FACTORS INFLUENCING USE OF IMPROVED POSTHARVEST STORAGE TECHNOLOGIES AMONG SMALL SCALE MAIZE FARMERS: A CASE OF KILOLO DISTRICT, TANZANIA

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

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ABSTRACT

Specifically, the objectives of the study were: to identify the commonly used postharvest storage technologies commonly by maize farmers, to determine small scale farmers' knowledge on the use of improved postharvest storage technologies, to determine the perception of small scale maize farmers toward the use of improved maize postharvest storage technologies and to identify factors influencing the use of improved maize postharvest storage technologies. The cross-sectional research design was used for the study. The population included all small scale maize farmers in the study area and sample size was 260 respondents. Data were collected using personal interviews, Focus Group Discussions (FGD) and non- participant observation. Descriptive statistics such as means, frequencies, percentage and inferential statistics such as a binary logistic regression model were computed. The commonly used postharvest storage technologies were traditional storage technologies such as traditional granaries, bamboo basket and polythene bags and 60% of small scale maize farmers had low knowledge on the use of improved storage technologies. The study further found that 80% of small scale maize farmers had positive attitude toward the use of improved storage technologies. Formal education, access to credit, extension services, membership in farmers groups and distance from home to the market place were the factors influencing the use of improved postharvest storage technologies. This study recommended that, extension agents should increase their contact with farmers, the government should subsidize improved postharvest storage technologies with a high initial cost in order to enhance their use and Kilolo District Council and extension officers should encourage farmers to form groups for community storage such as cereal banks and warehouse receipts system.

DECLARATION

I, TWILUMBA JOSEPH KADEHA, do declare to the Senate of Sokoine University of Agriculture that this dissertation is my own original work done within the period of registration and that it has neither been submitted nor concurrently being submitted in any other institution.

Kadeha — 13.11.2018

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(MSc. Student)

The above declaration is confirmed by;

13/11/2018

Dr. A. A. Kyaruzi — Date

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DEDICATION

This work is dedicated to my parents: Ms. Blandina Msigwa (MD) and my late father Joseph Kadeha who laid down the foundation of my education.

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LIST OF ABBREVIATIONS AND ACRONYMS

AGRA	Alliance for Green Revolution in Africa
AMCOS	Agricultural Marketing Cooperatives Societies
ASDS	Agricultural Sector Development Strategic
CFI	Clinton Foundation Initiatives
DAEO	District Agricultural and Extension Officer
DAICO	District Agricultural, Irrigation and Cooperative Officer
FAO	Food and Agriculture Organization
FAOSTAT	Food and Agriculture Organization Statistics
FGD	Focus Group Discussions
GAP	Good Agronomic Practices
GDP	Gross Domestic Product
KDC	Kilolo District Council
LGA	Local Government Authority
MDGs	Millennium Development Goals
NBS	National Bureau of Statistics
PHL	Post Harvest Losses
PICS	Purdue Improved Crop Storage
RUDI	Rural and Urban Development Incentives
SACCOS	Saving and Credit Cooperative Society
SMS	Subject Matter specialists
TAFSIP	Tanzania Agricultural and Food Security Investment
TDV	Tanzania Development Vision
URT	United Republic of Tanzania
USAID	United States Agency of International Development
VICOBA	Village Community Bank

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background Information

Agriculture is the major economic activity for the majority of Tanzanians, employing about 75% of the labour force (URT, 2016). The crops sub sector, especially cereals has been identified and prioritized as a major source of food in Tanzania (Homan *et al.*, 2013). More than half of cultivated land in Tanzania is allocated to cereal crop production (FAOSTAT, 2014). Of all staple and cash crops cultivated in Tanzania, maize is the major staple crop (USAID, 2010). For instance, it takes about 60% cultivated food crops (URT, 2016). Maize production in Tanzania is dominated by small scale farmers who produce about 85% of total production (FAOSTAT, 2014). Maize is grown almost in all regions of Tanzania as a food crop; however, the southern zone regions (Iringa, Rukwa, Ruvuma, Njombe, and Mbeya) are the largest maize producers in the country, accounting for over 45 % of the total annual maize production (USAID, 2010). Furthermore, maize accounts for 31% of the total food production, constitutes more that 75% of cereal consumption and contributes about 34-36% of total average daily calorie intake in Tanzania (Zorya *et al.*, 2011).

Studies by AGRA (2013) and FAOSTAT (2014), show that overall maize production in Tanzania has grown at an annual rate of 4.6% over the last 25 years. Furthermore, the total area under maize production has increased from 1630 hectares in 1990s to over 4000 hectares in the 2010s (Barreiro, 2012). However, these developments have not resulted into ensuring food security and increasing income to small scale farmers in Tanzania.
For example, the Household Budget Survey of 2012 (URT, 2016) estimated that poverty and extreme poverty levels were at 28.2% and 9.7%, respectively. Although they are far apart, both measures share two common implications: poverty levels are unacceptably high and the

target of reducing poverty to poverty level of 18% by 2015 as was envisaged in the Millennium Development Goals (MDGs) has not been realized (Barreiro, 2012). These two are very much linked with food shortages and food insecurity in general.

The problem of food shortage in developing countries could be overcomed by the use of a variety of modern agricultural technologies (URT, 2012). Experience shows that strides have been made by the Tanzania Government in promoting the use of agro-inputs (fertilizer, seeds, pesticides and machinery). All these efforts have resulted in increased food crops production including maize. Despite the increased maize production, periodic food shortages have been experienced. One of the reasons is that postharvest losses have remained high. This shows that storage issues remain to be tackled as the use of improved storage technologies may have remained down, although advantageous. Some of the benefits that can accrue to farmers from the using of improved agricultural storage technologies include reduced risks of postharvest losses, thus leading to food availability and quality products for marketing during high demands.

There are many reasons for failure to reduce poverty among rural people. Post-Harvest Losses (PHL) are one of the key factors for the majority who depend on crop production (AGRA, 2013). The PHL of cereals in Eastern and Southern Africa accounts for over 40 % of the total crop loss in sub Saharan Africa countries (ibid, 2013). In Tanzania, for example the PHL is between 30-40 %, while in Kilolo District, PHL in 2012 was between 25 – 30% and in 2015 was between 22 – 28% (RUDI, 2016). Poor post-harvest handling practices, poor infrastructure, weather variability, biotic factors such as insects, bacteria, pathogens, viruses, and fungi, often aggravate such losses that result in reducing the quality and quantity of the products (Shiferaw *et al.*, 2013). Thus impeding efforts to reduce poverty and improve food security. Postharvest losses occur during different processes from farm to consumption, including harvesting, threshing/shelling, drying, storage and transportation. The focus of this study was on postharvest losses of maize grains during storage after harvest, specifically the use of improved storage technologies.

As stated before, Iringa is one among biggest maize producer in the southern zone. Kilolo District is one of the Districts in Iringa Region that produce maize. There are about 81 225 small scale farmers involved in the production of maize and a total area of about 74 980 hectares are under maize production in the district (KDC, 2016). Maize production levels have changed over time. For example, ten years ago the average production was 1,620 metric tons per year with an average production of 2.5 tons per hectare (KDC, 2016). Despite the high production potential, farmers in the district have not been able to get out of the poverty trap and they are still prone to food insecurity (URT, 2012). For instance, in Kilolo 33.6 % of the population are below the poverty line and the number of poor people per square kilometer is seven (Kuwawenaruwa *et al.*, 2015). Among other factors responsible for such situation are high PHL which is between 22-28 % in the study area (RUDI, 2016), this is especially important since most cereals, including maize, are produced on a seasonal basis, and in many places there is only one harvest per year, which itself may be subject to failure (FAOSTAT, 2014).

In order to assure availability of food throughout the year, it is important for the farmers to have access and know how to appropriately use improved storage technologies. This is because appropriate knowledge, skills, attitude on storage technologies and institutional support are important in the use of postharvest storage technologies and hence reduce postharvest losses resulting from storage pests and pathogens (Kimenju *et al.*, 2009; Tefera *et al.*, 2011). Apart from ensuring food availability, proper storage has a number of advantages such as stabilization of market prices and to enable farmers meet conditions for accessing credit. Since stored produces can be used as collateral for accessing credit (Tefera *et al.*, 2011). Lack of collateral among small scale farmers has been a limitation to access credit (Letaa *et al.*, 2014). On the other hand, access to credit is an important factor for the adoption of improved agricultural technologies among farmers (Venance *et al.*, 2016).

Cognizant of the above, the Kilolo District Council in partnership with the private sector (Including One Acre Fund, Rural and Urban Development Initiatives and Clinton Foundation Initiatives) for years have taken various initiatives to improve crop storage in order to reduce PHL. For example, in 2014, One Acre Fund implemented a two years project in the study area which targeted 200 farmers. The objective of the project was to supply inputs recommended for an acre for the target maize farmer and promoted the use of improved storage technologies. On the other hand, RUDI, in the same year implemented a three years project which targeted 224 farmers' groups. The main objective of the project was to introduce a warehouse receipts system and establish demonstration plot for each group on GAP for maize production. Furthermore, the Clinton Foundation in 2016 trained 230 groups of farmers on GAP, improved postharvest storage technologies and demonstrated the use of PICS, metal silo technologies for each group.

Generally, initiatives aimed at increasing agricultural production through training on GAP, increase the number of farmers who are practicing GAP and promoting the use of improved postharvest storage technologies in order to reduce PHL in the study area. In this partnership, the private sector provided materials for training and Kilolo District Coucil through the Agriculture Extension Officers disseminated knowledge for GAP and use of improved storage technologies. Together with promotion of effective traditional storage technologies, practices and knowledge on technologies improved technologies were highly promoted through various channels including extension agents, radio, television, training and written materials. Some of postharvest storage technologies promoted include Purdue Improved Crop Storage (PICS), improved granaries, storage chemicals and metal silo. The Initiatives of the local government and partners were founded on the understanding that efforts to improve maize production and bring about the desired impacts should go hand in hand with building farmers' capacities on the use of technologies and improving infrastructure to reduce PHL. It follows that improving crop storage could help increase farmers 'earnings and assure food security (WFP, 2012). This is because PHL of maize grain caused by poor postharvest handling technologies including storage that lowers the income and standards of living to farmers. For example, in Tanzania, postharvest losses represent more than 557 metric tons of maize, the amount which is enough to meet national food requirements for a period of about two months (URT, 2012).

1.2 Problem Statement and Justification

1.2.1 Problem statement

Despite the efforts taken by the Government and private sector to promote the use of improved postharvest storage technologies in the study area, experience shows that the extent to which farmers are using improved storage technologies is still low and postharvest losses are still very high at 22 -28% in Kilolo (KDC, 2016). In Tanzania and particularly in Kilolo District, empirical evidence of the use of postharvest storage technologies is limited. In view of the above, there was a need to conduct a study to determine the extent of use and factors influencing the use of improved storage technologies among small scale maize farmers in the study area is evident.

1.2.2 Justification of the study

Food storage is crucial in enhancing food security and stabilizes commodity markert prices by maintain availability of quality product at household level and supply to the markert. This is only possible farmers adopt and properly use improved postharvest technologies.However,much still need to promote better and more efficient technologies for storage , in order to achieve increased food security and high incomes among small scale maize farmers. Currently in the study areas, extension officers have conducted little studies to determine the factors influencing the use of improved postharvest storage technologies, this study will assist agriculture extension planners and practitioners to best ways to improve the use of improved storage technologis and thus reduce postharvest losess. Moreover, knowing the factors that influence the use of improved storage technologies will assist in designing effective agricultural extension programs for increased adoption of storage technologies thus improve livelihoods. Furthermore, will help policy makers to design and formulate policies and strategic plans in the areas of postharvest leading to reduced PHL eventually contribute to the attainment of national and international target as envisaged in Tanzania Development Vision (TDV), Sustainable Development Goal (SDG), ASDP II and MKUKUTA I and II.

1.3 Objectives of the Study

1.3.1 Overall objective

The overall objective of the study was to determine factors influencing use of improved postharvest storage technologies among small scale maize farmers in Kilolo District.

1.3.2 Specific objectives

The specific objectives of the study were to:-

1. Identify postharvest storage technologies commonly used by small scale maize Farmers in Kilolo District.

2. Determine small scale farmers' knowledge on the use of improved postharvest storage technologies in the study area.
3. Determine the perception of small scale maize farmers toward the use of improved maize postharvest storage technologies in the study area.
4. Identify factors influencing the use of improved maize postharvest storage technologies in the study area.

1.4 Research Questions

i. What are the improved maize postharvest storage technologies commonly used by small scale maize farmers in the study area and why?

ii. To what extent farmers are knowledgeable on the use of improved maize post harvest storage technologies in the study area.

iii. What is the attitude of small scale maize farmers towards the use of improved maize post harvest storage technologies?

iv. What are the factors affecting the use of improved post harvest storage technologies in the study area.

1.5 Theoretical Framework

The study was guided by the theories of adoption (Rogers, 2003) and rational choice (Becker, 1964). Adoption of technologies is influenced by nature of technology, communication channels used, time since the technology introduced, and social system (Rogers, 2003). The social system here is referred to as the socio-economic characteristic of people to which the technology is introduced such as access to extension services, awareness, and knowledge on storage technologies and training on storage technologies. On the other hand, rational choice as an economic principle, farmers are rational in their capacity to devise, choose, and put into practice effective means of storing their produces and maximize their profit and meet their food requirements (Okoruwa *et al.*, 2009).

The issues like markets, access to credit, cost of technology, durability, effectiveness and efficiency of technology and wealth level have an influence on the use of technology. Therefore, since this study looks of the use of postharvest improved technologies which is depends of information flows, possibility to test before decision to use. This can be explained well from adoption and rational choice theories from a social point of view. But the adoption of a particular technology and its subsequent used may be influenced by personal choices as informed by gain or losses anticipated or experienced before. This can correctly be understood from a rational choice theory. Therefore the study uses theories to complement each other.

