Bishop Stuart University

Effects of Post-Harvest Handling on Maize Farmers' Income in Nkoma Sub-County Kamwenge District

By

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Declaration

I, **Ayebazibwe Ubard,** do declare that this dissertation entitled "**Effects of Post-Harvest Handling on Maize Farmers' Income in Nkoma Sub-County, Kamwenge District**" is my original work and that no part or the whole of it has ever been submitted to any other institution for any award.

Signature .... Date ...06/03/2023.......

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Approval

We certify that this dissertation titled **"Effects of Post-Harvest Handling on Maize Farmers' Income in Nkoma Sub-County, Kamwenge District"** was done under our supervision

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Dedication

This work is dedicated to my beloved parents who have been the pillars behind my success today because of their social, financial and moral support rendered to me, their constant prayer and comfort which all contributed greatly towards the end of my dissertation.

Acknowledgement

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List of Abbreviations

ECA	Eastern and Central Africa
EUT	Expected Utility Theory
FAO	Food and Agricultural Organization
NARO	National Agricultural Research Organization
PHHT	Post-Harvest Handling Technologies
PSFU	Private Sector Foundation Uganda
RTC	Rational Choice Theory
SSA	Sub-Saharan Africa
WFP	World Food Program

Abstract

This study was on the effect of post-harvest handling on maize farmers' income in Nkoma Sub-County, Kamwenge District. The study objectives were to: identify post-harvest handling technologies and practices on maize farmers' income; establish the role of training in post-harvest handling technologies on maize farmers' income; assess the effects of the post-harvest technologies and practices on the incomes of maize farmers. The study adopted a cross-sectional survey design applying quantitative and qualitative approaches for data collection. Data was captured from a sample of 150 respondents using both questionnaire and interviews. Data was analyzed using SPSS version 16 to generate both descriptive and inferential statistics. The study identified different post-harvest handling technologies and practices used by maize farmers in Nkoma sub-county, Kamwenge District such as; threshing, drying, storage, winnowing, shelling, grading and packing. The study identified that there were factors affecting the use of maize post-harvest handling technologies on Smallholder maize farmer's income. These were; price fluctuation of maize grains, human and financial capital, excessive field heats and lack of on-farm storage facilities and knowledge on post-harvest handling practices. The study further concluded that specific post-harvest technologies/practices had an effect on household income generated. Technologies/practices such as; drying ($p < 0.002$), storage ($p < 0.00$), winnowing ($p < 0.01$), grading and packaging ($p < 0.001$) presented a significant association with household income. The study concluded that different post-harvest handling technologies/practices such as; drying, storage, winnowing, grading and packaging have a significant contribution on household income however the rate of use of these practices is still low due to different socio-economic and institutional factors. The study therefore recommended more education for farmers on the technologies since this influences farmers' decision to adopt technologies. Farmers should be assisted in acquiring value addition facilities such as threshing and grinding machines to improve packaging. Farmers must be supported through credit services so to acquire advanced postharvest handling technologies and equipment.

Key Words: Effects, Post-harvest handling, maize farmers' income,

Chapter one

Introduction

1.1 Background of study

In agriculture, postharvest handling is the stage of crop production immediately following harvest, including threshing, cleaning, drying, sorting, packing, storage and among others (Abbas, 2019). The instant a crop is removed from the ground, or separated from its parent plant, it begins to deteriorate. Postharvest treatment largely determines final quality, whether a crop is sold for fresh consumption, or used as an ingredient in a processed food product (Brown et al., 2016). The most important goals of post-harvest handling are keeping the product cool, to avoid moisture loss and slow down undesirable chemical changes, and avoiding physical damage such as bruising, to delay spoilage. Sanitation is also an important factor, to reduce the possibility of pathogens that could be carried by fresh produce, for example, as residue from contaminated washing water (Brown et al., 2015).

After the field, post-harvest processing is usually continued in a packing house. This can be a simple shed, providing shade and running water, or a large-scale, sophisticated, mechanised facility, with conveyor belts, automated sorting and packing stations, walk-in coolers and the like. In mechanised harvesting, processing may also begin as part of the actual harvest process, with initial cleaning and sorting performed by the harvesting machinery. Initial post-harvest storage conditions are critical to maintaining quality. Each crop has an optimum range of storage temperature and humidity. Also, certain crops cannot be effectively stored together, as unwanted chemical interactions can result.

In tropical countries in general, most grains have a single annual harvesting season, although in bimodal rainfall areas there may be two harvests (e.g., Ghana and Uganda). African producers harvest grain crops once the grain reaches physiological maturity (moisture content is 20-30%) (FAO, 2011). At this stage the grain is very susceptible to pest attacks. Poor farmers sometimes harvest crops too early due to food deficiency or the desperate need for cash. In this way, the food incurs a loss in nutritional and economic value and may get wasted if it is not suitable for consumption. Quality cannot be improved after harvest, only maintained; therefore, it is important to harvest at the proper maturity stage and at peak quality (Kabak & Dobson, 2016).

Most farmers in Africa, both small and large, rely almost exclusively on natural drying of crops by combining sunshine and movement of atmospheric air through the product; consequently, damp weather at harvest time can be a serious cause of postharvest losses (De Lima, 2017). Grains should be dried in such a manner that damage to the grain is minimized and moisture levels are lower than those required to support mold growth during storage (usually below 13-15%). This is necessary to prevent further growth of fungal species that may be present on fresh maize grains (FAO, 2011).

