of storage. A discussant stated that majority of the farmers have had from the radio about modern forms of storage they did not know where to get them. The local shops and also those in Kitui town did not stock them.

A female focus group discussant narrated,

> I have learnt about the hermetic bags from a women group I am a member. Yes I agree it is a good method but the prices are too high for many for us. They sell to us at 250sh per 50kgs bag which is way too expensive since I buy the gunny bag at 30sh.

These sentiments were echoed by the location chief and assistant chief who observed that the farmers could not afford to purchase the hermetic bags since majority of them live from hand to mouth due to poverty and food insecurity.

The agricultural extension officer, however, indicated that the prices were fair and affordable. This was in comparison to the post-harvest losses incurred by the farmers. One mode of storage that failed is the metal silos, which were not utilized due to the initial cost, which was high for the farmers and also considering the usually poor harvest. However, hermetic bags are affordable and failure to use them could be due to the farmers lack of knowledge coupled with poverty and the fear of the unknown. The director KDC, indicated that they had invested and built a communal storage facility in neighboring location kyambiti. This was aimed at dealing with post-harvest cereal loss. The communal storage was faced with challenges mainly economic. The farmers could not store cereals in the warehouse since the cereals were a source of income and needed to sell in times of need. However, the KDC director was in agreement with the area extension officer that inadequate knowledge was the main reason why the farmers had not utilized improved storage methods.

From the foregoing discussion, awareness of improved forms of storage did not benefit the local farmers either because of economic constrains or inadequate knowledge regarding the modern storage facilities and thus fail to contribute towards reducing post-harvest cereal loss. Field observations revealed that only a few of respondents had adopted to the use of improved storage bags despite majority indicating they were aware of them.

4.5.3: Adoption of Improved Forms of Storage and Post-harvest Loss of Cereals

The adoption of modern methods of storage and its contribution to post-harvest cereal loss was assessed. Results on the utilization of improved methods are presented in table 4.11. In a majority of the households (92%), they had not adopted improved methods of storage only a small number (8%) of the household utilize modern methods of cereal storage. The findings further indicate that a significant number of respondents (76%) who utilized improved methods did not experience post-harvest cereal losses compared to (34%) of the respondents who had not adopted modern forms of storage. However, the results of cross tabulation reveal that there is no significant association between adoption of improved storage facilities and post-harvest cereal loss.

Table 4.114: Adoption of improved storage and household post-harvest cereal loss

Distribution by adoption of improved storage system	**Frequency**	**Percent**	**cereal Loss**		**No cereal loss**	
			F	**%**	**F**	**%**
Yes	29	8	7	24	22	76
No	314	92	208	66	106	34
Total	**343**	**100**				

$p>0.05$

Source: Field survey data (2017)

The results demonstrate that improved storage facilities still influenced post-harvest cereal loss albeit insignificant. This can be explained by the small intake rate of improved storage facilities. Adoption reduced post-harvest cereal loss. A female discussant observed that since she learnt about the improved storage methods from women group she attended and used the hermetic bags there was no turning back.

> The problem of post-harvest losses was a gone problem. The maize is protected for a long period and the best part of it is because I do not have to use the

pesticides which are not long lasting and one has to repeat now and then. I just dry the maize and store.

This narrative showed that the utilization of modern methods improve the household livelihood and food security.

A male FGD discussant explained that since he began using hermetic bags his maize business became better. He observed "I do not have to sell when the prices are low. I also do not have to keep on repeating the process of preventing cereals from infestation thus I am able to carry out other activities". The director KDC and the extension officer who were both key informants reported that farmers who had used modern methods of storage did not experience losses. The two received reports from *barazas* seminars and extension trainings which they carry out to educate the farmers on post-harvest management strategies.

Observations showed that households that utilized improved method of storage had cereal reserves which were not in any way affected. This suggests that improved method of storage plays a vital role in reducing post-harvest loss thus curbing hunger, poverty, and food insecurity.

Figure 5: Sample of uninfected maize stored in a hermetic bag

CHAPTER 5

5.0 DISCUSSION, CONCLUSION AND RECOMMENDATIONS

5.1 Discussion of Findings

The chapter discusses findings on the factors influencing households post-harvest cereal loss. They include demographic and socio-economic factors which are gender, age, level of education, alternative sources of livelihood and marketing of cereals. Environmental factors and post-harvest management strategies which include mode of storage currently utilized, knowledge of improved methods, and adoption of modern methods of storage and their influence on post-harvest cereal loss are also discussed.

5.1.1 Socio-economic Factors and Household Post-harvest Cereal Loss

This section is in line with the first objective of the study which sought to assess the influence of socio-economic factors on household post-harvest cereal loss.

5.1.1.1 Post-harvest Cereal Loss Status in Wikililye Location

Analysis of the household post-harvest cereal loss (maize) in the area of study indicated that a majority of the households (63%) experienced some form of post-harvest cereal loss while (37%) reported that they did not experience post-harvest cereal loss. Many households sell their produce immediately after harvest at very low prices. The effect of pest on stored cereals was confirmed through direct observations where maize was largely infested by pests such as *osama* and weevils. Farmers indicated this was a major challenge. Poor traditional methods of storage were also evident, which further increased post-harvest cereal losses. This concurs with earlier studies by De Lima (1987) in Kenya who identified insects and rodents as the main causes of post-harvest losses in durable crops. The study also concurs with Gabriel and Hundie (2006) who found out that majority of the farmers (93.3%) perceived an imminent risk of grain lose due to attack by storage pest and/or other factors if they stored their crops for longer period of time.

As already indicated cereal infestation by pest was a major cause of post-harvest losses. The findings are in agreement with the World Bank, FAO, and NRI (2011) report in eastern Africa including Kenya, which indicated that 63% of the total post-harvest cereal losses by smallholders farm households are due to storage-related issues including lack of storage, infestation by pest and poor quality storage technologies. The findings further concurs with a study by Mihale et al. (2009) who reported that insects are responsible for between 10-60 % of the post-harvest losses of grains in developing countries. Other causes included pesticide failure, poor storage systems and high cost of buying both the pesticides and means of storage, and presence of moulds in their produce. The findings of this study closely correspond to those of ANSAF (2016), in Tanzania which showed that 5.8% of the respondents reported moisture, 10.8% reported fake chemicals and 58.9% indicated higher prices of storage pesticides as major causes of post-harvest cereal loss.

5.1.1.2 Gender and Household Post-harvest Cereal Loss

The gender of the household respondent is an important factor in determining household food security because it has an impact on decision making, roles or activities assigned to each gender on farm activities and operations, on who controls and takes care of produced food, which in turn plays a major role in influencing post-harvest cereal losses. The findings of the study showed that 58% of the respondents were females while (42%) were male. This does not concur with the findings of ANSAF(2016) in Dadoma and Manyara Districts in Tanzania which findings indicated that (57.5%) of the respondents surveyed were female. Similarly study conducted by Mondiale (2011) revealed that women make up some 55-80% of agricultural labor force in Sub-Saharan Africa.