1.6 Conceptual Framework of the Study

The use of improved storage technologies among small scale maize farmers may be influenced by factors related to farmers. Also by factors related to institutions, responsible for extension advisory and related services and factors related to technology itself. In reality, all these are determined or shaped by the general political, social, economic and cultural contexts. Factors related to a farmer include socio-economic status, level of production, where factors related to the institution include access to extension service, access to credit, costs of technology, availability of agriculture inputs, farmers' organizations and factors related to technology are durable, effectiveness and efficiency (Okoruwa *et al.*, 2009; Rogers, 2003).

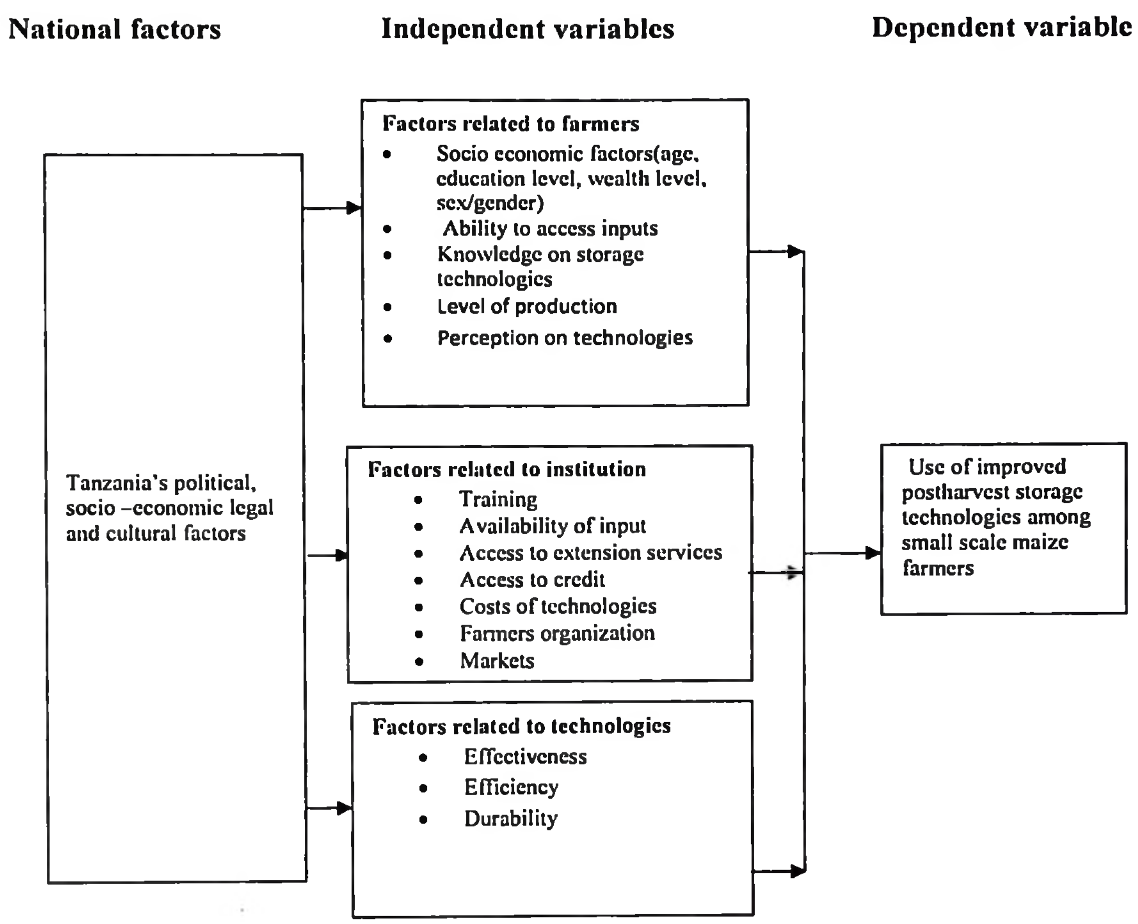

Figure 1: Conceptual framework

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Overview

This chapter reviews relating literature on factors influencing the use of improved postharvest storage technologies. It reviews the literature on common post harvest storage technologies used by small scale maize farmers, farmer's knowledge on the use of improved postharvest storage technologies, farmers' perception on the use of improved postharvest storage technologies and factors influencing the use of improved postharvest storage technologies.

2.2 Definitions of Key Operational Terms and Concepts

In the study, the following key concepts and terms were construed to have the following meanings and interpretations:

2.2.1 Improved postharvest storage technology

Improved postharvest storage technology is the technology that increases the life span of a given product and maintains quantity and quality for a desired period. Improved storage technologies include improved granaries, cribs, metal silo, storage chemicals and PICS (Kimami, 2016).

2.2.2 Small scale farmers

Small scale farming (or smallholder farming) is typically characterized by the size of land ownership which is less than two hectares (Ndunguru *et al.*, 2014). Small scale farmers operate mostly in rural areas, and are the biggest group in the agricultural sector as a whole and are non-commercially.

2.2.3 Postharvest Losses (PHL)

PHL is losses which occur between harvest and the moment of human consumption. They include on-farm losses, such as when grain is threshed, winnowed and dried as well as losses along the chain during transportation, storage and processing. Post harvest losses are measurable reduction in foodstuffs, which may affect the quantity or quality or both. For many households, such losses threaten food, nutrition, and income security (World Bank, 2011). They also contribute to high food prices by removing part of the food from the supply chain.

2.2.4 Quality loss

This is a reduction in the quality of food grain so that its market value is reduced or loss of quality resulting from the deviation of a product characteristics from its target value. Quality losses lead to inferior food nutritional value, food borne health hazards, and economic losses when the produce misses market opportunity or loss of attributes that make it appealing to consumers (Hodges *et al.*, 2011).

2.2.5 Quantity loss

This is a loss of part of or whole grain, resulting from various processes from harvesting to consumption. Quantity loss can be caused by leakage, during transport, for example, if sacks have holes or are insecurely attached. It is often the result of prolonged infestation and consumption by insects, rodents and birds or poor packaging. Quantity loss from pests is not immediately apparent and may deceive an inexperienced purchaser. It can be checked by taking an equivalent amount of clean, healthy cereal, milling the two samples and weighing the flour from each. The poorer sample will produce less flour (FAO, 2008).

2.3 Commonly Postharvest Storage Technologies Used by Farmers

Farmers are using different postharvest storage technologies for storing their produce. The purposes of storing are to ensure food is available throughout the year and to enable farmers to sell their produce when the price is reasonable. Bahiigwa *et al.* (2017), studied factors influencing use of food storage structures by agrarian communities in Northern Uganda, found that the postharvest storage structures which are commonly used by farmers were metal silo, zero flying bags, polythene bags and traditional granaries. Likewise, the Agriculture Non State Actors Forum (ANSAF, 2016), study on farmers' access to post harvest technologies, conducted in Dodoma and Manyara Regions in Tanzania found that farmers used postharvest storage technologies such as polythene bags, plastic containers, granaries and storage chemical (Phostoxin and Actelic Super Dust). The study found that 67.7% of the farmers used and knew that insecticides can protect their stored maize and 28.3% farmers used other storage technologies.

Another study done in Uganda by Oluwato *et al.* (2015) on the impact of improved storage technology among smallholder farm households found that the storage technologies which are commonly used by maize farmers are single-layer woven polypropylene bags called "kaveras" (71%); heaped-in-house, where maize is left on the cob (11%); granaries (8%); and private off-farm facilities (2%). The use of hermetic (airtight) technology was less than 1% of their respondents. However, despite significant advances in food storage methods, many farmers in Africa still rely on traditional storage technologies. Although relatively simple and inexpensive to buy and maintain traditional storage technologies lead to substantial post-harvest losses (Maonga *et al.*, 2013). Furthermore, despite the knowledge of inefficiency of traditional storage technologies are still used. For example, Gitonga *et al.* (2015) found that traditional storage practices in Africa countries cannot guarantee protection against major storage pests of staple food crops like maize. Likewise, Abass *et al.* (2014) found that when grains were stored in traditional storage facilities are highly attacked by storage pests because it is difficult to maintain air tightness in order to discourage favourable condition for deterimental pests and microorganisms.

2.4 Farmer's Knowledge on the Use of Improved Postharvest Storage Technologies

Farmers' knowledge is the capability of a farmer to coordinate a wide range of socio-technical skills within specific localities and networks towards desired outcomes (for instance proper use of improved postharvest storage technologies). An important aspect of farmers' knowledge is that it is tied to action. This means that it is not just a mental capacity, but also carries elements of practical and physical skill (Mwanga, 2002). Therefore farmer's knowledge on the use of improved postharvest storage technologies is how farmers are capable to use the storage technologies as recommended in order to maintain the quality and quantity of stored product.

According to the study done by Kamanula *et al.* (2011) on farmers' insect pest management practices in the protection of stored maize and beans in Southern Africa, about 63% of respondent had low knowledge on the use the of improved postharvest storage technologies. The study also found that the majority of respondents had low knowledge on the use of improved postharvest storage technologies due to poor extension services, insufficient information and community awareness on improved postharvest storage technologies were responsible for the low knowledge among small scale farmers (AGRA, 2013; Maonga *et al.* 2013). Also, Ndunguru *et al.* (2014) reported that 86% of farmers in Tanzania had limited knowledge of methods for proper management of improved postharvest storage technologies.

According to Gitonga *et al.* (2015) farmers can only adopt the new system if they are sufficiently informed about it. Moreover, after having decided whether to use an innovation, adopters also decide whether to modify it. The study of Doss *et al.* (2003) on the use of wheat storage technology in Eastern Africa cited several reasons given by farmers for not using improved storage technologies. The first was not being aware of the technologies or their benefits; this included misconceptions about the related costs and benefits, given the complex sets of decisions that farmers had to make in relation to storage technologies. This may be due to the fact that appropriate technologies for farmers' conditions were not available or that farmers preferred to use local technologies. However, FAO (2008) and URT (2012) argued that low ratio of extension personnel to farmers may contribute to lack of knowledge and awareness of improved storage mechanisms and technical knowhow among small scale farmers.

2.5 Perception of Small Scale Farmers on the Use of Improved Postharvest Storage

Perception of the characteristics of new agricultural storage technologies is also important factors associated with farmers' demand and use of it. Farmers may subjectively evaluate the cultural aspects of new technology in a different way (Ani, 2002). Thus, understanding farmers' perception is important in designing and promoting the use of improved storage technologies. Also the intensity of an individual's attitude towards an innovation is a major determinant of the anticipated adoption behaviour (Lemon, 2010). The attitude of a decision-maker towards an innovation depends on his/her valuations of the set of characteristics of that innovation (Wossink *et al.*, 2007). Negative perceptions of innovation characteristics are sometimes mentioned as a main reason for not using it. It may also explain the limited adoption by farmers of some innovations derived from on-station research (Becker, 2001).

A study conducted by Michelle (2005) on use of soybeans in Togo revealed that the adoption rate of improved storage technologies is usually higher, if the technologies meet farmers' expectations. Improved storage technologies will be adopted or used at higher rates if it is technically and economically superior to local systems. They are also superior if they result in higher quality of stored products compared to ordinary traditional technologies. Likewise, Neill and Lee (2001) argue that the use of improved agricultural storage technologies also affected by their perception of the amount of initial costs for purchasing them and labour required. Also, Martel and Weber (2007) conducted a case study of the marketing of dry beans in Honduras, argued that farmers use improved storage technology because they perceived that these methods could reduce other associated costs common with traditional methods. In addition, to reducing risk of losses due to damage during storage. According to Martel *et al.* (2000), Benin farmers used technology that was consistent with their needs, their cultural status and their attitude towards the particular class of innovations.

According to Ani (2002) and De Groote *et al.* (2013) perceptions of the specific characteristics of the innovation are important in determining whether to use the technology or not. The above studies imply that farmers' attitude is significant factor in the use of improved postharvest storage technologies, holding negative attitude towards new innovation has an impact on its use. Farmers' perception of the production characteristics of crop variety such as yield, maturity rate, drought resistance, and insect resistance determine selection and storage technology to be used (Hintze *et al.*, 2003).

Kimenju *et al.* (2009) and Gitonga *et al.* (2015) studying the impact of Metal Silos for households' maize storage and analysis of alternative maize storage technologies in Kenya found that farmers considered perceived effectiveness of the technology against insect pest as a very important criterion; followed by life span or durability of the technology. Tefera *et al.* (2011) and De Groote *et al.* (2013) studies on the metal silo as an effective grain storage technology and effectiveness of metal silo and super grain bag in Kenya argue that metal silos were perceived as effective in controlling maize weevils and the larger grain borers (LGBs) compared to the use of pesticides such as Actellic Super Dust and Phostoxin.

2.6 Factors Influencing the Use of Improved Postharvest Storage among Small Scale Farmers

Socio-economic characteristics such as age, education level, marital status, land size, income and economic status influence adoption of improved technologies among small scale farmers. In Mozambique, Saha *et al.* (2004) reported that the level of education attained by household head is positively associated with households' adoption behaviours. They revealed that education level of household head positively influenced households to quickly respond to their current low agricultural productivity by using improved storage technologies that increased productivity, household income and their standard of living. However, they also reported that most household heads in Mozambique were illiterate and had attended school for only few years. Also education level seems an important determinant for the use of improved postharvest storage technologies, according to Adegbola *et al.* (2010) on economic analysis of storage technologies in Benini, who found that the household heads who were highly educated preferred to use improved postharvest storage technologies compared to farmers with low education level.