1.1.1 Historical Background

Maize production and consumption has been central for human survival across many countries. Maize is believed to have originated from Central America; a region which was dominated by wild maize Teosinte and Zea Mexicana, (ACDIVOCA, 2010: 2). An archaeological study of the bat caves in New Mexico revealed corncobs that were 5,600 years old by radiocarbon determination and most historians believe that corn was domesticated in the Tehuacan Valley of Mexico (Lance and Garren, 2002). In 1880, the United States grew over 62 million acres of corn. By 1900, this figure had reached approximately 95 million acres; while by 1910, it was over 100 million acres (Lance and Garren, 2002) and 91.7 million acres in 2019 (USDA) https://www.usda/media/blog/ci. According to a two year research conducted by Honduras by Raboud et al. (1984) found that post-harvest damage and losses of stored maize amounted to 12.5% and 8.1%, respectively (averaged for the two study years) in central America. Maize is one of the main crops grown in Eastern and Central Africa (ECA) as a staple food by over 70% of the population, (Asea. et al, 2014: 1). Maize was introduced in Uganda in 1861 and has since become a major part of the farming system, ranking third in importance among the main cereal crops (finger millet, sorghum and maize) grown in the country (USAID, 2010). Uganda’s small-scale farmers have traditionally cultivated maize for food and for income generation currently Uganda produces 2,575,000 tonnes in 2019 down from the previous approx. 4,000,000 tonnes 2017.https:knoema.com/.

1.1.2 Theoretical Background

This study used the Rational Choice Theory (RTC) and Expected Utility Theory (EUT) to understand how farmers' choices for post-harvest handling technologies affect their income. Rational Choice Theory is a framework for understanding and often formally modelling social and economic behaviour (Lawrence and Easley, 2008). Rational Choice Theory, attempts to deduce what will happen when individuals are faced with a situation such as farmers choice of post-harvest handling technologies of grains (Okoruwa, Ojo, Akintola, Ologhobo and Ewete, 2012). This theory is important to predict the maize farmer's behaviour in choosing the most suitable available post-harvest technologies depending on their economic status which will determine the quantity and quality of the maize grain obtained.

1.1.3 Contextual Background

Maize is an important crop grown in most parts of the Uganda for food, feed and income, (Asea.et al, 2014:1). Maize being one of the major crops regionally exported and it was considered to be a stepping-stone towards poverty eradication (Private Sector Foundation Uganda (PSFU), 2005) but due to high post-harvest losses, this was not achieved. The maize sub-sector is estimated to provide a livelihood for about 3 million Ugandan farm households, close to 1,000 traders and over 20 exporters (UBOS, 2011). The regional maize production however is dominated by smallholder farmers whose production is generally characterized by small farm acreage (0.5- 5 ha) (MAAIF, 2013:1), low yields (1.0 -1.8 MT/ha) and high production costs and consequently low returns. Unfortunately, the quality standards of maize grain produced in Uganda is generally low and a lot is lost during the process of harvesting, transport, storage and processing. The major maize growing sub-regions in Uganda are Busoga (eastern) region Bunyoro (mid- western) region (MAAIF, 2013:1). Kiryandongo district has a population of 133,541 males and 134,647 (UBOS, 2014) and the major economic activity is farming that contributes 60.61% of the total population (UBOS, 2011a: 6). The highest proportion of the households grows maize at a rate of 67.2% of the total households in the region (UBOS, 2011).

Similarly, Masindi district has a population of 148,264 males and 144,687 (UBOS, 2014) and also the major economic activity is farming that contributes 43.93% of the total population (UBOS, 2011b: 8). The highest proportion of the households grows maize at a rate of 32.45% of the total households in the region (UBOS, 2011).

The Expected Utility Theory on the other hand is founded on the fundamental assumption that a decision maker, as a farmer this context, always chooses that option, for which the expected value of the decision to choose a post-harvest technologies to use which maximizes his expected utility of wealth, therefore they will always chose the technology that requires least investment (Okoruwa et al, 2009). This theory is very important to predict farmer's choice of selecting the appropriate technology to use which is available hence having a great effect on the quantities and quality of maize hence affecting the selling price and income.

1.1.3 Conceptual Background

The proposed study was founded on the conceptualization that Post-harvest handling technologies affect maize farmers' income in Uganda. Post-harvest handling technologies will be analyzed in terms: availability, training and adoption. According to Okoruwa et al (2012), post-harvest loss of grain which ranges from 20- 30 % caused by bad practicing of poor post-harvest technologies, lowers the income and standards of living of the farmers. Post-harvest handling processes of harvesting, drying, shelling, treatment and storage are very important in terms of minimizing losses not only in quality but also in quantity (Asea. et al, 2014). Storage as one of post-harvest handling technology offer an opportunity to improve farm incomes by storing crops and selling at premium prices when demand outstrips supply later in the post-harvest period (Florkowski and Xi-Ling, 1990) hence this proves that post-harvest technologies have a great effects on farmers income. According to the study by Bokusheva et al, (2012) conducted in Central America found out that completion of training course about post-harvest handling technologies was one of the main determinants of achieving household self-sufficiency in terms of food production and security . Davis,Hands, and Maki, (1997) stated that decision making of adopting a given post-harvest technology depends on the risks and uncertainty involved as this would affect the quality of maize harvested and income after maize sales. As quality is an important determination of crop retail prices, effective storage is crucial to improve agricultural incomes and food security for small scale farmers (Thamaga- Chitja, 2004). The most widely used post-harvest handling technology is maize storage which would enable smallholder and larger producers to improve on their income through maize sales during scarcity times (World Bank, 2011).

1.2 Problem Statement

Providing farmers with the basics in Post-harvest handling technologies help to increase earnings of farmers (FAO, 2011). Okoruwa et al (2012) emphasized that post-harvest loss of grain is caused by improper use of post-harvest technologies, lowers the income and standards of living of the farmers. The post-harvest losses represent more than 20 million metric tonnes of grain in Uganda, valued at over $4b annually which is enough to feed 48 million people and the losses are attributed to the factors that affect the use of post-harvest technologies (Dunford, 2015).Post-harvest loses would be reduced to increase farmer's income through proper use of post-harvest handling technologies (WFP, 2012).