From findings of the current study it is evident that majority of the household respondents were female a scenario not typical in most rural areas in Kenya. Male headed households account for up to 70% while only 30% of households are headed by female according to KNBS (2007). The varying incidence of male household heads in the study area as

compared to the national proportion was explained by the fact that many male heads had left the villages for the urban areas to look for employment opportunities in order to provide for their families. This explanation compares favorably with that of FAO (2003) in sub Saharan Africa, where it was noted that women were found in the homes where the males move to the cities to look for employment. This explains why majority of the respondents in the study area were females.

Albeit statistical analysis indicating no significant association between gender and cereal loss, raw data indicate gender of the household respondents had an impact on post-harvest cereal loss since more males than females experienced loss. The findings indicated that 39% of female interviewed reported they did not experience post-harvest cereal loss compared to male respondent households (34%) who reported no loss. These findings concur with a study of post-harvest loss perceptions from surveys on living standards in Malawi, Tanzania and Uganda by Kaminski and Christiaensen (2014) who found out that households females respondents experienced lower post-harvest cereal losses. The lower post-harvest losses reported in female respondent households in the study area was attributed to the social cultural role of women as the ones who are in charge of food and cereal harvest and post-harvest activities. They are better equipped with information regarding post-harvest management activities; they learn from women groups in the study area. The higher percentage of post-harvest cereal loss situation for male respondents households was due to lack of important information regarding post-harvest activities: men are less involved in these activities. In Wikililye Location, education and information about post-harvest cereal management and prevention of loss is provided mainly in women groups. It is also women who largely benefit from subsidized hermetic bags, the modern storage bags, which preserve cereals better and keep cereal borers away.

Various studies indicate that female farmers are more likely to embrace and adopt changes, which reduce post-harvest loss of their produce and thus improve their

livelihoods (Bayard et al., 2007; Dolisca et al., 2006; Mzoughi, 2011; Newmark et al., 1993). Other studies, however, arrived at different findings. For example (Kereth et al., 2013; Rugumamu, 2012) in their studies in Tanzania found that women contribute to cereal losses in that they do not have adequate information on proper crop harvesting and handling techniques resulting in significant damage by insect pests during storage and marketing. In the current study, women more than men, were likely to acquire new knowledge on crop preservation through women groups and *barazas*.

Drawing on the diffusion theory Rodgers (2005), argues that there are many qualities in different people that cause them to accept or not to accept an innovation. In his five steps or stages to the process of adopting an innovation, the first stage is knowledge, in which an individual have to become aware of an innovation in order to adopt. The second stage is persuasion where individual after gaining knowledge has to be convinced to adopt. Decision comes next followed by implementation and finally confirmation. The situation in Wikililye Location is that men lack the knowledge and information of the improved methods to adopt hence experiencing more post-harvest cereal loss compared to the females. With lack of knowledge all others stages cannot be implemented.

5.1.1.3 Age of Respondents and Household Post-harvest Cereal Loss

The age of the household respondent was considered an important factor influencing post-harvest loss of cereals since it influenced farm activities and the likelihood of adoption of improved modern methods of post-harvest losses control. Findings of this study indicated that most of the households respondents (36%) in the study area were aged 60years and above, followed by informants between 40-59years (34%). The least number of respondents (30%) were below 39years old.

The age distribution shows that young people (age 39 and below) are few (30%) suggesting not many young people are venturing into farming. Many of the youths have migrated to urban areas in search of employment while the older people come back after

retirement. Kinsella (2001) found out that the overarching reason for rural population aging is the age-selective nature of rural-urban migration, whereby younger people migrate to the towns and cities leaving behind older people. Another contributor is the return migration of older adults from urban cities back to their rural homes due to among other reasons retirement. The results of the current study concur with a study in Tanzania by ANSAF (2016) which showed that the lowest percentage (28%) of the sample in the study area were age 35 and below. The results also support the study by Ekong (2003) which concluded that farming in sub Saharan Africa (SSA) including Kenya, is dominated by older farmers especially between ages 41-50 years. The study in Wikililye revealed that the involvement of the young population in agriculture was very minimal mainly due to young people's negative attitude towards agriculture as a whole, and inadequate or lack of policies that make agriculture more attractive to the young and educated. The older have negative perceptions and attitudes towards any effort to bring change. The young farmers who are also more educated are more receptive to new ideas and embrace and adopt new technologies. It is thus necessary and much easier to positively influence young people to use modern agricultural technologies in order to improve agriculture especially production and management of cereals to curb loss.

Majority (59%) of the respondents above 60 years experienced higher post-harvest cereal loss. Respondents within age group 40-59 years (48%) followed while respondents below 39 years experienced the least post-harvest cereal loss (40%). The comparatively reduced post-harvest cereal loss among the younger respondents households is attributed to their ability to adopt new changes and innovative forms of cereal storage as well as their economic ability to purchase the best preventive measures since they are able to diversify their sources of income. The young people are also more educated and are updated of the best practices to control and reduce post-harvest cereal loss. The majority of the small holder farmers in Wikililye location are old and use traditional ways of farming and cereals management, are reluctant to adopt new innovations and

technologies. Advanced age may, therefore, contribute to households post-harvest cereal loss hence food insecurity.

Findings of this study are in consistent with studies by Savadogo et al. (1998) in Burkina Faso who found age to influence agricultural activities especially embracing new technologies, which are meant to reduce loss of cereals and improve agriculture as a whole to deal with hunger and food insecurity. The old are conservative and tend to avoid risks, are reluctant to try out new technologies and innovations. Thus they rather stick to the traditional way of doing farming, which may contribute to the amount of cereal loss. The young, on the other hand, are receptive to new ideas and are energetic and readily adopt modern methods of farming and technologies to reduce loss of cereals.

According to Rogers (2005) theory of adoption to innovation, all stages of adoption are influenced by age. Knowledge, persuasion, decision making, implementation and confirmation depend on the age of the adopter. Although according to Greeley (1982) traditional post-harvest systems tend to be fairly efficient he also attest to the fact that change negatively affects these systems. It is evident that contemporary production and consumption patterns have changed and this has rendered traditional systems inadequate. The older people lack the modern knowledge, are reluctant to take risks and refuse to be persuaded about the advantages of embracing change and this influences their decision making on adoption of new innovations. On Rogers's categories of adopters, the older are classified as laggards who are bound by tradition and are very conservative. They are very skeptical of change and are the hardest group to motivate to adopt innovations. They are more so resistance towards innovations and are risk averse. In Wikililye Location, the trend of the old being resistant to change still persists, which may result in increased post-harvest cereal loss.