Maonga *et al.* (2013) on adoption of metal silo in Malawi, found that formal education of household head, consistently had a positive relationship to adoption of small metal silo technology. It could be argued that education level supports the adoption of small metal silo technology in Malawi among small maize farmers. Likewise, Uaiene *et al.* (2009) who studied determinants of agricultural technology adoption in Mozambique found that completion of at least lower primary school implies a much higher propensity to adopt new technology than lower or zero levels of education. The findings are supported by Challa and Tilahun (2014), Ume and Ochiaka (2016) and Raphael (2014). This means that educated farmers are more likely to adopt new innovations in a short time compared to uneducated farmers. Generally it is clear that education influence adoption of agricultural technologies. One explanation of this is that according to Gardebroek *et al.* (2007) educated farmers are able to better process information, allocate inputs more efficiently, and more accurately assess the profitability of new or improved, and easily adapt to environment as compared to farmers with no education.

Kimatu *et al.* (2012) and Gitonga *et al.* (2015) studies on impact of Metal Silo on households maize storage and analysis of alternative maize storage technologies in Kenya, found that institutional factors such as policy, access to extension services, information, and access to credit facilities influence farmers adopting storage technologies. Also, according to Venance *et al.* (2016) and Akudugu *et al.* (2012) found that farmers who have access to formal credit are likely to adopt improved technology than those who have no access to credit. Credit helps farmers to have extra money for purchasing agricultural inputs which facilitate a farmer to adopt a new technology. Also Zorya *et al.* (2011) argued that poor farmers often do not have access to appropriate credit to finance farming inputs and capital investments, which are key to increasing adoption rates and raising agricultural productivity. Farmers who have access to formal credit were likely to adopt improved technology than those who had no access to credit.

Idrissa *et al.* (2012) and Raphael (2014) reported that extension service is another determinant affecting adoption of new technology. They argued that access to extension services play an important role in the adoption of new agricultural technologies among farmers. Extension contact determines the information that farmers obtain on production, storage, processing activities and the application of innovations by extension agents (Idrissa *et al.*, 2012). Farmers who are exposed to information about new technologies by extension agents through training, group discussion, demonstration, attending agricultural shows, access to leaflets, magazines and radio and other form of information delivery tend to adopt new technologies (Onasanya *et al.*, 2007). Access to agricultural extension messages is believed to have a positive influence on technology uptake by farmers. For example, Barungi *et al.* (2015) found that the probability of adopting Napier grass in Uganda was 25.6% higher for farmers with access to extension services than for those without access to extension services. A study on the adoption of new storage technologies carried out by Khanna (2010) in India found that agricultural productivity remained low in Fata region in India as compared to other settled areas of the province. The reasons included poor extension services and lack of communication between the rural people and extension agents. The study indicated that the benefits of farmers who had access to extension services resulted in improvement in their production with the use of better storage technologies.

According to study done by Rao (2006) training influences the use of improved post harvest storages because training increases farmers experience in relation to adoption. Through training farmers are able to understand the nature of risks associated with each of the new technologies and are willing to face the risks associated with the method. However, Iheanacho (2000) and Ani (2002) indicated that training to a large extent affects farmers' technical know-how and decision making. Besides, it influences the farmers' understanding of climates and weather conditions as well as other factors affecting storage. Also, reported that greater effectiveness of extension methods can be ensured through regular training by providing farmers with required facilities, reorganization of extension programs and involving local leaders as agents for the dissemination of information.

Furthermore, according to Rogers (2003) there is inconsistence between the relationship of age and innovativeness, and that earlier adopters of agricultural innovation were young farmers. Social status is shown by a variable such as possession of wealth, occupation, prestige, self perceived and income is the identification with social class. However, social status is usually positively related to innovativeness (Rogers, 2003). Also Maonga *et al.* (2013) found that farmers possessing high status are easier to adopt as compared with low status because they are wealthier and have large sized unit of farm In addition, their social status, enabling them to be able to search and get information on improved practices, income level of farmers have an impact on the adoption of recommended agricultural practices. In this case they can purchase and manage different type of storage technologies.

Another factor is membership in a farmers' organization has an influence on the use of improved post harvest storage technologies. According to Lwala *et al.* (2016) found that membership in farmers groups had influence on the use of improved postharvest storage technologies due to the fact that, farmers organizations provides a social platform where could meet and share ideas concerning the technologies, but also get better access to information related to improved storage technologies (Wekesa *et al.*, 2003; Bahiigwa *et al.*, 2017). Also a study conducted in Kenya's Embu District by Ouma *et al.* (2002), found that 90% of farmers who are using postharvest storage technologies had attended training in groups and more than 60% of the farmers were members of farmers cooperative or farmers' group. Another advantage of group membership is that farmers had access to credit to purchase inputs improving agricultural production (Ouma *et al.*, 2002). Since a group act as a social collateral.

Cost of technology is the factor influence the use of improved postharvest storage technologies. Okoedo (2009) revealed that non availability and high cost of improved storage technologies also account for farmers not using them. This matches the findings of Satyanarayani *et al.* (2009) for poor adoption of improved storage technologies in India, where18.5% complained of high costs of the improved systems and non-availability of the technology. Also, FAO (2008) found that many times farmers with more resources in terms of capital, land and labour that are capable. Most farmers rely only on farming as their main source of income thus neglecting other economic activities which can also generate income. In terms of resources, wealthier farmers have better access to extension information and stand a better chance to use their own resources to experiment with new and improved storage mechanisms (CIMMYT, 2003). to take advantage and adopt new or improved methods and practices The major problem with the modern technologies is that they have been lowly adopted due to high initial cost of technology and lack of technical knowhow among farmers (Orokura *et al.*, 2012; Maonga *et al.*, 2013). From literatures above, it is evident that many studies on the use of storage technologies among small scale maize farmers were done outside Tanzania and in particular there is no study on the same in the study area. Therefore, this study intended to bridge this gap. The aim is to found out if the situation in the study area confirm or divert from exsting knowledge of the use of improved storage technologies.

CHAPTER THREE

3.0 RESEARCH METHODOLOGY

3.1 Overview

This chapter described the methodology used by this study, it is divided into six sections; the first section describes the study area, followed by the research design, study population, then data collection procedures finalized by data processing and analysis procedures.

3.2 Description of the Study Area

3.2.1 Geographical location

The study was conducted in the Kilolo District, Tanzania. Kilolo is one of the four Districts in Iringa Region. Located at 7^0 and 8.3^0 South of equator and longitude 34° – 37° East of Greenwich. Kilolo District is bordered to the North by Mpwapwa District, to the South by Mufindi District, to the East by Kilombero District and to the West by Iringa District. The larger part of Kilolo District is dominated by clay loam soil which is suitable for maize production. District receives reliable rainfall ranging between 1000 mm - 1600 mm per annum. The district lies on altitude of 1200 - 2700 meter above sea level (KDC, 2016). The District was selected due to its high potential for producing maize. As statistics show that the current maize production level is on an average of 2.5 tons/ha but postharvest loses stand at 22-28% (RUDI, 2016) and existence of initiatives promoting the use of improved postharvest technologies.

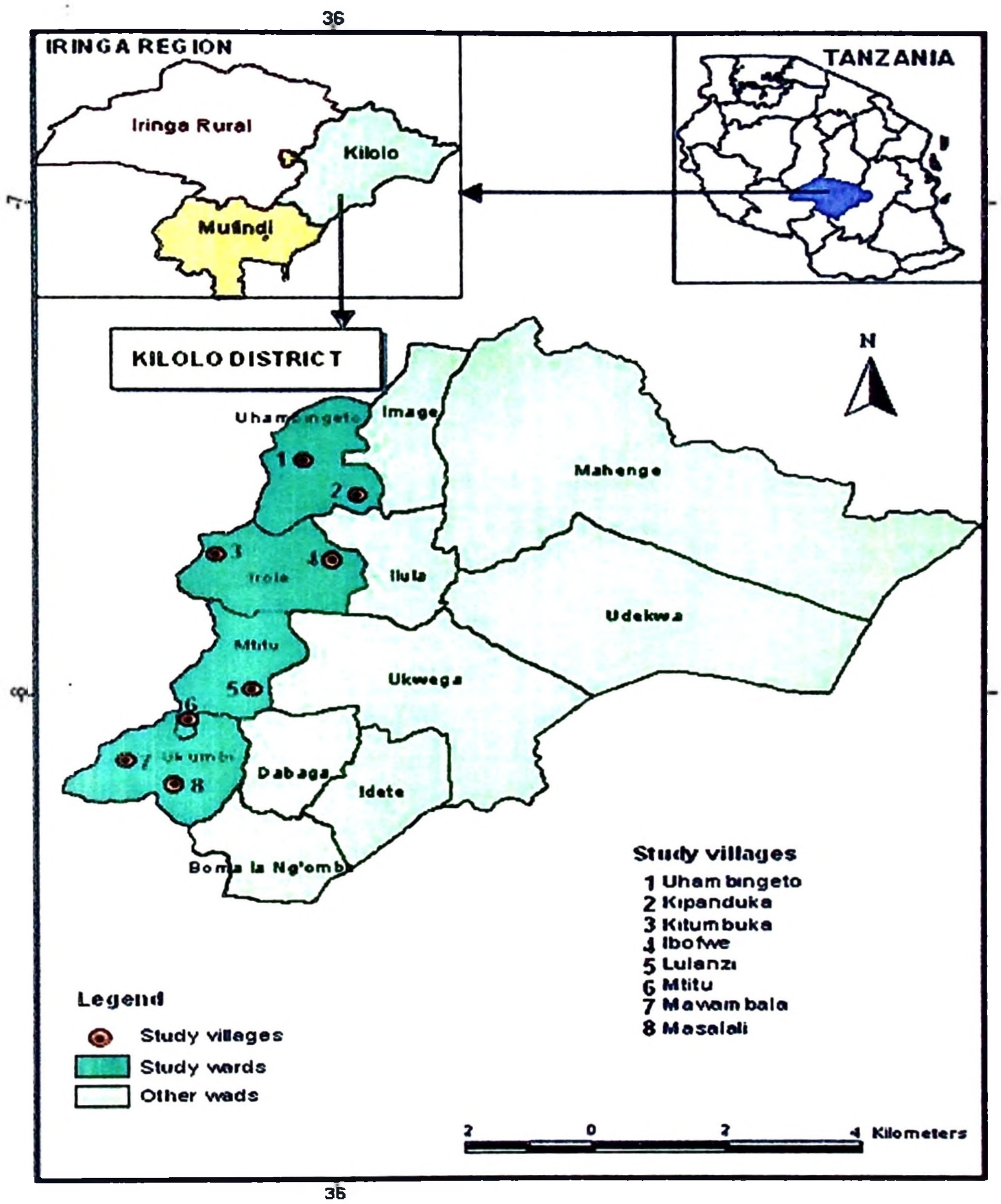

Figure 2: Map showing location of the study

3.2.2 Population, land and administration units

According to URT (2012) Population and Housing Census, Kilolo District has a population of 218 130 whereby 112 274 are females and 105 856 males. The District has a total of 4 181 885 sq km arable land where 1 672 740 sq km is under maize production. Administratively the District has three divisions, 12 wards and 96 villages, an average household size of 4.3 with 50 726 households.

3.2.3 Economic activities

Dependence on natural resources is high, with over 90% of the households being dependent on natural resources for food production, medicinal plants and fuel wood, charcoal and building materials. Major livelihood strategies of the inhabitants, include crop production, agro forestry and livestock keeping. Crop production is contributing 75% of food and income to people in the district. Maize is among the major crop grown in the District followed by beans, tomatoes, onion and round potatoes (KDC, 2016).

Table 1: Production trend of maize in Kilolo District

Cropping season	Area under production in Hectare	Production in tones/ha	Total production in tones
2015	66 442	2.1	139 528
2016	68 104	2.5	170 260
2017	63 891	2.7	172 505
2018	58 654	2.7	158 365

Source: (KDC, 2018)

3.3 Research Design

This study employed a cross-sectional research design (Kothari, 2004), because it allowed data collection at a single point at a time. Cross-sectional designs allow gathering of data once and involve relatively a larger number of subjects. Another reason for choosing this design was due to its suitability for descriptive purposes as well as the determination of the relationships between the variables (Bryman, 2015).

3.4 Study Population

3.4.1 Population

Population of the study was all small scale farmers producing maize in the study area and they have effective use of improved postharvest storage technologies.These population make true inference of the entire population.

3.4.2 Sampling frame

Total list of selected population in the study area to represent entire population within Small scale maize procures in Kilolo. The lists of respondents were obtained from Village Extension Officers within selected ward for the study.

3.4.3 Sampling procedure

Purposively sampling technique was employed to select four wards (Ukumbi, Mtitu, Irole and Uhambingeto) because the promotion of the use of improved postharvest storage technologies was done in those wards. Simple Randomly Sampling was used, where a rotary technique was employed to select villages. The sample size for the study was 260 respondents which were selected randomly from the list of small scale maize farmers from select villages. Twelve key informants; District Agricultural, Irrigation and Cooperative Officer (DAICO), three Subject Matter Specialist (SMS), four extension officers were selected for interviews and Focus Group Discussion (FGD).

3.5 Data Collection Procedures

Two phases of data collection involved. Phase one involved reconnaissance survey of the study area while the second phase involved administering the questionnaire.

(a) Reconnaissance survey

The first step was to conduct a reconnaissance survey. The researcher visited the study area for familiazation and met with the DAICO and had initial discussion with the officers, whereby eight villages for study were identified. Then the researcher assisted to select villages. In this visit she together met with villages leaders and extension officers participated in the process of selecting respondents.

(b) Pre-testing of survey instruments

Pre testing of the instrument was done by the researcher in Ihemi ward in Iringa District from two villages where 26 farmers were randomly selected for pre- testing the instrument one month before data collection. Some modifications were made on the instrument after pre-testing to improve the reliability and validity before the main activity. The revised instrument was used for data collection during the main study.