In spite of the fact that many interventions have been developed to reduce post-harvest loss, there is still lack of effective and efficient grain post-harvest technologies which leads to an average of 13.5 % post-harvest losses in SSA (Rural 21, 2013). There is no empirical study that has been conducted to show the relationship between post-harvest handling technologies and maize farmers' incomes in Kamwenge district which prompted the researcher to carry out the study in this study area.

Okoruwa et al (2012) conducted a study on Post-harvest grain management storage techniques and pesticides use by farmers in South-West Nigeria. However, this study did not look at other important aspects like the training background of maize farmers which was considered in this study. Atukwase Kaaya and Muyanja (2012) carried out the research about the dynamics of mycotoxins like fumonisins in maize during storage using the traditional storage structures commonly used in Uganda. This study only considered storage practices yet, harvesting, drying and threshing can reduce maize quality and further reduce farmers income as a result of selling at low prices. This situation only continued on both smallholder and large scale farmers selling their grain soon after harvest cheaply as a result of limited training on use of proper post-harvest technologies which has affected their income. Therefore, there was a need to conduct a study on the effects of post-harvest handling technologies and maize farmer's incomes in Nkoma Sub-county, Kamwenge district. This area was studied because it was one of the leading areas in Kamwenge with maize big harvest and has experienced too much maize post-harvest losses

1.3 Main objective of the study

The main objective of the study was to investigate the perceived effects of the post-harvest handling technologies on maize farmers' income in Nkoma Sub-county, Kamwenge District.

1.4 Specific objectives of the study

i. To identify post-harvest handling technologies and practices on maize farmers' income in Nkoma sub-county, Kamwenge District

ii. To evaluate the factors affecting the use of maize post-harvest handling technologies on maize farmer's income in Nkoma sub-county, Kamwenge district

iii. To assess the effects of the post-harvest technologies and practices on the incomes of maize farmers in the study area.

1.5 Research Questions

i. What are the post-harvest handling technologies and practices used in Nkoma sub-county, Kamwenge district?

ii. What are the factors affecting the use of maize post-harvest handling technologies on maize farmer's income in Nkoma sub-county?

iii. What are the effects of post-harvest handling technologies on maize farmers' income in Nkoma sub-county, Kamwenge district?

1.6 Scope of the study

1.6.1 Content scope

The study limited itself to post harvest handling technologies as the independent variable which considered three dimensions: PHHT availability, PHHT training and PHHT adoption whereas Maize farmers' income with three dimensions as well namely; quantity of maize, quality and the price at which maize grains was sold.

1.6.2 Geographical scope

The study was conducted around South Western Uganda specifically in Nkoma sub-county, Kamwenge district. This district is one of the major maize growing district in south western region(MAAIF, 2013). The Mid-western region is second to the eastern region in production of maize which is 497,745MT (UBOS and MAAIF, 2011) and due to the fact that the highest proportion of the households grows maize at a rate of 67.2% and 32.45% of the total households in Kamwenge district, this is why Kamwenge district was selected for this particular study. One cooperative was selected in each district and a representative farmers were interviewed. The warehouse operators and officials that provided technical assistance were also interviewed.

1.6.3 Time Scope

The study was estimated to be completed in one year. This time frame was specifically chosen because it's easy to understand the income growth of farmers as farmers could easily remember what had happened in past five years. This time was chosen on the basis that farmers were expected to have gained the experience in maize post- harvest handling technologies and benefited from using them since they would be able to remember the quantity and quality of maize sold as a result of using best post harvest handling technologies.

1.7 Significance of the study

This study may contribute to the understanding of the effects of the Post-harvest handling technologies and Maize farmers' income in Uganda. In addition to this, the study may;

Help in policy planning for future use of post-harvest handling technologies at all levels.

The knowledge may be useful in promoting research post-harvest handling technologies aiming at minimizing post-harvest losses between harvesting and actual consumption.

The study results will help future researcher to use them as source of literature for related study.

The study results will help the researcher to acquire his Master of agriculture and Rural Innovations of Bishop Stuart University.

1.8 Definition of operational terms and concepts

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

Aflatoxin: These are poisonous substances produced by fungi and make the grain unfit for consumption.

Moisture content of grain: This is a way of expressing how much water is contained within the grain.

Post-harvest damage: This is physical alteration caused by biotic or abiotic agents in the value chain from production in the field up to time of consuption.