5.1.1.4 Education and Household Post-harvest Cereal Loss

Education is an important variable because it improves an individual's ability to make informed decisions and choices. It has the potential to influence or hinder the acceptance of improved storage technologies such as metal silos and hermetic bags. Education facilitates farmers adoption of innovations Okoedo-Okojie et al. (2009). Findings of the current study show that majority (64%) of the respondents had attained primary education and (19%) secondary education and a significant number of respondents (10%) had no formal education. A small percentage (7%) had post secondary education. A study done in Kenya by CIMMYT (1993) reported similar findings that majority of the farmers had primary school education and relied on traditional farming practices. Formal education is important since it increases household ability to make informed decisions and adoption of new innovations or behaviors. In addition, the process of information flow is catalyzed by education, which enables an individual to explore, as wide as possible, different pathways of getting information about best agricultural practices (Ersado, 2006).

From the current study majority of the respondents that had attained secondary level of education and post secondary education reported lower post-harvest losses of cereals compared to those with no education or had primary level at 72% and 50% respectively. Thus the findings suggest that education plays a significant role in post-harvest cereal management. These findings are at variance with the findings of a similar study in Kenya by Ognakossan et al. (2016) who observe that the level of education does not influence post-harvest maize losses. However, similar surveys in Malawi, Tanzania and Uganda by Kaminski and Christiaensen (2014) reported that in households where the household respondent had a post primary education, they were perceived to have lower magnitude of post-harvest losses. The current study findings further concur with the findings of Basavaraja et al. (2007) in Karnataka, India who found out that education of farmers significantly influence the post-harvest losses of grains at farm level.

Higher education acted as a catalyst for farmers in Wikililye to adopt improved methods of post-harvest management. These farmers were able to make informed decisions, involved themselves in other forms of economic activities, and were able to use skills to reduce post-harvest loss of cereals. These findings support those of a study by Odia (2017) in Nigeria who found out that increased agricultural productivity as well as reduced post-harvest losses depend primarily on the education of the rural farmers to understand and accept the complex and scientific changes, which are difficult for the uneducated rural farmer to understand. The findings of the present study are also consistent with previous studies by Kumar and Kalita (2017a) who found out that lack of knowledge contributes to a significant amount of cereal loss during the post-harvest activities particularly in the developing countries.

The current study support Rogers (2015) diffusion theory where the first three stages, which include knowledge, persuasion and decision making are considered important in the adoption of new technologies of post-harvest crop management. Individuals with higher levels of education are able to acquire knowledge from different sources, for example newspaper, radios and extension officers but are also able to understand and apply the new knowledge. Those with education are also open to changes, easy to persuade and, therefore make informed decisions. Based on the categories of adoption of innovation, education is of imperative. Individuals with some level of education are classified as innovators, early adopters and to an extent early majority. The higher the level of education the more the likelihood that an individual adopts to an innovation.

5.1.1.5 Marketing of Cereals and Household Post-harvest Cereal Loss

The study further sought to determine whether marketing of cereals influenced post-harvest cereal loss. The findings indicated that majority of the respondents (63%) did not market their cereals. In Wikililye Location majority of the people are small scale farmers many of who have small farms (about 2 hectares) on which they practice mixed farming and, which produce little that can barely sustain the households from one harvest to the

next. Not much cereals is, therefore, left for the market. Similar findings obtained in a study in the larger Kitui by Recha et al. (2013) who reported that the average farm size among the households in Kitui is 2 hectares. The findings further concur with a study by Gabriel and Hundie (2006) in Ethiopia where more than one-half of total cereal production does not reach market place, it is consumed within the farm households. However, the foregoing not withstanding a small proportion in Wikililye (37%) sold their produce to meet mainly their basic socio economic needs such as school fees, and daily expenditure. Some of the farmers sold their cereals immediately after harvest in order to avoid losses due to infestation by pests. These findings concur with Tefera and Abass (2012) study in Dadoma Tanzania where 60% of the production by farmers is sold within the same month of harvesting. This contributes to the nearly perpetual food insecurity situation of farmers.

Results on the influence of marketing cereals on households post-harvest cereal loss indicated that households that sold their produce reported higher percentage of post-harvest loss (68%) than households who did not sell their harvest (60%). From the focus group discussions and key informant interviews, it was revealed that many farmers sold their produce immediately after harvest and when the prices are low thus experiencing economic loss. The study findings are in line with the findings of Kaminski and Christiaensen (2014) in East Africa who observed that when it comes to marketing versus auto-consumption, losses appear higher when a larger share of the maize harvested is marketed. In Dadoma and Manyara of Central and Northern Tanzania Abass et al. (2014) observe that three factors were the key reasons that compelled the farmers to sell their cereals soon after harvest. These were household expenditure need, cash needs for school fees and perception of surplus produce above storage capability. This further confirms the observation by Stathers et al. (2013) that farmers sell their cereal produce due to financial needs. Similarly Tefera et al. (2011b) earlier hinted that the smallholder farmers practice of selling their farm produce immediately after harvesting only to buy the stocks back at an expensive price just a few months after harvesting constitutes a

pathway to poverty, hunger and food insecurity. The implication of sale of cereals soon after harvest is that farmers miss the opportunity to increase their revenue from sale of their produce resulting from good prices if they stored them for a longer period. Thus storing the produce until when the market prices are much higher provides an important income opportunity to small holder farmers and can contribute to reduction of poverty and hunger and increase food security.

The current study is supported by Rogers (2005) diffusion of innovation theory captured well in the third stage of the theory (decision making) where individuals make decisions irrespective of the implication the decision has on post-harvest cereal loss. Individual households make decisions to market their produce in order to meet the household expenditure needs such as cash for school fees or even for leisure including money for alcohol. This contributes to post-harvest cereal loss because they sell immediately after harvest at throw away prices.

5.1.1.6 Alternative Source of Income and Household Post-harvest Cereal Loss

The respondents' alternative sources of income were explored in the study. The findings show that the main source of income for the majority of people in Wikililye Location (70%) was farming. Others in addition to farming were involved in non-farm and formal employment and combined they account for (30%). These sources of income include, among others, casual labour, small businesses, *bodaboda* riders (motorcycle riders) and construction work. Farming was reported as the main source of income of the households in Wikililye. The current study findings are comparable to those of the County Government of Kitui (2013) which indicated that the majority of residents derive their incomes from farming. The County Government estimates that more than 87% of the population in the County depends on farming.