3.5.1 Primary data

Semi -structured questionnaire and interview schedule were used to collect data from respondents within a limited time. The survey instrument was designed specifically farmers who are producing maize and using postharvest storage technologies to store their produce.

a) Semi-Structured questionnaire

Semi -structured questionnaire was to obtain primary data from the selected respondents. The questionnaire contained both close and open-ended questions. Open-ended questions were used to grasp information from the respondents, while the close-ended questions required the respondents to choose an answer given in the questionnaire. Data collection started on the last week January, 2018 and ended on the fourth week of February, 2018.The principle researcher and four enumerators assisted to administer the questionnaires. At the end of the field work the completed questionnaires were checked for clarity and accuracy of answers by researcher and enumerators.

(b) Key Informants and FGDs

In order to get detailed information, the following key informants were interviewed: four Ward Extension Officers, four Ward Executive Officers and Four SMS from Department of Agricultural in the District. Four FGDs were conducted and had six participants per each group .The key informants and FGDs gave information on factors influencing use of improved postharvest storage technologies.

3.5.2 Secondary data

Secondary data included the number of farmers who were producing maize, area under maize production, average production of maize per hectare and postharvest losses from Kilolo District report and reviewed of literature from printed books, journals, thesis and unpublished reports from the National Agricultural Library (SNAL), websites and individuals. These data enabled to get information on postharvest storage technology, level of use, knowledge, perception and determinants of improved postharvest storage technologies among small scale maize farmers.

3.6 Data Analysis and Processing

3.6.1 Quantitative data analysis

Data collected from semi-structured questionnaire were coded, edited and analyzed using appropriate computer software, Statistical Package for Social Sciences (SPSS) version 16. Descriptive statistics such as mean, standard deviation, frequency and percentages were computed for objective one, two and three;- Objective two, respondents were requested to respond to 10 items meant to measure their understanding on the technical recommendations for the use of improved storage technologies. Respondents were required to respond to a given statement by indicating Yes or No to each statement. Finally the score was categorized into *less knowledgeable*, *knowledgeable* and *highly knowledgeable*. Also objective three, respondents were required to indicate whether they strongly Agree, Agree, Undecided, Disagree or Strongly Disagree for each statement. For data analysis Agree and Strongly Agree responses were combined and treated as Agree, on the other hand, Strongly Disagree and Disagree responses were combined and treated as Disagree. The undecided or neutral responses indicated that the respondents knew nothing or were not sure thus leading into three points Likert scale. So analysis for perception was done using summated scores. For the purposes of data to be interpreted, the means of each item that were ranging from 1.5 and above was characterized as positive attitudes and for the values which were below the mean of 1.5 was considered as negative attitudes.

Inferential statistics was employed for objective four where a binary logistic regression model was used to identify determinants of the use of improved postharvest storage technologies among small scale maize farmers in the study area.

The logistic model was as follows:

Logit (Y) $= \log(\pi/1\text{-}\pi i) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \ldots\ldots\ldots\ldots\ldots\ldots \beta_{10} X_{10}$

Where Y a binary response variable, Y=1 if the trait is present in observation i and X= (x1, x2, x3, x4 and x10) is a set of independent or explanatory variables whereby X1 is acquired formal education, X2 Access to credit, X3 access to extension services. X4 Farm size and X5 Off farm income X6, Number of bags harvested, X7 maize variety used, X8 participation in training, X9 membership in farmers group and X10 distance from house to market place.

The dependent variable which was used with logit model is the use of improved postharvest storage technologies (meant that either respondent is using one or more technologies were treated as they were using improved postharvest storage technologies) value 1 for using improved postharvest storage technologies and value 0 not using improved postharvest storage technologies. The value 1 indicated the respondent who used improved postharvest storage technologies while the value 0 indicated the respondent who did not use it. For independent variables such as value 1 indicated farmers who had access to extension, credits, education, off farm income, membership in group/farmers organization service while 0 value indicated farmers who had no access to them (Appendix 1).

3.6.2 Qualitative data analysis

Qualitative data analysed followed a Content Analysis approach (Mayring, 2014).Where all elements of data set were examined to clarify concepts and constructs as well as the deconstruction of the textual data into manageable categories, patterns, themes and relationships. Therefore, data collected from FGD and key informants were, coded, summarized, categorized and analyzed for objective one, two and three

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Overview

This chapter presents the demographic characteristics of the respondents, postharvest storage technologies commonly used by farmers in the study area, farmers knowledge level on the improved postharvest storage technologies, farmers' perception on the use of improved postharvest storage technologies and factors influencing use of improved postharvest storage technologies.

4.2 Demographic Characteristics of the Respondents

4.2.1 Respondents' social-economic characteristics

Table 2 indicates the distribution of respondents by socio-economic characteristics. The majority of respondents (76.9%) were male headed households.This show that there is dominance of male leadership at household level in the study area. Regarding age of respondents,findings show that of all respondents (87.6%) were aged between 26-55 years, which is productive age .This means that respondents in the study area are capable of engaging in agriculture and other economic activities which improves their livelihoods. In respects to with the education level, most of the respondents (66.5%) had completed primary school education while only small proportion (1.5%) had attended post secondary education

With regard to cultivated area, data indicated that, majority of the respondents (73.5%) cultivated one to four acres while few of respondents (2.7%) who cultivated above eight acres. This shows that the agricultural sector in the study area is generally dominated by small scale farmers. Similar findings have been reported by (Mrutu *et al.*, 2014), in their

their study found that, agriculture sector in Tanzania is dominated by small scale farmers cultivate less than five acres.

Table 2: Respondents' socio-economic characteristics (n=260)

Variable	n	%
Sex of household head		
Male	200	76.9
Female	60	23.1
Age of respondents		
26-35	57	21.9
36-45	114	43.8
46-55	57	21.9
>55	32	12.4
Education level		
Non formal	49	18.8
Completed primary school	173	66.5
Completed secondary school	34	13.1
Post secondary education	4	1.5
Marital status		
Single	23	8.8
Married	215	82.7
Separated	8	3.1
Divorced	8	3.1
Widow	6	2.3
Household size		
1-3	39	15.0
4-6	70	26.9
>6	151	58.1
Total area under cultivation in acres		
1-4	191	73.5
5-8	62	23.8
Above 8	7	2.7
Household income level TZS(annual)		
<200 000	9	3.5
210 000 -400 000	165	63.5
410 000 -600 000	37	14.0
610 000 -800 000	30	11.5
>800000	17	6.5
Household head access to credit		
Have access to credit	73	28.2
Have no access to credit	187	71.8
Purposes of growing maize		
Consumption	33	12.7
Sale	4	1.5
Consumption and sale	223	85.8

With respect to household size, about 60% of household had more than six individuals within the household, which is higher than the average households size in Tanzania which according to National Bureau of Statistics is five individuals with the household (URT, 2012). On the aspect of annual income, more than three quarters of respondents (79.7%) earned less than TZS 600 000/= while only 6.5% earned above TZS 800 000/= annually. With regards to marital status, most of respondents (82.7%) were married while only 2.3% of respondents were widowed.

Findings further, indicate that the majority of the respondents (85.8%) grow maize for consumption and sale (Table 2). Since farmers experience low prices at harvesting time and high prices during planting sesson and in order to ensure availability of food through out the year storing of maize is a strategy to get more benefits. This means that maize is required to be stored in order to maintain the quality and quantity for consumption and sale. During harvesting time, usually there is a higher supply than demand and hence lowering price. For food security and economic purposes, there is a need for farmers to store their produce until the price is reasonable and ensure availability of produce throughout the year.

4.2.2 Respondents' crop production information

4.2.2.1 Major crops grown by respondents in the study area

Maize, beans, potatoes and vegetables (tomatoes and onions) were the major crops grown by respondents in the study area. The findings (Table 3) indicate that all respondents grow maize and beans while 56.9 % and 53.9% grow round potatoes and vegetables. Respondents grow maize, beans, potatoes and vegetables for consumption and sale while sweet potatoes and cassava were grown by few respondents for food in times of food scarcity. Since sweet potatoes and cassava are considered drought resistant crops, although very few farmers were involved in production of these crops.

Table 3: Crops grown by respondents in the study area (n=260)

Crop	n	%
Maize	260	100
Beans	260	100
Round Potatoes	148	56.9
Vegetables	140	53.8
Sweet potatoes	86	23.0
Cassava	55	21.1

Note: The percentage exceed 100% because of multiple responses.

4.2.2.2 Maize varieties grown by rrespondents for the last cropping season

More than half (50.8%) of respondents used local maize varieties. Through discussion with key informants, it was revealed that the majority of respondents in the study area were using local varieties. Responding to a question why they prefer using local varieties respondents said that because they are locally available, affordable and accessible. Also, varieties were perceived to be resistant to some diseases and storage pests even if have low yield potential compared to improved varieties. The remaining half of respondents used improved varieties as follows: 30% used DK8053, 11% used PAN 691 and 8 % used UH615 as shown in Fig. 3. The finding of this study is different from those of Lyimo *et al.* (2014) whom reported that about 30% of farmers in the county used improved seeds of maize. The reasons stated were the high cost of improved seeds of maize and unavailability of recommended maize seeds varieties basing on ecological zone in different parts of Tanzania.

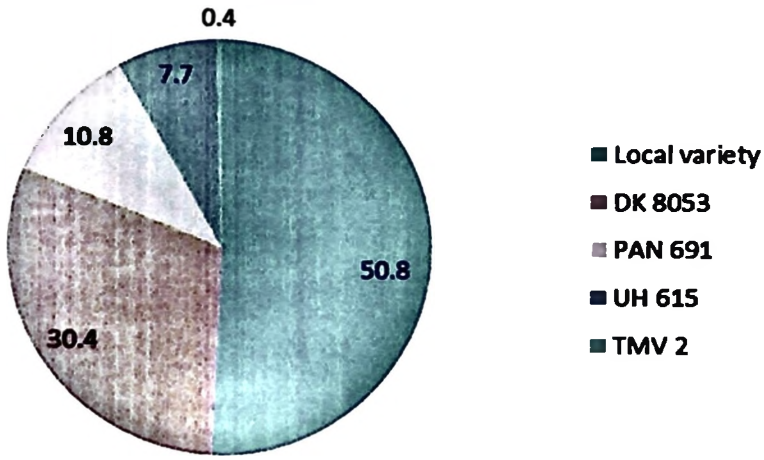

Figure 3: Maize varieties grown by small scale maize growers (n=260)

4.2.2.3 Yield of Maize in tons/ha in the last season

Findings (Table 4) indicate that, about 75% of respondent harvest between 1.5 to 3.75 t/ha. Only 21.9% of the respondents harvested 3.7 and above t/ha. This indicates that the average production of maize in the study areas 2.5 t/ha (KDC, 2016) which is higher than national average. According to Mrutu *et al.* (2014) and Magehema *et al.* (2014), the national average for maize production ranges between 1.2 and 1.6 t/ha while available show that which is extremely low to meet the available food demand.

Table 4: Yield of maize harvested tons/ha by respondents (n=260).

Yield t/ha	n	%
0.25 -1.25	5	1.9
1.26 -2.6	118	45.4
2.7 - 3.7	80	30.8
>3.7	57	21.9
Total	**260**	**100**

4.3 Postharvest Storage Technologies Commonly Used by Respondents

Study findings (Fig. 4) indicate common postharvest storage technologies used by small scale maize farmers in the study areas. These include polythene bags (65.4 %), storage chemicals (32.3%), traditional granaries (24.7%), PICS (18.2%), improved granaries (4.1%) and metal silo (2.2%). Generally, most of the respondents reported to use traditional storage technologies.

During FGD with participants, it was revealed that, traditional storage technologies are poor in maintaining the quality and quantity of stored products. This finding is similar to those of Gitonga *et al.* (2015) who reported that most of the African communities still rely on unimproved storage technologies for food storage because are simple and inexpensive to construct. The same author pointed that unimproved or traditional storage systems lead to substantial post-harvest losses. Further, during FGD it was revealed that farmers who were using traditional storage technologies sold their products soon after harvesting. The FGD further revealed that, farmers remained with only a little amount of food and little seeds for the next season. The findings of this study are comparable to those of Gitonga *et al.* (2015) and Abass *et al.* (2014) who reported that traditional storage practices in African countries cannot guarantee protection against major storage pests of staple food crops like maize.

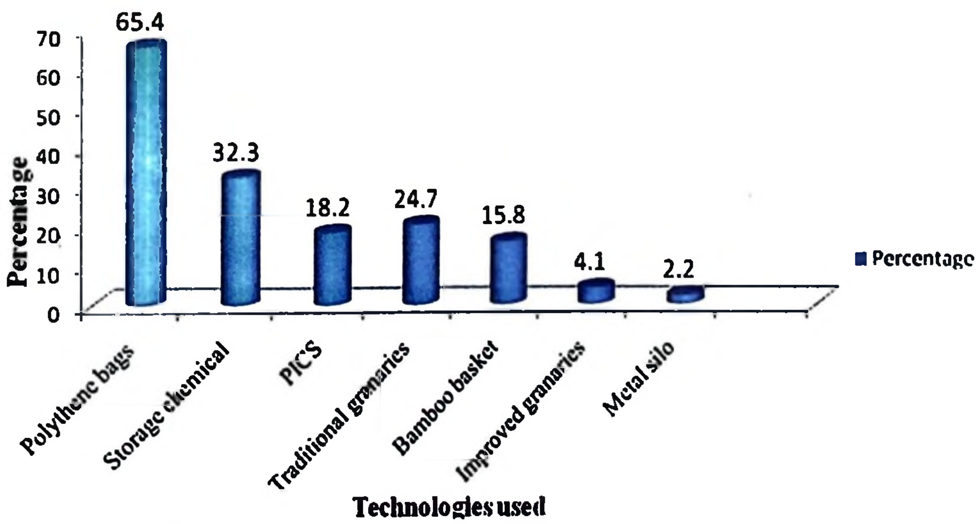

Figure 4: Postharvest storage technologies commonly used (n=260)

Note: The percentage exceed 100% because of multiple responses

On the use of storage chemicals, 32.3% of respondents used storage chemical such as Actelic Super Dust and Phostoxin. This proportion was higher compared to the use of improved postharvest storage technologies such as PICS and meta silo .This could be due to fact that the cost of storage chemicals was perceived at least cheaper by respondents and mostly available than other technologies in their areas .The findings of this study are similar to those of ANSAF (2006) conducted in Dodoma and Manyara, which found that large proportion of farmers (67.7%) used storage chemicals and knew that insecticides can protect their stored maize while only 28.3% farmers used improved storage technologies such as storage chemicals, hermatic bags and improved granaries.