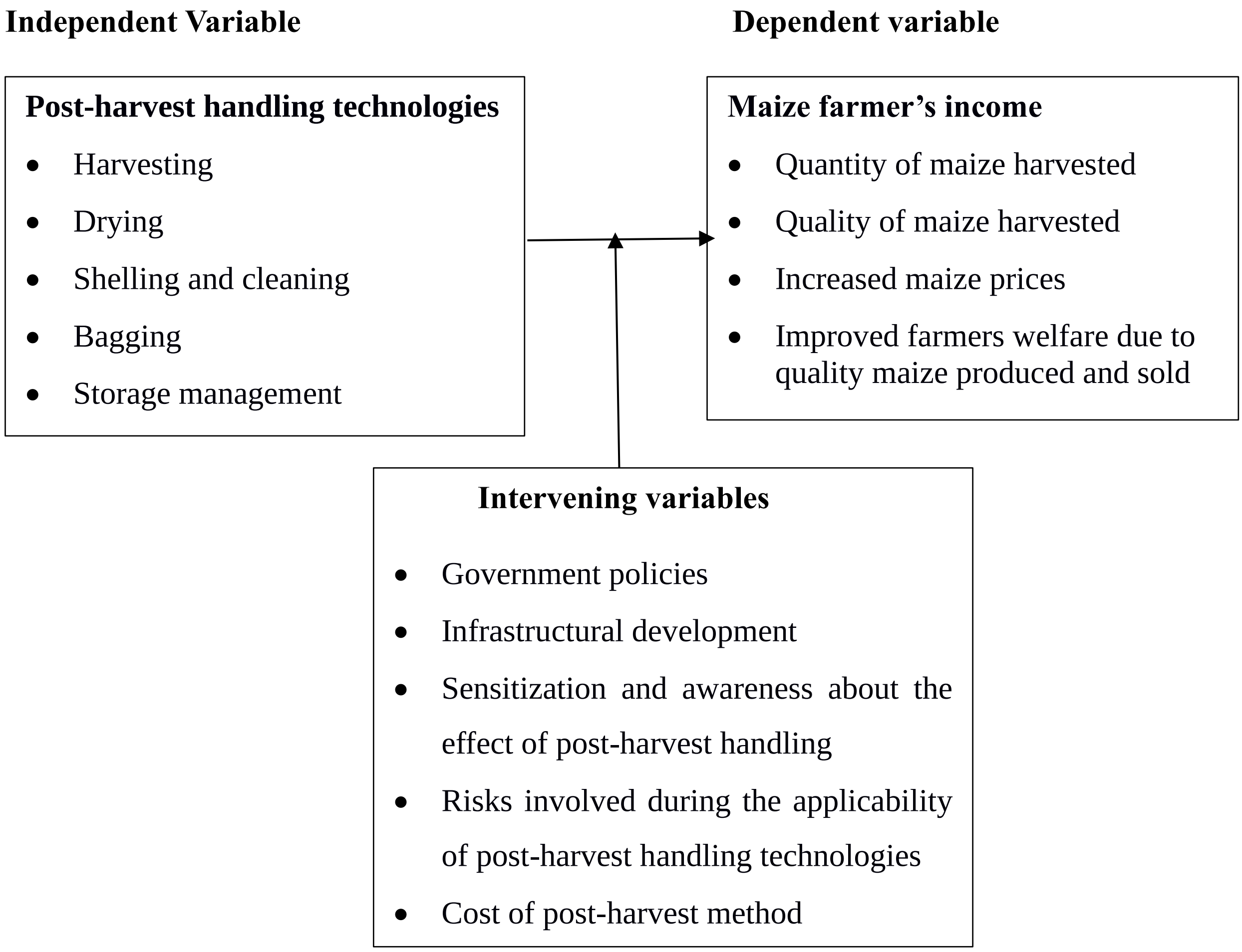
Post-harvest handling technologies: These are measures or activities done to ensure that the harvested product reaches the consumer, while fulfilling market/consumer expectations in terms of volume, quality, and other product and transaction attributes, including nutrition, food security, and product safety

Post-harvest Loss: This is the difference between total damaged and recoverable damaged grain still fit for human consumption of staple grains due to insect pests, rodents and birds

Post-harvest period: This is between physiological maturity of a crop and the time for its final consumption

Quality loss: This is a reduction in the quality of food grain so that its market value is reduced transaction attributes, including nutrition, food security, and product safety

1.9 Conceptual Framework



The conceptual frame work sets to look at the relationship between study variables where post-harvest handling practices/technologies is independent variable and maize farmer's income as a dependent variable. All post-harvest handling technologies lead to increased maize farmer's income. Government policies like strict rules on use of post-harvest practices when followed they may lead to increased quantity and quality of maize grain harvested, better infrastructural facilities enhances smooth transportation of maize grains and this would help to avoid spilling during transportation and improve their income through quality and quantity sold.

CHAPTER TWO

LITERATURE REVIEW

2.1 The Concept of Post-harvest Handling Technology

The primary role of an effective post-harvest handling system is ensuring that the harvested product reaches the consumer, while fulfilling market/consumer expectations in terms of volume, quality, and other product and transaction attributes, including nutrition, food security, and product safety. Post-harvest technologies include: harvesting, assembling, drying, threshing/shelling, milling, storage, packaging, transportation, and marketing (World Bank et al., 2011). FAO (2011) considers the post-harvest losses incurred during harvesting such as from mechanical damage and spillage and during post-harvest handling such as drying, winnowing, and storage (insect pests, rodents and rotting).

According to the National Agricultural Research Organization(NARO), reckless handling of maize cobs or grains lead to spillage and quantitative losses on most farms in Uganda as well as loss of quality as contaminated grains or cobs are mixed with the clean ones (AGRA, 2013). Currently, the national standard storage facilities for maize in Uganda can cater for only 550,000 metric tonnes out of 3.2 million of total production, according to ministry of Agriculture, 2014 projections. And as a result of the inadequate storage facilities and poor post-harvest handling practices, the country is struggling to compete in the grain market provided (Ladu, 2015).

2.2 Post-harvest handling technologies and practices on maize farmers' income

The factors affecting post-harvest technology choice are assets, income, institutions, awareness, labour and innovativeness by smallholder farmers (Muzari, 2012). The various institutional, economic, psychological and social factors are known to be important in determining the adoption of improved technologies (Adesina and Zinnah, 2019). Meinzen-Dick (2016), argues that the main factors affecting technology adoption among smallholders in Sub-Saharan Africa are assets, vulnerability, and institutions. Therefore this study will focus on dimension cost of the technology to be used in terms of its affordability to famers, the level of awareness as well as risks involved.

According to Muzari (2012), technology adoption depends on whether farmers have the requisite physical (material) and abstract possessions (e.g. education). A lack of assets or possessions will limit technology adoption (Meinzen-Dick et al., 2016). Researchers, policy makers and development practitioners therefore need to put more emphasis on the development of technologies with little requirements for such material and abstract possessions (Meinzen-Dick et al., 2014). Browning, Halcli, and Webster (2019: 1) states that people calculate the likely costs and benefits of any action before deciding what to do like the using a given post-harvest technology. Vulnerability factors deal with the effects of technologies on the level of exposure of farmers to economic, biophysical and social risks (Meinzen-Dick et al., 2016). Those technologies that have a lower risk have a greater appeal to smallholders who are naturally risk-averse (Meinzen-Dick et al., 2016). Davis, Hands, and Maki, (2017: 1) highlights that decision making of choosing a given post-harvest technology to use depends on the risks and uncertainty involved.