In the Wikililye study although statistical analysis indicating no significant association between alternative income and cereal loss, majority of the households (65%) with

alternative source of livelihood such as formal employment and nonfarm activities experienced slightly lower cereal loss (65%) compared to those who solely depended on farming as a source of livelihood (67%). Those with other sources, other than farming, have the ability to purchase better storage structures/facilities and can market their cereals when the prices are high since they are able to curb losses. These households were able to purchase quality seeds, which improved their production; the quality seeds were more resistant to pest infestation. Some had cereal reserves, which they planned to sell when the prices improved. This was unlike the households solely depending on farming most of which did not even have any cereal reserves in the store or *utaa* but relied on small purchases from the local shops and markets. This shows that farming is the main source of livelihood. However, it is not enough to sustain the needs of the households in Wikililye location. With post-harvest cereal loss aggravating the situation, food insecurity is inevitable.

To a small extent, the study findings are at variance with those of Kaminski and Christiaensen (2014) in Malawi, Uganda and Tanzania who reported that household wealth status had no influence on post-harvest cereal loss. They found out that poverty was not found to be associated with the degree of post-harvest loss. The findings are however, consistent with the findings of ANSAF (2016) in a study in Tanzania who noted that alternative income and labor availability beyond production were among the factors that facilitated the utilization of improved storage structures due to ability to purchase them and thus reduced post-harvest loss.

The current study is supported by Rogers (2005) adoption to innovation theory in which economic liquidity influence the rate at which individual adopts to an innovation. Individuals with the economic liquidity are classified and early adopters and innovators while individuals without financial ability are classified as laggards. The economic ability influences the rate at which an individuals adopts to an innovation.

5.1.2 Perception of Farmers on Environmental Factors Impact on Post-harvest Loss of Cereals

This study explored the impact of environmental factors on post-harvest cereal loss based on perception of farmers. The findings shows that majority (96%) of the respondents did not perceive environmental factors as contributing to post-harvest loss of cereals by the farmers. Only a few (4%) reported the presence of moulds attributed to moisture in their cereals particularly maize. The foregoing findings echo a study by ANSAF (2016) in Tanzania, which found that only 5.8% of the respondents in the study area reported that moisture contributed to post-harvest loss of cereals. There is a possibility that moisture content may negatively affect the quality of stored cereals. The findings also corroborate those of Ognakossan et al. (2016) which showed that environmental changes was considered to have minimal impact on post-harvest losses. In their study, which was carried out in different Agro Ecological Zones of Kenya including eastern part of the country, the authors found out that only 13% of the 630 respondents they interviewed across the country reported the problem of moulds and was the least problem reported by farmers in all Agro Ecological Zones compared to other factors such as insects and rodents.

The study also wanted to establish the influence of the environmental changes experienced on households post-harvest loss of cereals. Sixty nine percent of those who reported environment had an influence experienced higher loss compared to those who did not report being affected by any environmental factor (62%). This indicates that environmental factor though not reported by many tends to influence post-harvest cereal loss. The agricultural extension officer, a key informant, indicated that many farmers were affected by environmental factors but were not aware. As an example he indicated that LGB flourished well in high temperatures. His sentiments concur with a study by Kaminski and Christiaensen (2014) in Malawi, Uganda and Tanzania. They noted that hotter and more humid environments foster pest infestations and rotting causing

increased post-harvest cereal loss. Studies in other regions have had similar findings that bad weather conditions influence post-harvest losses of grains significantly (Basavaraja et al., 2007).

5.1.3 Post-harvest Management Strategies and Household Cereal Loss

This section is in line with the third objective of the study which sought to assess the influence of post-harvest management strategies on household cereal loss.

5.1.3.1 Effect of the Type of Storage Method Currently Used on Post-harvest Cereal Loss

The type of storage used plays a vital role in post-harvest loss of cereals or lack of it. Numerous studies indicate that maximum losses happen during the storage periods. This is the situation in developing countries and especially in Africa Kenya included (Hell et al., 2000). In Wikililye, the majority of farmers (72%) utilize gunny bags, a few (15%) use sisal sacks to store their crops. Only a small number (6%) of the respondents reported using other forms of storage such as *utaa* or never used any form of storage because they immediately used all the produce, through direct consumption and/ or sale. A small percentage (7%) reported using a form of modern storage mainly the hermetic bags. The findings of the study are in consonant with the findings of Omotilewa et al. (2016) in a study in Uganda. They reported that (71%) of their study households use polypropylene bags with traditional and improved granaries being utilized by only (8%) while others used off-farm facilities. Only 1% of the respondents from their sample used the hermetic (airtight) technology.

The findings of this study indicate that majority of farmers use traditional methods of storage. This concurs with Nukenine (2010) who observes that most Kenyan population use on-farm storage systems for the bulk production of cereals. These systems are characterized by traditional storage structures. The current study findings confirm another study in Kenya by Ognakossan et al. (2016) which found that the use of bags (polypropylene or sisal) for storage of shelled maize were the most common storage

practices. They also found out that there was a very low use of hermetic storage plastic bag technologies in the study area. Similarly the findings are in line with a study done by Wambugu et al. (2009) in Siaya and Busia in Kenya on storage practices. They reported that farmers have developed a variety of storage practices, the most common methods being gunny bags (55%), plastic containers (24%) and hanging over the fireplace (13%).

In the present study households that utilized gunny bags, sisal sacks and other forms reported higher losses of cereals. However, the majority (88%) of those who had adopted the improved storage methods reported not experiencing post-harvest cereal loss. Clearly, poor storage contributes to post-harvest cereal losses. Field observations showed that the forms of storage used by respondents were not effective. For example some households stored their cereals on cemented floor in a corner inside the house or *utaani*. Lathiya et al. (2008) have observed that the traditional storage systems are prone to invasion by agents of stored food losses including pests and rodents. Their study also corresponds with earlier studies by Ognakossan et al. (2016) in Kenya. The authors found out that farmers primarily used ordinary bags for storage (99.2%) in a designated storage room in the living house. Other studies in other parts of the world arrived at similar findings. For example Rembold et al. (2011) reported heavy post-harvest losses in Amuria and Katawi Districts in Uganda, which were caused by poor storage structures. And in Tanzania where Rugumamu (2012) conducted a study post-harvest losses of maize is about 20-30 % and as high as 40 % where farmers use traditional storage structures. Gitonga et al. (2013) in Kenya had similar findings. They reported that the traditional storage practices used by farmers cannot guarantee protection against major storage pests of staple food like maize thus leading to increased post-harvest losses.

5.1.3.2 Influence of Improved Storage Systems Awareness on Post-harvest Cereal Loss

An assessment of the farmer's knowledge on improved grain storage technologies revealed that 77% of the respondents were aware of the storage technologies while 33%

were not. This knowledge is higher compared to a study by ANSAF (2016) in Tanzania, who reported that only 55% of the respondents were aware of modern storage systems in the study area.

To further establish the influence of awareness of improved storage systems on post-harvest loss of cereals, more analysis indicated that a significant number (65%) of the household respondents that had knowledge of the modern methods experienced a higher post-harvest loss of cereals than those who had no knowledge (54%). This suggests that knowledge of improved technology did not have a positive effect on post-harvest loss of cereals. From the focus group discussions farmers indicated that despite them being aware they did not utilize them because they were not accessible and available and/or the cost of purchasing them was high. Similarly, Onemolease (2005) in Nigeria found out that despite dissemination of information on improved storage systems some farmers did not utilize them due to reasons such as high costs and non availability of resources and technology.