4.3.1 Respondents' perceived benefit of improved postharvest storage technologies

Regarding the benefits of using improved postharvest storage technologies in the study area. The results (Fig. 5), indicate that 54% of the respondents believed that improved postharvest storage technologies helped the households to have food throughout the season. Also, 30.8% of respondents perceived that when grains are stored by using improved postharvest storage technologies such as PICS and metal silo, the quality and quantity of stored grains were maintained and hence ensuring food security and made it easy possible to sell their products at premium prices. This is proved by fact that respondents in the study area who stored products by using improved postharvest storage technologies were found to have maize throughout the year compared to respondents who used traditional storage technologies. The findings are similar to those of Gladstone *et al.* (2002) who reported that more than 60 % of the farmers surveyed in their study were found to have maize grain in their silos at the beginning of the next harvest in comparison with only 29% of the non-users.

Another reported benefit of using PICS and metal silo was that they reduced women workload in the study area. This is because they maintain quality of the produce with no need for winnowing and sorting before processing or selling. The findings are similar to those of Bukosheva *et al.* (2012) who found that the use of improved postharvest storage technologies reduce women's workload due to the absence of daily shelling, winnowing, sorting and removal of grains for drying, which reduces gender inequalities. Another benefit reported by respondents is that they reduce costs of storage because they are durable. This finding is similar to the study done by Tefera *et al.* (2011) and De Groote *et al.* (2013) on impact of metal silos in Kenya who found that metal silos reduces cost of storage due to their durability.

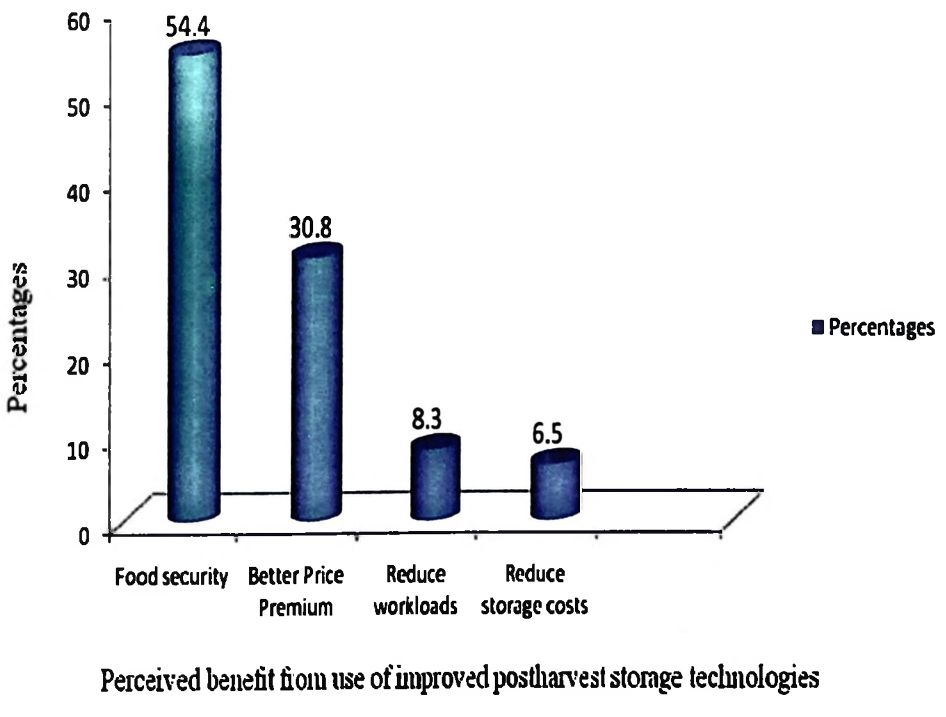

Figure 5: Respondents perceived benefit of improved postharvest storage (n=260)

Note: The percentage exceed 100% because of multiple responses

4.3.2 Respondents' reason for not using improved postharvest storage technologies

Findings (Table 5) show that 21.5% of respondents in the study area reported that they did not use storage chemicals in storing maize health problems if improperly used. Respondents were of the view that storage chemicals could contaminate the products and hence affect human health. This finding is similar to those of Manuku *et al.* (2013) who reported that the people of Matebele land in the southern province of Zimbabwe did not prefer the use of storage chemicals due to health concerns. Through FGD with participants in this study, it was revealed by participants that respondents in the study area were not using storage chemicals due to health concerns.

Table 5: Reasons for not using improved postharvest storage technologies (n=260)

Reasons	Technologies							
	Improved granaries		Storage chemicals		Metal silo		PICS	
	n	%	n	%	n	%	n	%
High initial cost	160	61.5	62	23.8	180	69.2	89	34.2
Lack of knowledge	64	24.6	58	22.3	41	15.8	84	32.3
Low returns	18	6.9	24	9.2	62	23.8	43	16.5
Contamination	22	8.5	56	21.5	4	1.5	4	1.5
Not available	7	2.7	15	5.7	30	11.5	22	8.5

Note: The percentage exceed 100% because of multiple responses

The findings of this study further revealed that over 60% of respondents reported that high initial costs for purchasing the technologies was a reason for not using improved granaries and metal silo. For instance, the initial cost for metal silo in the study area was 350 000 - 400 000/=TZS per piece. The cost varied geographically depending on the location of the respondents. On the other hand, lack of knowledge on the use of technologies such PICS (32%) and for metal silo (15 %). Similarly studies by Khann and Keatinge (2000), Okoedo (2009) and Doss (2003) who reported that high initial costs and inadequate knowledge are the some of several reasons attributed to poor utilization improved storage technologies among small scale farmers in Sub Saharan Africa. Findings further show that less than ten percent of respondents reported non availability of the technologies as a reson for not using them. The finding is in line with a study by Satyanarayani *et al.* (2009) who found 18.5% complained of non-availability of improved storage the technologies as a reason for poor adoption in India.

According to respondents, high initial cost and lack of knowledge were the main reasons for not using improved postharvest storage technologies such as metal silos and improved granaries.

4.4 Respondents' Knowledge Level on the Use of Improved Storage Technologies

4.4.1 Source of information on the use of improved postharvest storage technologies

Findings of this study (Table 6) show that about 48% of respondents in the study area relied on other farmers for getting information on improved storage technologies and only 34% got information from extension officers. Other sources of information were mobile phones (32%), radio (20.8%) and television (14.6%). This indicates that the major sources of information on improved storage technologies were fellow farmers. Similar findings were reported in the study done by (Masinde *et al.*, 2012) who found that farmers are commonly still depending on exchange advice informally with friends and neighbours. Other sources of information identified are traders (9.6%), researchers (8.8%) and tele-centres (1.6%). Likewise, Ayouade (2010) in Oyo state found that others source of information were posters, newspapers, research institutions and revealed that farm centres were the major sources of information for cowpeas production technologies. These points to the fact that farm centres could in addition to other sources be an important way of disseminating information among farmers.

During FGDs participants revealed that respondents had varying information needs and use different channels to get and share information among them. The findings are similar to those of Onasanya *et al.* (2007) who found that, informal communication among farmers is a key determinant of the use of improved technologies. Apart from informal communication channel, formal channel through agricultural extension was used by fewer respondents, probably due to low ratio between extension and farmers in the study area. In addition, they are not facilitated with transport facilities something that limit the extension agents to reach the majority of farmers. The situation becomes even worse in areas with sparsed populations and where the agent as to work up and down the mountains to contact farmers as it is the case with the study area. This has been found to reduce the effectiveness of extension services measured in terms of number of visits in a given time scale FAO (2008) and URT (2012). Oladosu (2004) pointed out that adoption and utilization of appropriate technology is largely dependent on the effectiveness of extension services and relevance of information disseminated and the ability of extension agents to persuade the farmers.

Furthermore, the findings of this study show that, despite an increase in the use of ICT-based communication technologies, for example radio, television and mobile phones. In Tanzania, in this study, ICT- they were used by less than 40 % respondents to access information on the use of improved storage technologies in the study area. Another interesting finding is that although the extension service agents have an obligation to train farmers on the use of improved storage technologies, in the study area only 10% of respondents reported training to be a source of information. Ayouade (2010) reported that greater effectiveness of extension methods can be ensured through regular training by providing farmers with required facilities, reorganization of extension programs and involving local leaders as agents for the dissemination of information.

Table 6: Source of Information on the use of improved storage technologies (n=260)

Source of information	Response n	%
Extension Officers	87	33.5
Other farmers	124	47.7
Mobile phones	82	31.5
Radio	54	20.8
Training	26	10
Television/Video	38	14.6

Note: The percentage exceed 100% because of multiple responses.

4.4.2 Respondents' knowledge level on improved postharvest storage technologies

To determine level of knowledge among the respondents on the use of improved storage technologies were requested to respond to 10 items meant to measure their understanding on the technical recommendations or practices for the use of improved storage technologies. These statements were generated from literature review and researchers understanding of the subject. Respondents were requested to respond to a given statement (all statements were positively stated) by indicating Yes for the statement they perceived to be correct or No for the statement they perceived to be incorrect. For each correct response was assigned one mark while for incorrect response was assigned zero mark. Respondents who scored less than five marks were categorized as less knowledgeable; those scoring between five and eight marks were categorized as knowledgeable and above eight marks were categorized high knowledgeable (Table7).

The findings (Table 7) indicate that more than 60% of respondents in the study area were less knowledgeable on the use of improved storage technologies. This could be attributed by insufficient training on improved storage technologies, poor extension services to farmers in the study area as indicated above. Also, poor access to information on the use of improved storage technologies in the study area led the respondents to have low knowledge.

Table 7: Respondents' knowledge level on the use of improved storage technologies (n=260)

Knowledge statements	Response Yes n	%
Harvesting matured/dried maize grain	180	69.2
Stored at Moisture Content of (12-14%)	45	17.3
Cleaning maize before storage	145	55.7
Tighten well (PICS)	55	21.2
Put on pallet(PICS)	18	6.9
Cleaning(metal silo) before storage	10	3.8
Caps are well tightened (metal silo).	12	4.6
Use recommended rate(storage chemical)	25	9.6
Rat guards used (improved granaries).	14	5.4
The inlet and outlets pots well closed (improved granaries).	22	8.5
Overall score		
High knowledgeable	32	12.3
Knowledgeable	68	26.2
Less knowledgeable	160	61.5
Total	**260**	**100**

Note: The percentage exceed 100% because of multiple responses

These findings are similar to those of Kamanula *et al.* (2011) on farmers' insect pest management practices of stored maize and beans in Southern Africa who found that, the majority of respondents had low knowledge on the use of improved postharvest storage technologies due to poor extension services, insufficient information and community awareness. These findings further are supported by the study done by Ndunguru et *al.* (2014) who reported that most of the small scale farmers (86%) in Tanzania have limited knowledge on the use of appropriate methods for proper management of storage technologies. AGRA (2013) and Maonga *et al.* (2013) also reported that farmers' low knowledge level on the use of postharvest storage technologies is directly associated with poor access to extension services, education level, wealth level, farmers organization, access to credit and geographical location of the farmers.

Data reveal that the majority of respondents knew that harvesting matured maize and dried up to at least (14%) moisture content and cleaning such as winnowing sorting the maize were important aspects for consider for efficient storage. However, findings further show that over (90%) of respondents had had low knowledge on the use of improved storage technologies. For instance, (90.4%) of respondents reported that they used storage chemical without knowing the proper rate to use. The implication is that they may over dose or underdose leading reduced efficiency and effectiveness of the chemical against storage insect pests.

Findings from FGD with DAICO, DAEO and Extension Officers confirmed that majority of farmers in the study area had low knowledge on the use of improved storage technologies as a result of the failure of the Department to implement capacity building activities for improving postharvest storage technologies due to budget constraints. To summarize, more than half of respondents reported had low knowledge on the use of improved postharvest storage technologies such as PICS, metal silos and storage chemicals.

4.5 Farmers' Perception on Improved Postharvest Storage Technologies

To determine farmers' perception on the use of improved postharvest storage technologies, Likert Scale type statements were used. There were nine attitudinal statements developed after reading literatures on postharvest storage technologies. Respondents were requested to indicate whether they strongly agree, agree, undecided, disagree or strongly disagree for each statement. For data analysis Agree and Strongly Agree responses were combined and treated as Agree, on the other hand, Strongly Disagree and Disagree responses were combined and treated as Disagree. The undecided or neutral responses indicated that the respondents knew nothing or were not sure thus leading into three points Likert scale as indicated in Table 8.

Findings (Table 8) indicate that half of respondents agreed that with the statement that metal silo, improved granaries, PICS and storage chemical technologies maintain the quality of stored products. Where by metal silo and PICS having higher rates 64% and 61% respectively. Of all four technologies, metal silo was highly perceived by respondent's durable (89%), environmentally friendly (65%) and product stored in metal silo to be safe for human consumption (84%). On the other hand, metal silos were perceived to have high initial cost (85%) closely followed by improved granaries. On the other hand, almost 90% of respondents agreed that improved granaries required high maintenance cost.