There are many post-harvest handling technologies that can be used by maize farmers depending on the cost of the technology. Rugumamu (2009) argued that, there is a missing link in post–harvest maize loss reduction in all the phases of post-harvest technologies. Therefore study by Lama, et al, (2014) found out the relationship between availability of appropriate technologies and post-harvest loss among maize farmers. Grains can be damaged during harvesting, threshing, or transportation and by a range of pests, insects, and molds. Improvements to storage, drying, and transportation can prevent damage and loss (Lama, et al, 2014).

Harvesting

African producers harvest grain crops once the grain reaches physiological maturity (moisture content is 20–30 percent). This stage the grain is very susceptible to pest attacks. Also, unseasonal rains at this stage can dampen the crop, resulting in mold growth and the associated risk of a flatoxin or other Mycotoxin contamination. Weather conditions at the time of harvest are a critical factor influencing PHL. More unstable weather conditions due to climate change leading to damper or cloudier conditions may therefore increase PHL (World Bank, 2011).

Two key indicators of when a plant is ready to be harvested are; it changes colour from green to light brown or yellowish. Moisture content at this point is 20-30%. Cereals like maize, sorghum and millet have a black layer just below the tip of the grain which determines the right time for harvest (USAID, 2013). Timing of harvest greatly affects the extent of aflatoxin contamination and the extended field drying of maize increased insect infestation and fungal contamination (Hell et al., 2008).

Drying

Maize is usually harvested with moisture content in the range of 18–26%, which is considerably higher than the 12–14% commercial standard for East Africa (ACDI/VOCA and USAID, 2011), therefore, drying is very important to reduce the moisture level to accepted level of 13.5% (CTA and EAGC, 2013). Most farmers in Africa, both small and large, rely almost exclusively on natural drying of crops from a combination of sunshine and movement of atmospheric air through the product, so damp weather at harvest time can be a serious cause of post-harvest losses (De Lima, 1982). Grains should be dried in such a manner that damage to the grain is minimized and moisture levels are lower than those required to support mold growth during storage (usually below 13–15 percent). Farmers should avoid contamination of the grain by using heavy polythene or Tarpaulin or use concrete slab so as to maintain the maize quality (MAAIF, 2013).

Majority of the farmers in Uganda dry the maize on bare ground and lack appropriate facilities to establish whether the maize has attained the recommended moisture content for storage (Kaaya and Kyamuhangire, 2006). There are three types of drying; sun drying, solar drying and mechanical or electrical drying and the choice of a famer to use a given method of drying depends on the cost and maize quantities. Researchers at Makerere University are currently developing a biomass-heated natural convection dryer that dramatically reduces drying time. In another example of improved drying technology, USAID's Feed the Future Initiative in Uganda is testing a mobile batch dryer. Other innovators are exploring solar drying methods and the use of plastic sheeting, concrete drying yards, raised platforms, and trays made of wire mesh or reed (Kaaya et al, 2010). Good drying reduces microbial activity, especially of moulds that may produce Mycotoxin (such as aflatoxin) (CTA and EAGC, 2013).

Shelling

Shelling or threshing is a process that frees the grain from the cob, seed head or pod. This process involves the removal of maize husks to check for damage. During this process, a lot of care is needed in order to avoid breakage of grain as a way of reducing risk of pests (USAID, EAGC, 2013). Shelling (hand-threshing) can be done with a hand-held sheller or using hands (ACDI VOCA, 2010). This process should be carefully done because it can assist in the development of insects that may actually be seen during the storage season (FAO, 2009).

Cereals especially, maize grains, can be prone to aflatoxin contamination, particularly when they come into contact with infested soil during harvesting, threshing, and drying, therefore during this process, farmers should ensures that maize should not get into contact with soil and water (Kimatu et al, 2012). According to APHLIS (2013) emphasis that most broken grain comes from poor post-harvest handling are seen especially during shelling/ threshing and may also be a consequence of pest attack and fungal contamination.

Storage

The main objective of grain storage is to maintain the quality of the produce for a long time (Okoruwa et al, 2012:2). Due to inadequate storage practices, farmers in the region including Uganda lose up to 40% of their harvest to insect, pests, mould and moisture (New Vision, 2015).

Traditionally clay-lined maize grain silos are used for storage in Africa. In each instance, subsistence farmers must take into account the difficulties of storing maize at optimal conditions and balance humidity, the moisture content of the kernels, and the potential for pest infestations (Meridian Institute, 2005). Temperature and moisture content of the cereal grains are the two key features affecting the resulting quality of the grain, biochemical reactions, dry matter losses, allowable storage times and overall storage management of the grain (Lawrence and Maier, 2010).

Much as farmers do not have storage space and containers, they struggle to protect the crop from mice and other pests (AGRA, 2013). Farmers in Africa increasingly store grains in polypropylene bags, but the poor aeration in these bags may encourage fungal growth and aflatoxin production, if the grains are not dried to a safe level (Hell et al., 2000). Poor condition and lack of adequate storage facilities resulting in significant post-harvest losses at various stages of the supply chain (World Bank, 2010).Traditionally in Uganda, maize is stored in different locally constructed storage structures such as granaries, Mudsilos, Tua, cribs and commercial stores or living rooms for a period of 2 to 6 months (Kaaya and Kyamuhangire, 2010).