The findings of this study reflects a similar study by Ognakossan et al. (2016) in Kenya who found out that despite being aware of modern systems of storage there was low use rate. They indicated that the probable reason for the low rate of use was lack of availability. Ognakossan et al. (2016) further reported that despite farmers receiving training on grain storage protection technologies that did not necessarily result in lower post-harvest storage loss as farmers who received training incurred similar magnitude of post-harvest losses just as farmers who did not receive the training. The results of the study also concurs with the adoption study by Moussa, Abdoulaye, Coulibaly, Baributsa, and Lowenberg-DeBoer (2014) of triple layer plastics in West and Central Africa. Their study showed that a key constraint to farmers use of this technology despite their awareness was local unavailability of the improved technology.

5.1.3.3 Adoption to Improved Storage Systems and Post-harvest Loss of Cereals

Findings of this study indicate that majority of the respondents (92%) had not adopted the improved storage methods with only a small proportion (8%) of the respondents reporting utilizing modern methods of storage mainly hermetic bags. The findings are similar to those of Ognakossan et al. (2016) in Eastern Kenya among other regions studied who observed that there was very low usage of hermetic storage plastics bag technologies and adoption of the same was minimal.

From the findings it is evident that a significant number of respondents (76%) who utilized improved methods did not experience post-harvest cereal losses compared to (34%) of the respondents who had not adopted even though no significant statistical association between adoption and cereal loss. The proportion of households experiencing post-harvest cereal losses was higher for households who had not adopted the improved storage system compared to households that had already adopted. The findings of this study are consistent with those of Villers, Navarro, and De Bruin (2010) who observed that hermetic storage was effective in avoiding post-harvest losses (storage losses of less than 1%), a situation also observed during long distance (international) shipments. This was also consistent with the findings of Costa (2014) who carried out an Action research Trial in Uganda and Burkina Faso to demonstrate the influence of improved post-harvest management practices using new technologies on post-harvest loss of cereals. The results demonstrated that irrespective of crop or storage period, use of improved practices and new technologies resulted in a high (about 98%) reduction in post-harvest cereal loss.

The adoption and usage of improved storage methods among the small scale farmers is challenged by both production rates and economic ability. In Wikililye Location, the utilization of mass/ communal storage system suffered similar fate. The communal storage facilities were built in an effort to reduce post-harvest loss of cereals due to poor storage facilities and low marketing power, which resulted in economic loss but this effort faced challenge. The farmers mainly rely on the cereal production to cater for their

basic socio economic needs and emergencies and thus did not produce enough and surplus to store in the communal storage. The current study findings confirms the findings of a study in Malawi by Mutungi and Affognon (2013b) where the utilization of both the metal silos and communal warehouses despite their popularization in the country is hampered by cultural and socio-economic reasons.

This study is supported by and agrees with all the adoption to innovation stages as propounded by Rogers (2015). This include knowledge in which the individuals are aware of the innovation but have no information about it. Then come persuasion where they become actively interested in seeking the knowledge about it. Decision making is the next stage where individuals decide as to whether to adopt to it or not by weighing out the innovation advantages and disadvantages. After that decision is implementation, which is the actual use of the innovation. The final stage is confirmation. In this study confirmation is done through personal experience of reduced post-harvest cereal loss, which provides impetus for farmers to continue using the innovation.

5.2 Conclusions

In conclusion, the findings of the study established that social economic factors influenced post-harvest cereal loss. The findings that women and younger people experienced cereal loss at a lower percentage is linked to both their acquired knowledge on post-harvest loss management practices and the younger people being more open to embrace change and adopt better loss management technologies. The women despite being encumbered with domestic chores had an advantage compared to men since they acquired knowledge and services from the women groups. The young respondents who were also households heads were seen to be more knowledgeable on protective measures. The young people had other sources of income; they were involved in other income generating activities hence it is safe to conclude that they were able to purchase and use better storage facilities. However, given that there is evidence that the majority household heads in Wikililye Location were the older category, measures and policies

have to put this into considerations in efforts to curb post-harvest cereal losses, food insecurity and hunger. Thus gender and age had an influence on the households post-harvest cereal loss.

Similarly, it is majority of the farmers with less education and who lacked alternative sources of income that were more prone to post-harvest cereal loss. These findings reflect the actual situation where rural households are often the less educated, poor, and composed of the old members in the society. However, those more educated with tertiary and above levels of education experienced lower post-harvest cereal loss. The findings further indicate that marketing of cereals had an influence on post-harvest cereal loss. This was despite the lower number of households who sold their produce. This is attributable to the lower prices that farmers sell their cereals particularly soon after harvest, and the farmers exploitation by buyers.

Secondly, in examining the influence of environmental factors on post-harvest cereal loss, the study found out that weather changes although reported by a few farmers affected cereals especially during storage. Those who reported the influence of environment in terms of presence of moulds or aflatoxins *(mbuka)* on their cereals, also reported a higher percentage of cereal loss. Although the farmers indicated that they adequately dried their maize in the sun, the agricultural extension officer a key informant held that environmental factor is much bigger problem that negatively impacts post-harvest cereal loss. Thus the current study suggests, albeit to a small extent, that environmental factors have a bearing on post-harvest cereal loss. The farmers perceptions and influence of environmental factors on post-harvest cereal loss requires in-depth investigation.

Thirdly, the study assessed the post-harvest management strategies specifically the influence of storage on post-harvest loss of cereals. The study found out that in Wikililye Location majority of the farmers utilized mainly gunny bags and sisal sacks with the least

number using the hermetic storage bags. Some used the fire smoking method where they store them on top of the fireplace a place they referred as *utaani*. This is an indication that traditional storage methods are prevalent in Wikililye. The study further determined whether farmers had the knowledge of improved storage system. It was found out that majority were aware although few had utilized them. This was due to non-availability, expensive to purchase, rigidity of the farmers who are used to the traditional methods of storage and other reasons. The use of improved technologies proved useful as one of the ways of mitigating post-harvest loss of cereals.

5.3 Recommendations

1. The trainings offered at Wikililye Location mostly center on women groups. The study therefore recommends that there should be integration of men and women in the training with the intention of giving both gender equal opportunities to acquire new and relevant knowledge. This will enable them to gain knowledge on effective post-harvest loss mitigation practices.
2. On the farmers' perception of environmental factors influencing post-harvest cereal loss, it is the recommendation of this study that further research be carried out to determine the extent and contribution of environmental issues to post-harvest cereal loss since the both the farmers and the extension officer perception differ.
3. On the awareness of post-harvest storage management strategies, it is evident that households' farmers have some information regarding the storage facilities. However the level of uptake is low. The study recommends that in addition to providing knowledge on better storage management strategies, restraining factors should be put into consideration. This involves availing the facilities and ensuring that farmers are not exploited on prices. The dormant storage facilities for the communal storage system activation would also go a long way in reducing post-harvest loss.