During FGDs participants revealed that improved granaries are not much durable as other technologies like PICS and metal silos, thus requires regular maintenance compared to other improved postharvest storage technologies which are found in the study area. Also its surprising that 58% of respondents agreed with the statement that stored products are safe to human consumption with regards to using storage chemical due to lack of knowledge on the side effects of storage chemical especially when applied without considering their recommended rates.

Table 8a: Respondents' score on the items of the Likert type scale used to assess perception on use of improved postharvest storage technologies (n=260)

Attitudinal statement	Technology											
	PICS						Metal silo					
	Disagree		Undecided		Agree		Disagree		Undecided		Agree	
	n	%	n	%	n	%	n	%	n	%	n	%
Highly maintain the quality and quantity of stored products.	43	16.5	59	22.7	158	60.8	65	25.0	28	10.8	167	64.2
Relatively is durable	48	23.5	82	31.5	140	53.8	39	15.0	54	20.8	232	89.2
It is is environment friendly	66	25.4	43	16.5	151	58.1	29	11.2	61	23.4	170	65.4
When used to store products are Safe for human consumption	58	23.5	12	4.6	190	73.1	12	4.6	219	11.2	219	84.2
The technology require high initial cost	190	73.1	12	4.6	58	23.5	13	5.0	25	9.6	222	85.4
It require high maintenance cost	211	81.2	12	4.6	37	14.2	240	92.3	8	3.1	12	4.6
It is prone to rodents attack	211	81.2	12	4.6	37	14.2	240	92.3	8	3.1	12	4.6
It is less effective against insects storage pests	24	9.2	191	73.1	45	17.3	240	92.3	12	4.6	8	3.1
When used stored products exposed to thieves	190	73.1	37	14.2	33	12.7	232	89.2	25	9.6	3	1.2

Table 8b: Respondents' score on the items of the Likert type scale used to assess perception on use of improved postharvest storage technologies (n=260)

Altitudinal statement	Technology											
	Storage chemicals						Improved granaries					
	Disagree		Undecided		Agree		Disagree		Undecided		Agree	
	n	%	n	%	n	%	n	%	n	%	n	%
Highly maintain the quality and quantity of stored products.	84	32.2	26	10	150	57.7	38	14.6	82	31.5	140	53.8
Relatively is durable	173	66.5	75	28.8	12	4.6	16	6.2	12	4.6	167	64.2
It is is environment friendly	178	68.5	53	20.3	29	11.2	82	31.5	64	24.6	114	43.9
When used stored products are safe for human consumption	96	36.9	12	4.6	152	58.5	30	11.5	150	57.7	80	30.8
The technology require high initial cost	169	65	12	4.6	79	30.4	78	30	106	40.8	173	66.5
It require high maintenance cost	96	36.9	12	4.6	152	58.5	4	1.5	24	9.2	232	89.2
It is prone to rodents attack	228	87.7	20	7.7	12	4.6	98	37.7	150	57.7	12	4.6
It is less effective against insects storage pests	150	57.7	38	14.6	82	31.5	190	73.1	25	9.6	45	17.3
When use to store products exposed to thieves	234	86.1	10	3.8	16	6.2	180	69.2	40	15.4	40	15.4

By using a three- point rating responses (2=Agree; 1=Disagree; and 0=Undecided), means standard deviation values associated with each item for each technology were determined (Table 8). For the purposes of data to be interpreted, the means of each item that were ranging from 1.5 and above was characterized as positive attitudes and for the values which were below the mean of 1.5 was considered as negative attitudes.

The findings (Table 9) showed that for all five positive phrased statements, respondents perceived that when products are stored in improved storage technologies such as PICS and metal silos were safe for human consumption (mean 1.55) but when considering the mean of each technology, metal silo had a mean of (1.81), compared to storage chemical (mean 0.98). This implies that respondent perceived that stored maize using metal silo were relatively more safer for human consumption. On effectiveness, metal silo was perceived effective on the grounds that it creates an unfavorable environment for the growth of microorganisms like fungus (Aspergillus flavus) which is the causative agent of afflatoxin in grains. However this is true when metal silo are well cleaned and dried and maize stored with recommended moisture contents (12%-14%).

Table 9: Respondents score on their perception using mean and standard deviation towards improved postharvest storage technologies (n=260)

Attitudinal statements	Technologies									
	Improved granaries		PICS		Metal silo		Storage chemical		Overall	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Highly maintain the quality and quantity of stored Product	1.85	0.47	1.75	0.54	1.88	0.45	1.54	0.52	1.75	0.50
Relative is durable	1.65	0.56	1.67	0.34	1.88	0.45	1.12	0.38	1.69	0.58
It is environment friendl	1.67	0.63	1.55	0.68	1.81	0.52	0.98	0.32	1.55	0.64
When used to store products are safe for human	1.51	0.64	1.68	1.59	1.84	0.42	1.25	0.64	1.52	0.56
consumption	1.77	0.55	1.77	0.55	1.81	0.52	0.94	0.38	1.57	0.60
The technology require high initial cost	1.34	0.64	1.25	0.58	1.18	0.28	1.26	0.66	1.24	0.55
It require high maintenance costs Prone to	1.34	0.64	1.25	0.58	1.23	0.61	1.56	0.56	1.25	0.48
rodents attack	0.94	0.36	1.25	0.58	1.23	0.61	1.56	0.58	1.25	0.48
It is less effective against storage pests	1.89	0.44	1.44	0.67	1.42	0.62	0.58	0.22	1.32	0.43
When used to store products exposed to thievies										

Improved postharvest technologies are durable because when used they last longer as revealed in the study area (mean 1.69). Therefore, improved storage technologies such as PICS, improved granaries and metal silo can be used to store product for more than three years and hence reducing costs of purchasing technologies each year. Also, they are environment friendly (Mean 1.52) compared to traditional storage technologies as they help to preserve trees, bamboos and grass by not requiring intensive use of such forestry products. Thus, maize improved storage structures are potential in contributing to environmental conservation efforts because they reduce the use of forest product and hence maintaining natural vegetation. The findings are in consistence with Stathers *et al.* (2013) who found that improving postharvest management techniques can also help build resilience against current and future climate-related shocks and reduce the need for expanding farmland and damage to environmental services, including carbon sequestration (mitigating the effects of global warming).

Further analysis indicated that on average respondents rated high (mean 1.75) the statement that when the product is stored in improved granaries, metal silos and PICS increases lifespan, maintain its quantity and quality for a desired period of time. Specifically metal silos was highly rated (mean 1.88) followed by improved granaries (mean 1.85) and PICS (mean 1.75). In the study area respondents perceived that metal silo and PICS as effective. This means that they are perceived more positively on maintaining the quality and quantity of stored products (over 60% agreed) compared to products stored by using storage chemicals technologies. These findings are different to those of Kimami's (2016) who found that small proportion (33%) of respondents perceived that metal silo technology maintained quantity and quality of stored grains Likewise, Gladstone and Hruska (2002) found that about 60% of the respondents were found to have maize grain in their silos at the beginning of the next harvest in comparison with only 29% of the non-users. For instance, when products stored either in PICS or metal silo are free from infestation and this could be because of their characteristics of not allowing insects to invade the products and free from contamination. These findings are in agreement with the study of Tefera *et al.* (2011) and De Groote *et al.* (2013) who found that metal silos were effective in controlling maize weevils and the larger grain borers (LGBs).

Also, the study findings show that generally respondents perceived high initial cost for purchasing the improved postharvest storage technologies (mean 1.57.) The mean score for improved granaries was 1.77 and for metal silos was 1.81. For example metal silos are made up of galvanized iron sheets which are expensive. Okoedo (2009) also found that the high initial cost of improved storage technologies accounts for farmers not using storage technologies. Also the findings of Satyanarayani *et al.* (2009) reported that the poor adoption of improved storage technologies in India was caused by high initial cost of the improved storage technologies in India was caused by high initial cost of the improved systems. With regard to the study area 69.2% of respondents complained on the high initial cost for purchasing metal silos and 61.5% of respondents complained on high cost for the improved granaries as discussed earlier in Likert scale above.

Generally, respondents positively perceived metal silo, improved granaries and PICS to be more effective while storage chemical was negatively perceived on the ground of health concern or implication.

4.6 Factors influencing the Use of Improved Postharvest Storage Technologies among Respondents

4.6.1 Tests of goodness of fit

Table 10 indicates the Log likelihood ratio 42.29 (which is the difference between the null model and model with independent (s) variables). In order to test a goodness of fit, the Omnibus Test of Model Coefficients like the log likelihood ratio test statistics is used because the Omnibus test statistics measures the overall model fit as it tests the hypothesis. For the null hypothesis (Ho): All coefficients of the independent variable are equal to zero and for alternative hypothesis (H1): At least one coefficient of an independent variable is not equal to zero. According to the results shown in Table 9, the null hypothesis was rejected because the p. value of the Omnibus was 0.002 which was less than 0.05. This implies that, the logistic regression can be used to model the data (Pallant, 2007).

Table 10: Mode evaluation

Tests	X^2	df	p-value
Model evaluation overall			
Log likelihood ratio tests which is equal to Omnibus Test of Model Coefficient	42.29	10	0.002
Percentage Accuracy in Classification (PAC):			
Null model = 62.1			
Model with predictors =78.5			
Cox& Snell R^2 = 0.43			
Negelkerke R^2 = 0.61			

4.6.2 Description of the estimated coefficients of determinants of the use of improved postharvest storage technologies

The results in Table 11 indicate that the predictors of the use of improved storage technologies were: acquired formal education, access to credit, access to extension services, membership in farmers' organizations and distance from home to the market place. These coefficients were statistically significant at $p<0.05$ while farm size, training, off farm income variety and number of bags harvested had no significant influence on the use of storage technologies at $p<0.05$.

The predictors which were statistically significant are discussed as follows:

Acquired Formal education

The presented results (Table 11) indicate that the use of improved postharvest storage technologies among small scale maize farmers is associated with formal education. Data indicated that as the respondents acquired a formal education it increases the chances of using improved postharvest storage technologies by 2.12 times at $p < 0.05$ when other factors are kept constant. This means that, when the respondents acquire formal education they are likely to use the improved storage technologies as compared to those without formal education.

Table 11: Binary Logistic Regression for the determinants of use of selected improved postharvest storage technologies (n =260)

Variable	B	S.E	wald	d.f	P.value	Exponent (β)	95.0% C.I for EXP(B)	
							Lower	Upper
Acquired formal education	0.751	0.375	4.124	1	0.042*	2.119	1.026	4.160
Access to credit	0.295	0.561	1.865	1	0.027*	1.343	1.809	3.276
Access to extension services	1.127	1.328	7.990	1	0.031*	3.086	1.208	4.752
Farm size	1.073	2.001	12.951	1	0.110	2.924	2.050	8.404
Off farm income	1.140	1.339	2.412	1	0.058	3.127	2.788	12.673
Number bags harvested	-2.833	0.320	6.806	1	0.109	0.059	0. 032	1.413
Variety	-1.528	1.313	2.723	1	0.092	0.217	0.112	2.037
Training	1.576	0.438	4.642	1	0.063	4.835	3.725	16.274
Membership in group	0.802	0.296	7.397	1	0.016*	2.229	1.283	3.798
Distance from market place	-0.627	0.449	1.947	1	0.033*	0.534	0.219	1.517
Constant	**-1.334**	**1.585**	**1.327**	**1**	**0.567**	**0.261**		

***Statistically significant at p<0.05**

This could be because they get information from various sources such as books, magazine and leaflets as they can read and write and have a chance of memorizing information concern with improved storage technologies. The findings are similar with Maonga *et al.* (2013) in adoption of metal silo in Malawi who found that, formal education had a consistently positive relationship to adoption of small metal silo technology. Also

Adegbola *et al.* (2010) in Benin found that the respondents who had formal education preferred to use improved postharvest storage technologies compared to their counterparts who were did not have it. Similarly Uaiene *et al.* (2009) in Mozambique found that completion of at least lower primary school implies a much higher propensity to adopt new technology than lower or zero levels of education.

Access to credit

The findings of the study (Table 11) show that, access to credit increase the odds of using improved postharvest storage technologies by 1.34 times at $p<0.05$ when other factors are kept constant. This means that, the respondents in the study area who had access to credit we more likely to use the improved postharvest storage technologies and other improved agricultural technologies compared to those who had no access to credit. The findings of this study are similar to those of Venance *et al.* (2016), Letaa *et al.* (2014) and Akudugu *et al.* (2012) who found that farmers who had access to formal credit were likely to adopt the improved technology than those who had no access to credit. Credit helps farmers to have the means to purchase agricultural inputs which facilitate a farmer to adopt new technologies. In the study area, only 28.2 % of respondents had access to credits and 71.8 % had no access to credit because most of them were poor such that had few assets that could be used as collateral for loan security as usually demanded by the creditors. Another predictor is access to credit from different sources like banks such as MUCOBA (Mufindi Community Bank) which is dealing with the provision of credit for supporting agricultural activities in the study area. This had an association with the use of the improved postharvest storage technologies.

Access to extension services

Access to agricultural extension messages is believed to have a positive influence on technology uptake by farmers. Findings (Table 11) show that access to extension services in the study area increased their chances of using improved postharvest storage technologies by 3.09 times when other factors are kept constant. This means that respondents that Had regular contact with extension agents are more likely to use improved storage technologies and other improved agricultural technologies, as well as how to apply the technology. These findings are similar to those of Uaiene *et al.* (2009) in Mozambique who found that, contact with extension agents had a positive effect on uptake of metal silos based on the adoption theory. Implying that extension visits and contacts increased the probability of uptake of a new technology by farmers. Since extension agents have two main roles which are educational and communication, it means that access to extension services enable access to information. Also, Maonga *et al.* (2013) who conducted study on influence of extension services on metal silos adoption found that, the probability of adopting small metal silo technology was 44.5% higher for smallholder farmers with access to agricultural extension services than those without access. Barungi *et al.* (2013) found that the probability of adopting Napier grass in Uganda was 25.6% higher for farmers with access to extension services than for those without access to extension services.