Processing through dry and wet milling

The dry milling of maize as practiced today has its origins in the technologies used by the native populations who domesticated the plant. The best example is the method used to make arepa flour or hominy grits (Campbell & White, 2015).The old technology was soon replaced by a grinding stone or stone mill, followed by the grits mill and finally by sophisticated tempering-degerming methods. The products derived are numerous, with their variety depending to a large extent on particle size. They are classified into flaking grits, coarse grits, regular grits, corn meal, and corn flour by means of meshes (Amaike & Keller, 2017). Their chemical composition has been well established and their uses are extensive, including brewing, manufacturing of snack foods, breakfast cereals and many others.

Wet milling

The largest volume of maize in developed countries such as the United States is processed by wet milling to yield starch and other valuable byproducts such as maize gluten meal and feed. The starch is used as a raw material for a wide range of food and non-food products. In this process clean maize is soaked in water under carefully controlled conditions to soften the kernels (Kimatu et al. 2018). This is followed by milling and separation of the components by screening, centrifugation and washing to produce starch from the endosperm, oil from the germ and food products from the residues. The starch has industrial applications as such and is also used to produce alcohol and food sweeteners by either acid or enzymatic hydrolysis (Lance and Garren, 2017).

The latter is done with bacterial and fungal alpha-amylase, glucoamylase, beta-amylase and pullulanase. Saccharides of various molecular weights are liberated yielding sweeteners of different functional properties. These include liquid or crystalline dextrose, high-fructose maize syrups, regular maize syrups and maltodextrins, which have many applications in foods (Lance and Garren, 2017).

Packaging

It is also one of the important aspects to consider in addressing post-harvest losses in fruits and grains. It is enclosing food produce to protect it from injuries, tampering and contamination from physical, chemical, and biological sources (Kimatu et al. 2018). Some common packaging materials used include wooden crates, cardboard boxes, woven palm baskets, plastic crates, sisal sacks and jute sacks. Modified atmosphere packaging which is a new packaging technique is encouraged because it contains gases such as oxygen and carbon dioxide good to preserve the products (Lawrence et al. 2018).

2.3 The factors affecting the use of maize post-harvest handling technologies on maize farmer's income

There are various institutional, economic, psychological and social factors are known to be important in determining the adoption of improved technologies (Adesina and Zinnah, 2019). Meinzen-Dick (2016), argues that the main factors affecting technology adoption among smallholders in Sub-Saharan Africa are asset vulnerability and institutional training centres.

According to Muzari (2012), technology adoption depends on whether farmers have the requisite physical (material) and abstract possessions (for example education). Lack of assets or possessions will limit technology adoption (Meinzen-Dick et al., 2016). Researchers, policy makers and development practitioners therefore need to put more emphasis on the development of technologies with little requirements for such material and abstract possessions (Meinzen-Dick et al., 2014). Browning, Halcli, and Webster (2019: 1) states that people calculate the likely costs and benefits of any action before deciding what to do like the using a given post-harvest technology. Vulnerability factors deal with the effects of technologies on the level of exposure of farmers to economic, biophysical and social risks (Meinzen-Dick et al., 2016). Those technologies that have a lower risk have a greater appeal to smallholders who are naturally risk-averse (Meinzen-Dick et al., 2016). Davis, Hands, and Maki, (2017: 1) highlights that decision making of choosing a given post-harvest technology to use depends on the risks and uncertainty involved.

Human capital of the farmer is assumed to have a significant influence on farmers' decision to adopt maize post-harvest handling technologies. Most adoption studies have attempted to measure human capital through the farmer's Education, age, Gender, and household size (Newman & Mullins, 2010). Education of the farmer has been assumed to have a positive influence on farmers' decision to adopt the practices. Education level of a farmer increases his ability to obtain; process and use information relevant to adoption of a new post-harvest handling practices Senkondo, 2011).

Post-harvest handling periods/ stages

The physiological maturity of the fruit at harvesting stage has a major effect on quality (Beckles 2012). Care must therefore be taken as to when to harvest the fruit in order to attain the best quality. Post-harvest physiologists describe three stages in the life span of fruits and vegetables: maturation, ripening and senescence. The maturation is indicative of the fruit being ready for harvest (FAO 2008) and there are three maturity states at which grains can be harvested. It can be harvested either in matured green, partially ripened or ripened state. Maize being a climacteric fruit can be harvested at the matured green state allowing ripening and senescence to occur during the postharvest period of the fruit (Watkins 2016).

According to Moneruzzaman et al. (2009) and Orzolek et al. (2016), farmers targeting distant markets must harvest their grains in a matured red state. This will not only give the producers ample time to prepare the fruit for the market but also prevent mechanical injuries during harvesting. Meanwhile, farmers in most African countries harvest grains when they are partially or fully ripened. Fully ripened grains are susceptible to injuries during harvesting resulting in shorter shelf life (Watkins 2016; Reid 2012) This may be the reason why there are high level of losses in grains harvested at fully ripened stage in Africa.

Post-harvest handling containers

Grains are harvested by manual harvesting through use of hands instead of mechanical harvesting in most developing countries. In harvesting, care should be taken to avoid damages which can be an entry point for disease causing pathogens (Kitinoja, 2008). The majority of farmers from Africa use nylon sacks, wooden crates and woven baskets during harvesting and transportation. Overloading during harvesting can cause a buildup of excessive compressive forces resulting in crushing of grains that are found at the base of the containers (Hurst, 2010). The use of smooth surface shallow containers that will prevent overloading will therefore result in reduction in both mechanical injuries and crushing to the harvested grains and fruits Kitinoja (2008) has therefore recommended the use of plastic baskets and sacks for harvesting grains.