4. There are limited extension services in the study area which is linked to inadequate number of extension staff. Government should post more extension agents to cover more areas to effectively disseminate trainings on how to reduce post-harvest cereal losses in rural areas. Similarly private extension services should be encouraged to complement government efforts in training and educating the farmers.

5.4 Suggestions for Further Research

The finding from this study recommends the following areas for further investigation:
First the study suggests that further investigation be conducted to establish the actual amount of post-harvest cereal loss in Wikililye Location in particular Kitui County as a whole.

Secondly the study suggests an assessment of the environmental influence on household post-harvest cereal loss. This will involve determining the extent to which aflatoxins *(mbuka)* and moulds adversely affect cereal in Wikililye Location.

Third a similar study should be done using different locations to enable generalization of results on socio-economic, environmental and post-harvest management strategies influence on post-harvest cereal loss.

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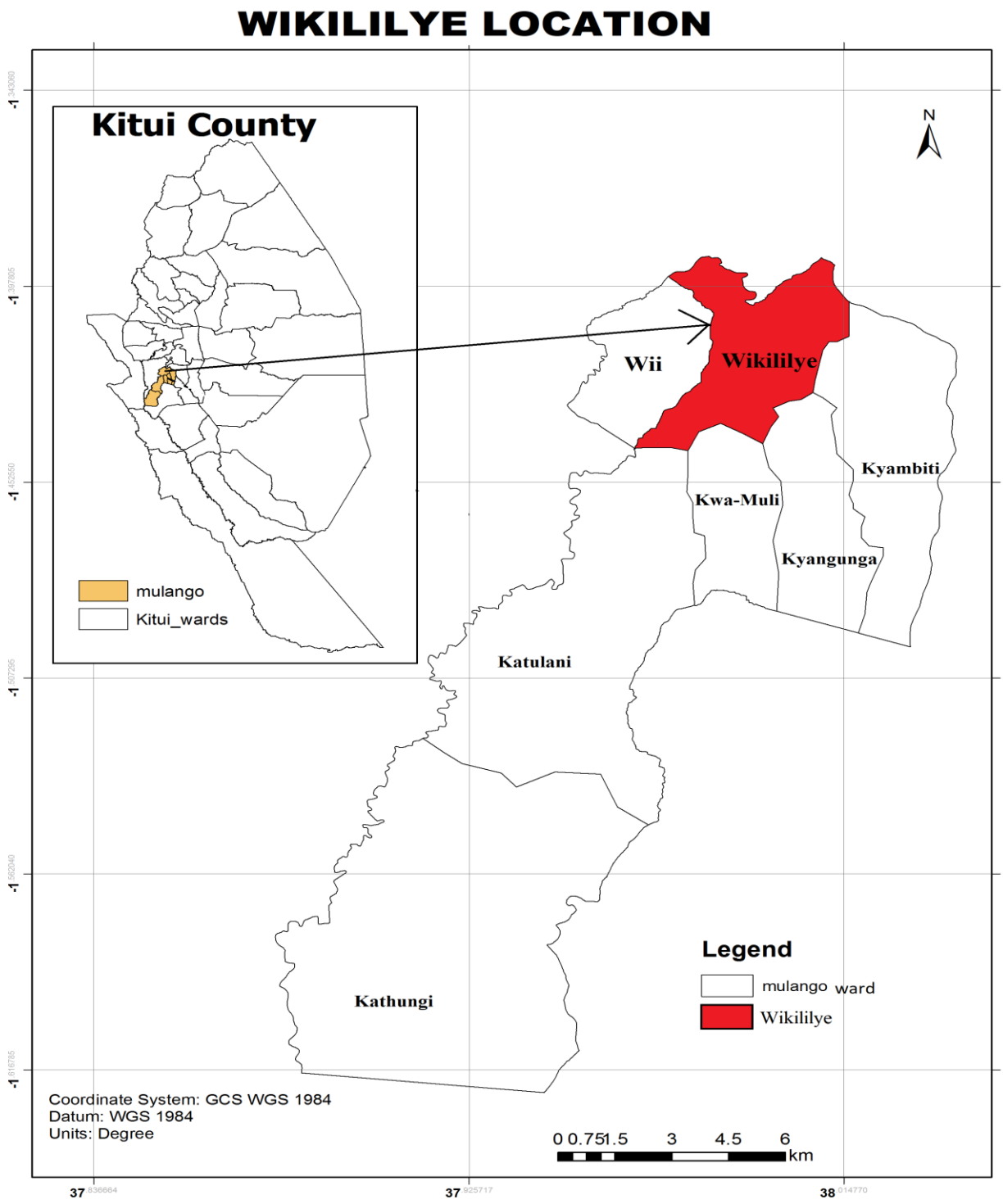

Source: Kitui County; GIS Office

Figure 6: Map of wikililye location

APPENDICES

Appendix1: Questionnaire Schedule

Introduction

Dear Respondent,

I am Wanjiku Agnes Njoki, a Master of Arts student at South Eastern Kenya University and currently undertaking a research study on "**Factors Influencing Households Post-harvest Cereal Loss in Wikililye Location of Kitui County"** as part of fulfillment for the requirements of a Masters degree in Sociology. I am talking to many people here in Wikililye about post-harvest grain loss and you have been identified as one of the informants in this study. The information you give is purely for academic purposes and will not be used for any other purpose. You are also free to terminate your participation at any stage of our discussion. This will not in any way affect you or any services you may be receiving here in Wikililye.

I have fully understood the contents of this statement and willingly agree to take part in this study.

Interviewee agreed to be interviewed Yes [ ] No [ ]

Location.....

Village.....

Signature of interviewee: .....

Date of Interview.....

Carefully listen to the question and respond. Thank you for your co-operation.