Membership in farmers' organization

Other predictor of the use of improved postharvest storage technologies is a membership in farmers' organization, The findings of this study (Table 11) show that there was a sufficient evidence that organization farmers who were members of (VICOBA, SACCOS and AMCOS mention the farmer groups) used improved storage technologies than non-members at $p< 0.05$. meaning that group membership increased the chances of using storage technologies by 2.23 times when other factors are kept constant. Probably farmers' groups provide social capital that enables access to credit that facilitates technologies adoption and use. This supported by membership in farmers groups enabled access a platform to purchase technologies and discuss issues concerning use of improved storage technologies and associated benefits. The findings supported by those of Wekesa *et al.* (2003) and Lwala *et al.* (2016) who found that membership in an organization, such as farmers association, could lead to better access to information related to adoption of improved storage systems through training, discussion and sharing experience due to fact that farmers who had membership in various groups could meet on several days and share ideas concerning farming activities.

Distance from home of respondents to the market place

Distance from home of respondents to the market place was found have a significant negative association with the use of improved storage technologies. It is indicated in Table 11 that a unit increase in distance to the marketplace leads to a decrease in chance to use improved storage technologies by 0.53 times at $p< 0.05$ when other factors are kept constant. This was because respondents who are close to the market place are more exposed to some of storage technologies such as the use of PICS and also they easily access the technologies. Long distance to the market place which is atypical of the situation in the study area may further limit the use of improved technologies. This result is consistent with those of Adegbola *et al.* (2010) and Idrissa *et al.* (2012) and who in their studies found that, there was an association between the distance to market place and adoption of modern technology. On the other hand, farmers that are close to sources of the improved technologies take advantage of their closeness and tend to adopt the innovations compared to those who stay far away from the sources of the technologies. With regards to the study areas, poor road networking coupled with difficult terrain make movement difficult that inhibits communication and accessibility of farmers to technologies such as PICS and metal silos. To summarize this section, it can be said that formal education, access to credit, access to extension services, membership in farmers group and distance from market place were critical factors influencing of the use of improved postharvest storage technologies among small scale maize growers.

CHAPTER FIVE

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Overview

This chapter presents the conclusions and recommendations based on the findings of the study. The chapter is divided into two subsections: conclusions and recommendations.

5.2 Conclusions

Based on the findings of the study, the following conclusions can be drawn.

(i) Traditional storage technologies such as polythene bags, traditional granaries and bamboo basket were the commonly used maize storage technologies to store maize in the study area as they were used by over 50% respondents. The low use of improved storage technologies such as PICS, metal silos and improved granaries was due to such reasons as high initial cost of technologies, low knowledge on how to use them and low returns from the produce.

(ii) 60 % respondents had low knowledge on the use of the improved postharvest storage technologies that led few respondents to be able to use the technologies as recommended. Further, fellow farmers were the main sources of information on the use of improved postharvest storage technologies.

(iii) The majority of respondents had positive attitudes on the use of PICS, Improved granaries and metal silos. On the account that the technologies are durable and maintain the quality and quantity of stored products, therefore products stored in these technologies were safe for human consumption and environmental fiiendly even if they require high initial cost and in addition improved granaries require high maintenance costs.

(iv) Acquired formal education, access to credit, extension services distance from home to market and membership in farmers groups are factors influencing the use of improved postharvest storage technologies among small scale maize farmers the study area.

5.3 Recommendations

Based on the conclusions drawn from the findings, the following recommendations are made:-

(i) Kilolo District Council in collaboration with private sector and other development partiners:-

- Should promote the use of improved post harvest technologies Such as PICS, Improved granaries and metal silos to ensure reduced PHL and ensure food security and increased income.
- Should develop training programs on capacity building of the extension officers to enable them to train small scale farmers on the maize postharvest handling.

(ii) The government should :-

- Continue to invest in formal education to ensure that the larger population access education as it was found to have a positive influence on the use of improved postharvest storage technologies.
- Should subsidize improved postharvest storage technologies such as metal silo, improved granaries and PICS which seems to have high initial costs but are more perceived most effective.

(iii) Extension agents/ officers should increase their contacts with farmers and educate them on the importance of the use of improved storage technologies and skills on how to use the improved storage technologies for maize storage through mass media and group based extension approaches.

(iv) Extension officers should encourage farmers to form groups for community storage mechanisms such as cereal banks and warehouse receipt systems.

REFERENCES

Adegbola, P. Y. (2010). Economic Analyses of maize storage innovations in Southern Benin. Dissertation for Award of MSc Degree at Wageningen University, The Netherlands. 45pp.

AGRA (Alliance for Green Revolution in Africa), (2013). *Establishing the Status of Post-Harvest Losses and Storage for Major Staple Crops in Eleven African Countries*. Alliance for Green Revolution in Africa, Nairobi, Kenya. 12pp.

Anakware, J. P., Obeng, O. D., Nuramah, K. O., Fatumbi, O. K. and Bonu, M. I. (2013). Use of the triple layer Hermatic bags against the maize weavils, Sitophilus in three varieties of Maize. *Journal of Entomology, Orthithology and Herpetology* 3(1): 10 – 12.

Ani, A. O. (2002). Factors inhibiting agricultural production among rural women in Southern Ebonyi State, Nigeria. Thesis for Award of PhD Degree at University of Maiduguri, Nigeria. 84pp.

ANSAF (Agriculture Non State Actors Forum), (2016). Assessment of genetic diversity of maize inbred lines and hybrids in central zone of Tanzania by using random amplified polymorphism markers. *American Journal of Research Communication* 2(4): 84 – 98.

Ayouade, A. R. (2010). Effectiveness of information sources on improved farmers' practices among cowpeas farmers in Oyo State. *Global Journal of Human Social Sacience* 10(4): 39 – 46.

Becker, G. S. (1964). *Human Capital: A Theoretical and Empirical Analysis*. Columbia University Press, New York. 219pp.

Becker, M. (2001). Potential and limitations of green manure technology in lowland rice. *Journal of Agriculture in the Tropics and Subtropics* 102(2): 91 – 108.

Bahiigwa, G., Owach, C. and Elepu, G. (2017). Factors influencing the use of food storage structures by Agrarian communities in northern Uganda. *Journal of Agriculture, Food Systems, and Community Development* 4(2): 116 – 119.

Baoua, I., Margam, I., Amadoul, L. and Murdock, K. (2016). Triple bag hermetic technology for controlling a bruchid in stored Hibiscus Sabdariffa grain. *Journal of Stored Products Research* 9(1): 20 – 22.

Barreiro, J. (2012). *Analysis of Incentives and Disincentives for Maize.* Technical Notes Series No 4. Food and Agriculture Organization, Rome, Italy. 12pp.

Barungi, B., Ng'ong'ola, D. H., Edriss, A., Mugisha, J., Waithaka, M. and Tukahirwa, J. (2015). "Factors Influencing the Uptake of Soil Erosion Control Technologies by Farmers along the Slopes of Mt. Elgon in Eastern Uganda". *Journal of Sustainable Development* 6(2): 9-25.

Bryman, A. (2015). *Social Research Methods* Fourth Edition. Oxford University Press, New York. 683pp.

Bukosheva, B., Smale, M., Brain, H., Duveiller, E. and Reynolds, M. (2012). Crops that feeds the World. Past success and future challenges to the role played by wheat in global food security. *Journal of Food Security* 3(5): 291 – 317.

Challa, M. and Tilahun, U. (2014). Determinants and impacts of modem agricultural technology adoption in west Wollega: the case of Gulliso District. *Journal of Biology, Agriculture and Healthcare* 4(20): 63 – 77.

Cunguara, B. and Darnhofer, I. (2011). Assessing the impact of improved agricultural technologies on household income in rural Mozambique. *Food Policy* 36(3): 378–390.

De Groote, H., Gitonga, Z. and Tefera, T. (2013). Effectiveness of metal silos and super grain bags in controlling maize storage pests in Kenya. *Journal of Development and Agricultural Economics* 7(9): 10 – 12.

Doss, C. R., Mwangi, W., Verkuijl, H. and de Groote, H. (2003). *Adoption of Maize and Wheat Technologies in Eastern Africa: A Synthesis of the Findings of 22 Case Studies*. CIMMYT Economics Working Paper Mexico. 3pp.

FAO (Food and Agricultural Organization), (2008). *Household Metal Silos: Key Allies in Food and Agricultural Organization Fight Against Hunger.* Agricultural and Food Engineering Technologies Service, Rome, Italy. 8pp.

FAOSTAT (Food and Agriculture Organization Statistics), (2014). Assessing purdue improved crop storage bags to mitigate fungal growth and afflatoxin contamination. *Journal of Stored Products Research* 59(1): 12 – 15.

Gitonga, Z., De Groote, H. and Tefera, T. (2015). Metal silo grain storage technology and household food security in Kenya. *Journal of Development and Agricultural Economics* 7(1): 22 – 23.

Gladstone, S., Astuias, L. and Hruska, J. (2002). Adoption of improved postharvest storage technologies in Malawi. *Journal of Crop Protection* 3(6): 24–45.

Homan, L., Renkow, M. and Sain, G. (2013). Variety characteristics and maize adoption in Honduras. *Journal of Agricultural Economics* 29: 307 – 317.

Hodges, R. J., Buzby, J. C. and Bennett, B. (2011). Postharvest losses and waste in developed and less developed countries: Opportunities to improve resource use. *Journal of Agricultural Science* 149(S1): 37 – 45.

Idrisa,Y. L., Ogunbameru, B. O. and Madukwe, K. (2012). Logit and Tobit analyses of the determinants of likelihood of adoption and extent of adoption of improved soybean seed in Borno State, Nigeria. *Greener Journal of Agriculture Science* 2(2): 37 – 45.

Kamanula, J., Sileshi, G., Belmain, R., Sola, P., Mvumi, M., Nyirenda, G., Nyirenda, P. and Stevenson, C. (2011). Farmer's insect pest management practices and pesticidal plant use in the protection of stored maize and beans in Southern Africa. *International Journal of Pest Management* 8: 41 – 42.

Khan, J. and Keating, H. (2000). Economic efficiency of resource-use in millet-based cropping system in Borno State of Nigeria. *Nigerian Journal of Tropical Agriculture* 2: 15 – 20.

KDC (Kilolo District Council), (2016). *Annual Report on the Activities Implemented in the Department of Agricultural, Irrigation and Cooperative*. Kilolo District Council, Iringa, Tanzania. 76pp.

KDC (Kilolo District Council), (2018). *Quarterly Report on the Activities Implemented in the Department of Agricultural, Irrigation and Cooperative*. Kilolo District Council, Iringa, Tanzania. 42pp.

Kimatu, R., Mcconchie, R., Xie, X. and Nguluu, S. (2012). *The significance Role of Post-Harvest Management in Farm Management, Aflatoxin Mitigation and Food Security in Sub Saharan Africa:* Central Avae Australian Technology Park, Australia. 143pp.

Kimenju, S. and De Groote, H. (2010). Analysis of Alternative Maize Storage Technologies in Kenya. Paper Prepared for Presentation at the 3rd International Conference of the African Association of Agricultural Economists. Cape Town, South Africa. 34pp.

Kimenju, S., De Groote, H. and Hellin, J. (2009). Cost Effectiveness of the Use of Improved Storage Methods by Small Scale Farmers in Eat Africa Countries: Preliminary Economic Analysis Report. International Maize and Wheat Improvement Centre, Nairobi, Kenya. 42pp.

Kothari, C. R. (2004). *Research Methodology, Methods and Techniques.* New Age International Publishers, New Delhi. 401pp.

Kshirsagar, K. G., Pandey, S. and Bellon, M. R. (2002). *Farmer Percpetions, Varietal Characteristics and Technology Adoption.* A Rainfed Rice Village in Orissa, Economic and Political Weekly, March. pp. 1239 – 1246.

Kuwawenaruwa, A., Baraka, J., Ramsey, K., Manzi, F., Bellows, B. and Borghi, J. (2015). Poverty identification for a pro-poor health insurance scheme in Tanzania: reliability and multi-level stakeholder perceptions *International Journal for Equity in Health* 14: 1 – 14.

Lemon, N. (2010). Attitudes and their measurement. New York. [https://pdfs.semanticscholar.org/1938/d0478df610ce4e87e2118df25e432a84b691.pdf] site visited on 12/06/2018.

Lyimo, S., Mduruma, Z. and De Groote, H. (2014). The use of Improved maize varieties in Tanzania. *African Journal of Agricultural Research* 9(7): 643 – 657.

Lwala, R. J., Elepu, G. and Hyuha, T. S. (2016). Effect of farmer field school on adoption of improved cotton production technologies in Eastern Uganda. *Journal of Agricultural Economics, Extension and Rural Development* 4(4): 419–428.

Magehema, A. O., Ladislaus, B. C. and Mkoma, S. L. (2014). Implication of rainfall variability on maize production in Morogoro, Tanzania. *International Journal of Environmental Sciences* 4(5): 412 – 438.

Maonga, B., Assa, M. and Haranan, E. (2013). Adoption of small metallic grain silos in propensity score matching. Storage technologies in Kenya and Cape Town, South Africa. [www.containerexchanger.com/steele-totes] site visited on 10/06/2018.