Excessive field heats and lack of on-farm storage facilities

The field heat of harvested crop is usually high, and should be removed as quickly as possible before any postharvest handling activity (Janet and Richar, 2010). Field heats also give rise to a sudden increase in metabolic activity and prompt cooling after harvest to reduce the metabolism is very important (Akbudak *et al.* 2012). The optimum temperature for maize harvesting of about 20ºC can be attained either in the early hours of the morning or late in the evening. Harvested fruit must be pre-cooled to remove excessive field heat if harvested at times other than the recommended periods. This can be achieved by assembling harvested fruits at a central point with a cooling system in place (Gaddi *et al*.,2012).

A study by Olayemi et al. (2010) revealed that, although about 46% of Nigerian farmers harvest their grains in the morning and 12% in the evening, most of them store the harvested grains under tree shades until buyers arrive. Tree shade is not reliable as it is likely to shift away from the produce when there is delay in the arrival of buyers. The fruits are therefore exposed to the scorching sun causing a buildup of field heat in the produce (Watkins 2016).

Knowledge on post-harvest handling practices

Farmers do not know the proper time to harvest and best postharvest technologies to use to reduce post-harvest losses (Mutabazi, 2019). They therefore do not understand the concept of sorting and grading grains by color and size to derive the most value from the product.

Packaging materials: The predominant packaging material is the raffia basket which is ergonomically unsuitable for the packaging of grains (Motlagh, 2013). These basket squash grains during stacking thereby making the farmers and traders lose significant portions of the harvest. Nylon sacks are yet to become mainstream in the industry (Miller, 2010).

Access to alternative markets**.** During peak periods, there is usually a glut in the open market which is the primary destination of grains for farmers (McDonald, 2004). This crashes the price, at times to levels whereby the costs of inputs and harvesting is higher than the going market price (Murema *et al*; 2019).

Price fluctuation of maize grains

According to the FAO (2016), China had an average maize production yield of 56 tonnes per hectare while Uganda had 3.9 tonnes per hectare. These yield numbers make it easier for Chinese farmers to drive down their prices such that the price per tonne of the processors drops, allowing him to produce a low-priced product. In Uganda, the price of the raw material is determined by the open wet market which is driven by consumer demand and product supply (Hossain, 2011). Maize grains are cultivated based on the target market i.e. low-cost cultivation for processors and while the consumer markets get the highest quality with rising product prices (Hossain, 2011). In Uganda, there is no differentiation in cultivation which is to the disadvantage of the processor. The recent exclusion of maize from items that can access foreign exchange from the Central Bank and higher import tariffs have not yielded any major results at the production and processing levels (Beckles, 2012).

Infrastructure facilities

Power, water, roads and agricultural infrastructure (mechanization) are either inadequate or non-existent in several production areas (FAO, 2018). This makes the processor provide some of these by himself thereby increasing the cost of production and reducing competitiveness.to take it to scale for widespread manufacture. Business management training for intending cottage millers is necessary for this model to work (Alenazi, 2019).

2.4 Effects of the post-harvest technologies /practices on the income of maize farmers

Post-harvest management is a crucial component of food production in developed countries. However, it is still neglected in the developing countries where large losses from farm to plate have been attributed to poor handling, distribution, storage, and purchase/consumption behavior (Zablotowicz, et al., 2009). Although the main investment in addressing global hunger has been on increasing food production, it needs to be complemented with comprehensive programs which address the huge postharvest losses especially in the famine prone Sub-Saharan countries. Recent studies have shown that this is surely one of the most sustainable alternatives to increasing food security (Sikora, et al., 2010). The highlight of this review, which links food security, farm management, Aflatoxin mitigation, and agribusiness and crop diversification to post-harvest management justifies an investment in reducing post-harvest losses in any country.

Effective postharvest management can contribute to conservation of scarce resources while minimizing the need to produce more food to cover the losses caused by lack of appropriate postharvest technologies and strategies (Menkir, A., et al., 2006). By the year 2025 it is estimated that the global food output must increase by about 75% to feed a population estimated to be close to 9 billion. Hence by then we shall need 2.8 billion tonnes of cereals, 5.3 billion tonnes of other crops, 1.6 billion tonnes of animal products. Hence, it is currently important to consider post-harvest grain management as strategic policy concern especially in the Sub-Saharan region where there is a dramatic increase in population growth and reducing agricultural land (Cary, et al., 2008).

Post-harvest handling techniques enhances quality of maize produce

The degree of excellence or superiority, is a combination of attributes, properties, or characteristics that give each commodity value, in terms of its intended use. The relative importance given to a specific quality attribute varies in accordance with the commodity concerned and with the individual (producer, consumer, and handler) or market concerned with quality assessment (Muyanja, 2012). To producers, high yields, good appearance, ease of harvest, and the ability to withstand long-distance shipping to markets are important quality attributes. Appearance, firmness, and shelf-life are important from the point of view of wholesale and retail marketers. Consumers, on the other hand, judge the quality of fresh maize grain, ornamentals, and vegetables on the basis of appearance (including 'freshness') at the time of initial purchase. Subsequent purchases depend upon the consumer's satisfaction in terms of flavor (eating) quality of the edible part of produce (Odeke, 2014). Following is a description of the factors that contribute to the various quality attributes of fresh produce. Postharvest treatment largely determines final quality, whether a crop is sold for fresh consumption, or used as an ingredient in a processed food product.

Post-harvest handling practices enhances proper hygiene of maize products through cleaning and disinfecting products. Proper hygiene is a major concern to all produce handlers, because of not only postharvest diseases, but also incidence of food-borne illnesses that can be transmitted to consumers (Perez. et al., 2012). The use of various disinfectants during postharvest treatment of maize must be observed. For instance, sodium hypochlorite solution has to be used to sterilise fruits in order to reduce the incidence of fungal infection before any postharvest treatment is applied. Fruits and vegetables should be treated with chlorinated water after washing to reduce the microbial load prior to packaging (Serna-Saldívar, 2012).