SECTION 1

Socio-economic Characteristics

1. Gender of household head: 1. Male [ ] 2. Female [ ]
2. Does the gender of the household head influence household post-harvest cereal loss? Yes [ ] No [ ]
3. How old are you (in years)?: 1. Below 29 years [ ] 2. 30 – 39 years [ ] 3. 40 – 49 years [ ] 4. 50 – 59 years [ ] 5. 60 years and above [ ]
4. Do you think age of the household head influence post-harvest cereal loss? Yes [ ] No [ ]
5. What is the highest level of education have you successfully completed?: None [ ] Primary [ ] Secondary[ ] Tertiary and above [ ]
6. Does the level of education influence post-harvest cereal loss? Yes [ ] No [ ]
7. Occupational status (of the respondents): 1. Informal employment [ ] 2. Formal employment [ ]
8. Does alternative source of income influence post-harvest cereal loss? Yes [ ] No [ ]
9. If yes why……
10. Marital Status: 1. Single [ ] 2. Married [ ] 3. Divorced [ ] 4. Separated [ ] 5. Widowed [ ]
11. Religious affiliation: 1. Catholic [ ] Pentecostal [ ] Muslim [ ] others (Specify)…….
12. How many acres of land do you have for growing food? 1. 0-5 [ ] 2. 6-10 [ ] 3. 11-15 [ ] 4. 16 and above [ ]
13. How many bags of maize did you harvest in the last season? 1. 0-2 [ ] 2. 2-4 [ ] 3. 4-6 [ ] 4. above 6 [ ]
14. Do you sell your maize? 1 [ ] yes 2 [ ] No
15. If yes when do you sell your maize? 1. Immediately after harvesting [ ] 2. After 3 months [ ] 3. After six months [ ] 4. After harvesting next season's [ ] 5. After a year [ ]. 6. After next season's [ ] 7 Never [ ]
16. If you sell immediately after harvesting

Explain why.....

17. Do you sell the surplus in case of high production? 1. Yes [ ] 2. No [ ]
18. Do you sell directly or involve middle men 1. Directly [ ] 2. Middle men [ ]
19. Who controls the price? 1. Farmer [ ] 2. Middle men [ ] 3. Any other specify……..
20. Does the amount of production contribute to the losses? 1. Yes [ ] 2. No [ ]
21. If yes to question 19 explain in what way…… …….
22. Where do you store your food? 1. [ ] Granary [ ] 2. Store in house with cemented floor 3. Other (specify)…….
23. What do you store your maize in? 1. Gunny bags [ ] 2. Sisal bags [ ] 3. Improved storage bags [ ] 4. Plastic container [ ] 5. Other (specify)……
24. Are there challenges you experience in storing your maize? 1. Yes […] 2. No [ ]…
25. If yes in Qn. 23 list the challenges……
26. How do you deal with the challenges you listed above?.....
27. Do you protect your maize after harvesting? 1. Yes [ ] 2. No. [ ]
28. If yes, explain how you protect your maize
29. Is the way you protect your maize effective? 1. Yes [ ] 2. No [ ] 3. Somehow [ ]
30. Do you sell your maize when the prices are low? 1. Yes [ ] 2. No [ ]
31. If yes, why.....

Perception of Environmental factors influencing households' post-harvest loss of cereals

32. Do you experience weather changes that interfere with your post-harvest processes? 1. Yes [ ] 2. No [ ]

33. Which weather changes have you experienced that interfere with this operations?
    i)
    ii)
    iii)
34. Is there rainfall or damp cloudy weather at harvest time so that grains are difficult to dry? 1. Yes [ ] 2. No [ ]
35. Do the weather changes affect the stored cereals in your stores?
    1. Yes [ ] 2. No [ ]
36. If yes in what ways?
    .....
    .....
    .....
37. To what extent do weather changes affect the amount of cereal losses after harvesting?
    1. To a very large extent [ ] 2. to a large extent [ ] 3. Neutral [ ] 4. to a small extent [ ] 5. to a very small extent [ ]

Household post-harvest management strategies

38. Which storage system do you currently use/used to use? 1. Traditional Granary [ ] 2. Sacks [ ] 3. Sisal Baskets/Kyondos [ ] 4. Airtight Plastic Bags [ ] 5. Plastic Containers [ ] 6. Other, Specify (e.g. Kiinga)……
39. Are there challenges you experienced with these storage facilities? 1. [ ] Yes 2. [ ] No.
40. If yes, explain……
    ……
41. Do you incur any post-harvest cereal loss due to rodents, pests, insects, rotting and/or any other reasons? 1. Yes [ ] 2. No [ ]

42. Are you aware of improved cereal storage systems? 1. Yes [ ] 2. No [ ]
43. If yes, where/ how did you learn about improved cereal storage systems?
    1. Extension Officers [ ] 2. Exhibition [ ] 3. Seminars [ ] 4. Baraza [ ] 5. Children [ ] 6. Neighbor [ ] 7. Any other specify…….
44. Have you adopted improved systems of storing maize? 1. Yes [ ] 2. No [ ]
45. If yes, which of the following cereal storage systems do you commonly use? 1. Improved granary [ ] 2. Metal bin [ ] 3. Shelving [ ] 4. Improved mud silo [ ] 5. Other, Specify……
46. If no what are the reasons for not adopting improved systems of storing cereals? 1. Do not know about them [ ] 2. Expensive [ ] 3.Lack of knowhow [ ] 4. Norms/ Beliefs [ ] 5. Other specify……..
47. In your opinion, do you experience post-harvest cereal loss? 1. Yes [ ] 2. No [ ]

Thank you for taking your time to participate in this study

.

Appendix 2: Guidelines for Focus Group Discussions

Date of Interview.....

Name of Facilitator.....

Venue of Interview.....

Name of Note Taker.....

S. No	Name of Participant	Gender	Contact (Phone no)
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
12.			

1. What are your views on post-harvest cereal losses in this community?
2. What contributes to cereal loses in this community?
3. Does age, level of education, and gender of members contribute to post-harvest cereal losses?

4. Do marketing of cereals among the Wikililye location residents contribute to post-harvest cereal loss?
5. What other economic factors do you think contribute to cereal losses?
6. Do climatic factors contribute to cereal losses in this community? Probe
7. What do people in the area rely on for post-harvest activities that may influence post-harvest cereals loss?
8. During storage of cereals are there climatic conditions that contribute to the loss of cereals in terms of quality? Probe
9. What measures do the community members employ to protect their cereals before storage?
10. How appropriate is s the storage system used by the households in this community?
11. What other storage systems are available to households in of this community.
12. What are constrains to the adoption of the more improved storage systems?
13. What measures has the government and nongovernmental organization taken to prevent cereal losses in this community?
14. How do such measures contribute to the reduction of cereal losses in the area?
15. What measures can be employed in the reduction of post-harvestloss of cereals?

Thank you for your assistance and valuable time

Appendix 3: Key Informant Interview Schedule

Date of Interview.....

Name of Interviewer.....

Venue of Interview.....

Name of Key Informant.....

Contact of Key Informant.....