Martel, P. V., Bernsten, R. H. and Weber,. M. T. (2007). Food Markets, Policy, and Technology: The Case of Honduran Dry Beans. Working Paper No. 79. Michigan State University, USA. 246pp.

Masinde, M., Bagula, A. and Muthama, N. J. (2012). The role of ICTs in downscaling and up-scaling integrated weather forecasts for farmers in sub-Saharan Africa. In: *Proceedings of the Fifth International Conference on Information and Communication Technologies and Development*. pp. 122–129.

Mayring, P. (2014). *Qualitative Content Analysis*. Theoretical Foundation, Basic Procedures and Software Solution Klagenfurt, Austria. 321pp.

Michelle, K. J. (2005). Technology adoption in West Africa: Adoption and non adoption of soybeans on the Togo-Benin Border. Dissertation for Award of MSc Degree at North Carolina State University, USA. 65pp.

Mwanga, J. N. W. (2002). Adoption of improved technologies for sorghum and pearl millet Production in Dodoma. Dissertation for Award of MSc Degree at Sokoine University of Agriculture, Morogoro, Tanzania. 85pp.

Ndunguru, G., Mamiro, P., Alenkhe, B., Mlingi, N. and Bekunda, M. (2014). Post-harvest food losses in a maize-based farming system, semi-arid savannah area of Tanzania. *Journal of Stored Products Research* 57(1): 49 – 57.

Neill, S. P. and Lee, D. R. (2001). Explaining the adoption and non- adoption of sustainable Agriculture: the case of cover crops in Northern Honduras. *Journal of Economy Development and Cultural Change* 49: 4 – 6.

Okoedo, O. (2009). Impact of the agricultural development programme activities in arable crop production on rural poverty alleviation in Edo State, Nigeria. Thesis for Award of PhD Degree at University of Benin, Benin City, Edo State, Nigeria. 126pp.

Okoruwa, V. O., Ojo, O. A., Akintola, C. M., Ologhobo, A. D. and Ewet, F. K. (2012). Post harvest grain management storage techniques and pesticides use by farmers in South-West Nigeria. *Journal of Economics and Rural Development* 4(1): 20 – 22.

Oladosu, I. O. (2004). *Review of Basic Concepts in Communication for Introducing Programme on Food Security.* New Age Publications, Ogbomoso. 87pp.

Onasanya, E. L., Adjargo, G. and Bosompem, M. (2007). The potential of Farmer Field School in cocoa extension delivery: A Ghanaian case study. *Journal of International Agricultural Extension Education* 21(2): 14 – 17.

Pallant, J. (2007). *Survival Manual. A Step By Step Guide to Data Analysis Using SPSS for Window*. Open University Press, England. 335pp.

Raphael, D. (2014). Determinants of adoption of early maturing maize varieties in Nzega district, Tabora region. Dissertation Award of MSc Degree at Sokoine University of Agriculture. Morogoro, Tanzania. 101pp.

Rashid, A. and Kurt, A. (2015). Current maize production, postharvest losses and risk of mycotoxins contamination: Low State. *Journal of Agricultural and Biosystem Engineering* 4(2): 12 – 14.

Rogers, E. M. (2003). *Diffusion of Innovations. Understanding Faculty Adoption of Technology Using the Learning/Adoption Trajectory Model: A qualitative Case Study*. Free Press, New York. 541pp.

RUDI (Rural Urban Development Initiative), (2016). Annual Report on Warehouse Storage System in Kilolo District. Alliance for Green Revolution in Africa Tanzania. [https://operations.ifad.org/ documents/654016/b0b9c8b5-e418-4992-9683-58f72125e3f2] site visited on 10/06/2018.

Satyanarayari, S., Kurmvanshi, S. M. and Soni, S. N. (2009): Technological status (adoption Pattern) of Soyabean cultivation in district Sagar in Madhya Pradesh. *Journal of Crop Research* 8: 1-5.

Stathers, T., Lamboll, R. and Mvumi, B. M. (2013). Postharvest agriculture in changing climates: Its importance to African smallholder farmers. *Food Security* 5(3): 361–392.

Tefera, T., Kanampiu, F., De Groote, H., Hellin, J., Mugo, S., Kimenju, S., Beyene, Y., Boddupalli, P. M., Shuferaw, B. and Banziger, M. (2011). The metal silo:

An effective grain storage technology for reducing post-harvest insect and pathogen losses in maize while improving smallholder farmers' food security in developing countries. *Journal of Crop Protection* 30(3): 240 – 245.

Uaiene, R. N., Arndt, C. and Masters, W. A. (2009). *Determinants of Agricultural Technology Uptake in Mozambique, Discussion Papers, No. 67E, National Directorate of Studies and Policy Analysis.* Ministry of Planning and Development, Republic of Mozambique, December 2009.

URT (United Republic of Tanzania), (2016). *Agricultural Sector Development Programme II. Framework and Process Document.* National Printing Company, Dar es Salaam, Tanzania. 121pp.

URT (United Republic of Tanzania), (2012). *National Strategic for Growth and Reduction of Poverty II.* Ministry of Finance and Economic Affairs, Dar es Salaam, Tanzania. 217pp.

URT (United Republic of Tanzania), (2012). *Population and Housing Census.* Government Printers, Dar es Salaam, Tanzania. 219pp.

USAID (United States Agency of International Development), (2010). *Postharvest Losses in Maize Based on Farming Systems of Semi-Arid Area of Tanzania.* United States Agency of International Development, Dodoma, Tanzania. 98pp.

Venance, S. K., Mshenga, P. and Birachi, E. A. (2016). Factors Influencing on-Farm Common Bean Profitability: The Case of Smallholder Bean Farmers in Babati District, Tanzania. *Journal of Economics and Sustainable Development* 7(22): 196 – 201.

Wekesa, E., Mwangi, W., Verkuijl, H., Danda, K. and De Groote, H. (2003). *Adoption of Maize Production Technologies in the Coastal Lowlands of Kenya.* Kenya Agricultural Research Institute, Nairobi, Kenya. 34pp.

WFP (World Food Programme), (2012). *The State of Food Insecurity in the World. Economic Growth is Necessary but Not Sufficient to Accelerate Reduction of Hunger and Malnutrition.* Food and Agriculture Organization, Rome, Italy. 65pp.

Wossink, G. A. A., De Buck, A. J., Van Niejenhuis, J. H. and Haverkamp, H. C. M. (2007). Farmer perceptions of weed control techniques in sugar beet. *Journal of Agricultural Systems* 55(3): 409 – 423.

Yakubu, A. K. (2012). Reducing losses to maize stored on forms in East Africa using hermatic storage. Thesis for Award of PhD Degree at University of Iowa State. Ames, Iowa. 270pp.

Zorya, S., Morgan, N., Diaz Rios, L., Hodges, R., Bennett, B., Stathers, T. and Lamb, J. (2011). *Missing Food, the Case of Postharvest Grain Losses in Sub-Scharan Africa.* Report No. 60371. The World Bank, Washington DC. 10pp.

APPENDICES

Appendix 1: Summary of data collection and analysis

S/N	Objective	Type of data to be collected	Methods of data collection	Analysis of data
1.	Identify postharvest storage technologies commonly used by maize small scale farmers in Kilolo District	Types of postharvest technologies used	Semi-structured questionnaire Key informants FGD	Descriptive statistics on frequencies and percentages
2.	Determine smallholder farmers' knowledge on use of improved post harvest maize storage technologies in the District.	Sources of information on the use of improved storages. Recommended practices on the use of improved postharvest storage technologies.	Semi-structured questionnaire Key informants FGD	Descriptive statistics on frequencies and percentages
3.	Determine farmers' perception on Improved postharvest storage technologies in the District.	Effectiveness efficiency and durability of technology Cost of technology(initial and maintenance)	Semi-structured questionnaire three point of likert scale	Descriptive statistics on frequencies, percentage, standard deviation and mean.
4.	Identify determinants influencing the use of improved postharvest storage technologies in the District	Age, education level, sex, and wealth level). Level of production, access to extension services, costs of technology, markets farmers' organization,	Semi-structured questionnaire	Binary logistic regression was employed to determine association between variables/determinants.

Appendix 2: Questionnaire for respondents

For research on, factors influencing use of improved postharvest storage technologies among small scale maize farmers in Kilolo District, Tanzania.

Name of Interviewer ....Date.....................

Division.............................Ward...........................Village ....

A. Demographic characteristics of farmers.

1. What is the sex of the Head of Household 1. Male 2. Female
2. What is age of household years?..
3. What is the marital status of the head of household.................................
4. What is the education level of the household head?....................................
5. What is the household size?...
6. What are the main purposes of growing maize?......................................
7. What is the total area of your farm in acres?...
8. What is the total area of your farm in acres under maize production?.....................
9. Which maize variety did you plant in your farm in the last season..................
10. How many bags of maize did you harvest last season per acre .... (100 Kg/ bag)
11. Do you have other source of income apart from maize production?
    1. Yes, 2. No
12. If answered Yes in Q12 above, what are the other sources of income? (please mention)...

B: Postharvest storage technologies used by maize farmers.

13. Have you ever stored maize harvested during the last three seasons? 1 Yes 2. No
14. If, Answered YES in Q 13 above, which postharvest storage technologies did you use? (Tick which ever apply)

Technologies	Used	Not used
Traditional granaries		
Bamboo basket		
Polythene bags		
Purdue Improved Crop Storage		
Metal silo		
Storage chemicals		
Improved granaries		

15. There is any benefit obtained as the results of using improved postharvest storage technologies?

(i) Yes (ii) No

16. If Yes, what benefit obtained?

....

....

17. What were reasons for not using improved postharvest storage technologies?

Technologies	Reasons for not using
Purdue Improved Crop Storage	
Metal silo	
Storage chemicals	
Improved granaries	

B. Farmers knowledge on use of improved postharvest storage technologies

18. Where did you get information on the use of maize improved postharvest storage technologies?

i. Extension agent

ii. Fellow farmers

iii. Television

iv Radio

v. Training

vi. Others specify..........

19. Farmers' knowledge on use of improved storage technologies? **(Tick where appreciation)**

Statements/Practices	**Response**	
	Yes	**No**
Harvesting mature and dried maize		
Maize stored with moisture content of 12 -14%.		
Maize is clean before storage.		
When PICS are used to store product triple layers are well tighten		
Metal silo are cleaned before storage		
Farmers put PICS On pallets.		
Farmers put PICS On pallets.		
Farmers when use storage chemical considers the recommended rates.		
Rat guards are used when product is stored in improved granaries.		
The inlet and outlets pots are well closed when improved granaries used to store products.		

C: Farmers' perception on the use of improved postharvest technologies.

20. By perception we mean is the process by which information or stimuli is received and transformed into physiological awareness, that farmers weighs the benefits to be delivered from adopting the technology before a decision was reached. Please circle the number under the word that best reflects the feelings to each statement on the following rating scale.

SA for Strong Agree =5, A for Agree = 4, U for Undecided = 3, D for Disagree= 2 and SD for Strongly Disagree =1.

Statement	**Responses**
Maintaining the quality and quantity of stored products	5 4 3 2 1
Technology is durable	5 4 3 2 1
Technology is environment friendly	5 4 3 2 1
Stored products are safe for human consumption	5 4 3 2 1
Required high initial costs	5 4 3 2 1
Have high maintenance cost	5 4 3 2 1
Prone to rodents attack	5 4 3 2 1
Less effective against insects storage pests	5 4 3 2 1
Stored products exposed to thieves	5 4 3 2 1

D. Factors influencing the use of improved postharvest storage technologies

21. Are you a member of any farmers' group or association?

    1. Yes 2. No

22. If yes, which organization do you belong?

    1. Farmer's field school; 2. Self-help group 3. Cooperative society

    2. Others (specify)..

23. Do you have access to credit? 1. Yes 2. No

24. If answered YES in Q 23 above, what are the sources of your credit? (Tick whichever apply)

    1. Bank; 2. VICOBA 3. SACCOS 4. Others, specify....................................

25. What are the conditions for getting credit?

    ....

    ....

26. Did you receive credit to facilitate Agricultural production activities last season?

    1. Yes 2. No

27. If answered YES in Q 26 above, which agriculture activities where facilitated

    ....

28. Did you receive extension services on use of post-harvest storage technologies during 2016/17 growing season?

    1. Yes 2. No

29. What are the costs involved in applying the improved storage post-harvest technologies (in TZS).

s/n	Technologies	Initial costs	Operational costs
1.	Purdue Improved Crop Storage		
2.	Metal silo		
3.	Improved granaries		
4.	Others (Specify)		

30. If applying storage chemical as a technology, list the chemicals you used and the unit price in the last season

s/n	Chemical	Amount	Unit price (TZS)
1.			
2.			
3.			

31. What are your opinions regarding ways to improve the use of improved maize storage technologies?

1. ....
2. ....
3. ....
4. ....

THANK YOU FOR YOUR TIME

Appendix 3: Checklist for key informants and FGD

Research Title: Factors influencing use of improved postharvest storage technologies among small scale maize farmers in Kilolo District, Tanzania.

A. Background information

1. Area under maize production in hectare
2. Production levels/potential
3. Total number of farmers producing maize

B. Postharvest storage technologies knowledge /awareness.

4. Total number of extension officers
5. Levels of awareness/knowledge
6. Improved postharvest technologies commonly used by maize farmers
7. Challenges facing the use of improved postharvest technologies

C. Training and grouping

8. Total number of farmers' groups in your District
9. Forms of farmers groups
10. Total number of farmers trained on improved postharvest storage technologies

D. Access to services

11. Percentage of farmers who are access to credits, inputs and extension services. Conditions for access to credits services
12. NGO's supporting improved postharvest storage technologies
13. Factors which hinder the use of improved postharvest storage technologies
14. District/Villages plans on the use of improved postharvest storage technologies.

THANK YOU FOR YOUR TIME