Sex of Key Informant: Female [ ] Male [ ]

1. According to you are there post-harvest losses of cereals in wikilye location?
2. What can you say about post-harvest loss of cereals in this area
3. Does gender, age, level of education, religion have an influence on post-harvest cereal loss?
4. What economic factors contribute to household post-harvest loss of cereals?
5. What are the measures in place to deal with these issues?
6. According to you, are there environmental/climatic factors that contribute to the household post-harvest loss of cereals in this community?
7. What are the storage systems in this area? How appropriate are they and why?
8. What is the level of knowledge of improved storage systems in Wikililye location?
9. What challenges do households face in adopting more improved methods of cereal storage?
10. Give suggestions that can help to ensure that the rate of post-harvest cereal losses is reduced in this community

Appendix 4: Published Papers


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Socio-Economic Factors Influencing Household Postharvest Cereal Loss In Wikililye Location Of Kitui County

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sciepub.com

Influence of Postharvest Storage Management Strategies on Postharvest Cereal Loss in Wikililye Location of Kitui County

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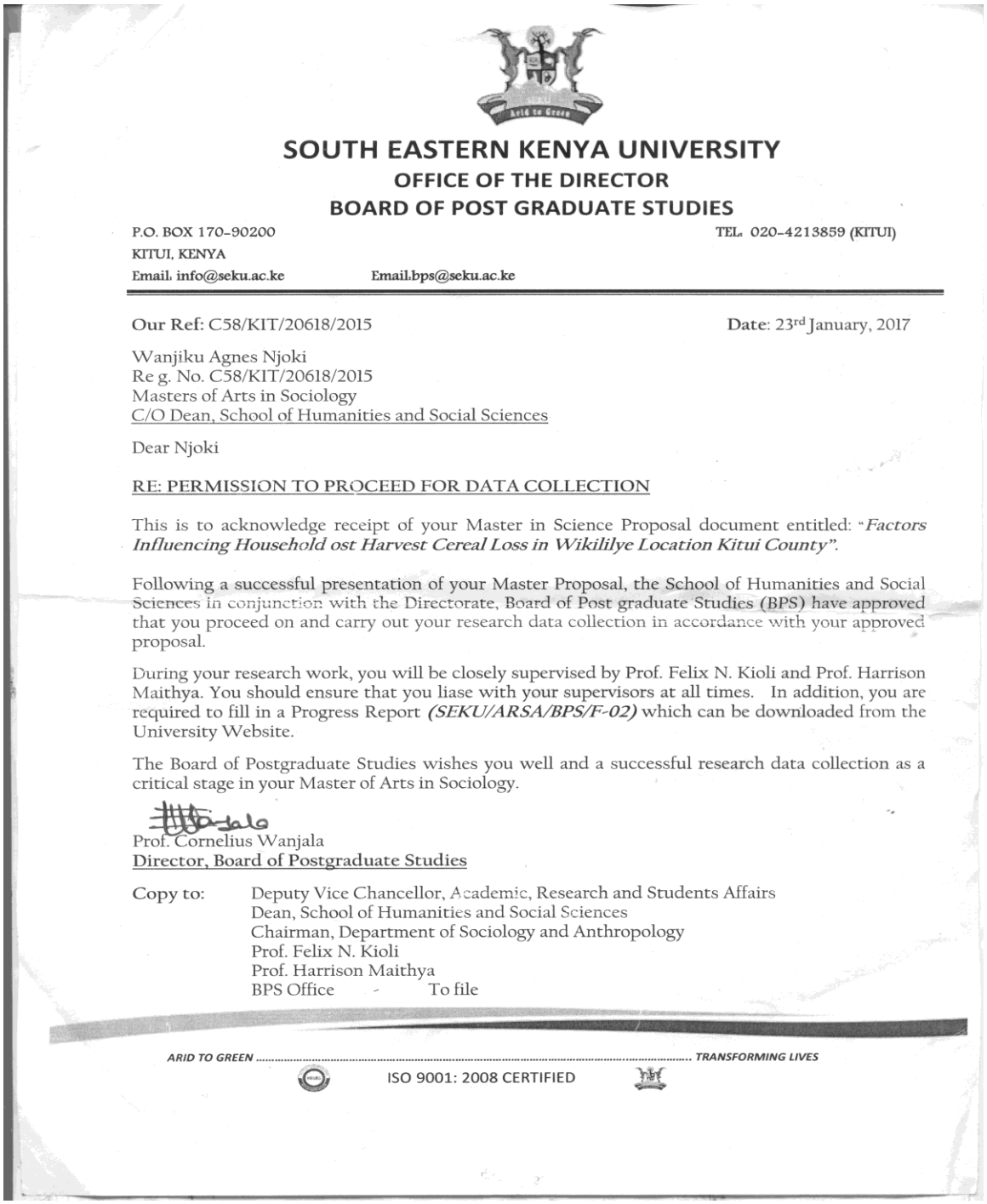
Abstract The study determined the storage management strategies influence on postharvest cereal loss in Wikililye Location of Kitui County. Quantitative data were collected using a structured questionnaire on343 households selected through systematic sampling method using population proportionate to size approach to select the actual number of respondents for each village. Focus Group Discussions and Key Informants purposively sampled were used to obtain qualitative data. The data were subjected to descriptive statistics and presented using tables and verbatim narratives. The findings revealed that majority (62%) of the respondents experienced postharvest cereal loss while a significant number (34%) did not. The study sought to determine the mode of storage currently utilized by the respondents and the findings indicated the majority (72%) utilized gunny bags. Knowledge of any

Appendix 5: University Data collection Authorization letter



SOUTH EASTERN KENYA UNIVERSITY
OFFICE OF THE DIRECTOR
BOARD OF POST GRADUATE STUDIES

P.O. BOX 170-90200 TEL: 020-4213859 (KITUI)
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Our Ref: C58/KIT/20618/2015 Date: 23rd January, 2017

Wanjiku Agnes Njoki
Re g. No. C58/KIT/20618/2015
Masters of Arts in Sociology
C/O Dean, School of Humanities and Social Sciences

Dear Njoki

RE: PERMISSION TO PROCEED FOR DATA COLLECTION

This is to acknowledge receipt of your Master in Science Proposal document entitled: "*Factors Influencing Household ost Harvest Cereal Loss in Wikililye Location Kitui County*".

Following a successful presentation of your Master Proposal, the School of Humanities and Social Sciences in conjunction with the Directorate, Board of Post graduate Studies (BPS) have approved that you proceed on and carry out your research data collection in accordance with your approved proposal.

During your research work, you will be closely supervised by Prof. Felix N. Kioli and Prof. Harrison Maithya. You should ensure that you liase with your supervisors at all times. In addition, you are required to fill in a Progress Report *(SEKU/ARSA/BPS/F-02)* which can be downloaded from the University Website.

The Board of Postgraduate Studies wishes you well and a successful research data collection as a critical stage in your Master of Arts in Sociology.

Prof. Cornelius Wanjala
Director, Board of Postgraduate Studies

Copy to: Deputy Vice Chancellor, Academic, Research and Students Affairs
Dean, School of Humanities and Social Sciences
Chairman, Department of Sociology and Anthropology
Prof. Felix N. Kioli
Prof. Harrison Maithya
BPS Office - To file

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