Addressing post-harvest losses through packaging. Packaging is also one of the important aspects to consider in addressing post-harvest losses in maize produces. It is enclosing food produce to protect it from injuries, tampering and contamination from physical, chemical, and biological sources. Some common packaging materials used include, woven palm baskets, plastic bags, sisal sacks and jute sacks (Atukwase and Kaaya, 2012). Modified atmosphere packaging which is a new packaging technique is encouraged because it contains gases such as oxygen and carbon dioxide good to preserve the products. The process of developing of post-harvest technology and its purposeful use need on inter disciplinary and most multidimensional approach which must include scientific creativity, technology innovation and institutional capable of interdisciplinary research (Cardwell, 2005).

CHAPTER THREE

METHODOLOGY

3.0 Introduction

Kothari (2004) defined research methodology as a way of systematically solving a research problem. This involves various steps that were followed by the researcher during the study. The chapter provided the research design, the study area, the target population, sampling procedure, methods of data collection and Data Collection Instruments, Data Quality Control (Validity & Reliability), data Analysis, measurement of the Variables and Research ethical considerations.

3.1 Research Design

According to Kothari (2004), research design is a plan, a roadmap and blueprint strategy of investigation conceived so as to obtain answers to research questions. It is a procedural plan that is adopted by the researcher to answer research questions objectively, accurately and economically (Kumar, 1996). This study used a cross-sectional survey design which adopted mixed methods. A cross-sectional study predominantly uses structured questionnaires and interview schedule for data collection with the intent of generalizing from a sample to a population.

3.2 Area of study

The study was conducted in Nkoma Sub-county, Kamwenge district .This study was conducted in three selected parishes of Nkoma sub-county and these parishes included Kabambiro, Kakinga, and Nkongoro. Kamwenge. District is bordered by Kyenjojo district to the north, Kyegegwa district and Kiruhura district to the northeast, Ibanda district to the east and southeast, Rubirizi to the southwest, Kasese district to the west and Kabarole to the northwest. Kamwenge district headquarters lies approximately 300 kilometres (190mi), by road, west of Uganda's capital, Kampala. The coordinates of the district are: 00 11N, 30 27E.

3.2 Study population

According to Amin (2005), a target population is the population to which the researcher ultimately wants to generalize the results. According to national population census 2014, the population of Kamwenge was estimated to be 332,000 people. The target population for this study were maize farmers, agricultural extension agents, community stakeholders from the selected parishes on Nkoma Sub-county in Kamwenge district.

3.3 Sample size

A sample is a subset of a population selected to represent characteristics of a population (Nesbary, 1999). The study was conducted on representative sample of 150 respondents. An optimum sample is one which fulfills the requirements of efficiency, representativeness, reliability and flexibility (Kothari, 2004). Amin (2005) emphasize that a researcher must determine the sample size that provided sufficient data to answer the research problem.

Using a sample is important to reduce costs, time and has a high degree of accuracy.

The sample size was determined using Solvins 1965 formula;

N = estimated population of maize farmers (650)

e = standard error = 5% (0.05)

$n = N/ 1+N (e)^2$

$650/1+650 (0.05)^2$

, n is required sample size, N is population size, $(e)^2$ is marginal error

n = 240 respondents.

It was from this sample size of the respondents that the researcher used 63% (response rate) of the respondents and this was attributed to limited resources in terms of finance, time and stationary to use during data collection where the required size was **150 respondents**. This number of respondents gave the most valuable and professional views that made the findings more credible. These included 135 maize farmer, 12 community stake holders and 3 agricultural extension agents.

3.4 Sampling techniques

The study used simple random sampling and purposive sampling techniques. Simple random sampling is where each and every item in the population has an equal chance of inclusion in the sample (Kothari, 2004). Simple random sampling was used to select maize farmers in the selected parishes of Kabambiro, Kakinga, and Nkongoro and every farmer has equal chances of being selected.

Purposive sampling is the deliberate selection of particular units of the population for constituting a sample which represents the universe (Amin, 2005). Purposive sampling was utilized to select, community stake holders and agricultural extension agents who were believed to be providing technical support because these were people expected to have knowledge on the phenomenon under investigation.

3.5 Data collection methods

Data collection methods are specific approaches that are applied to obtain information on the research problem (Kothari, 2004:95). The study employed both primary and secondary data collection methods explained below:

3.5.1 Primary data collection methods

The primary data is the information collected afresh and for the first time, and thus happen to be original in character (Kothari, 2004:95). The researcher used primary data collection methods by obtaining information for the directly from the respondents hence being original.

Survey questionnaires were used to collect quantitative data directly from maize farmers who carry out post-harvest handling technologies and key informant interview was used to collect qualitative data directly from agricultural extension workers and community stake holders. Questionnaires comprising of both open and closed ended questions were used for data collection.

3.5.2 Secondary data collection methods

The secondary data is gathering information from already existing sources which have already been collected by someone else and which have already been passed through the statistical process

(Kothari, 2004:95). This supplemented the primary methods and is expected to provide the researcher with an opportunity to gain more information about the phenomenon. The researcher reviewed the average maize production status of each farmer as well as the quality aspects. The researcher reviewed the different training materials of which the extension workers use in the different parishes selected, review of journals and use of internet access was considered.

3.6 Data collection instruments

Data collection instruments are tools that a researcher designs, tests and uses to obtain information from the intended sources (Amin, 2005: 261). The data collection tools or instruments that were used included; questionnaires and key informants interview guide.

3.6.1 Survey Questionnaire

A questionnaire was used to facilitate the quantitative data collection. A questionnaire is a form consisting of interrelated questions prepared by the researcher about the research problem under investigation based on the objectives of the study.

This is a device used for gathering facts, opinions, perceptions, attitudes and beliefs from a large number of people at a particular time. The questionnaire was chosen to collect this type of data because it was an efficient data collection mechanism especially when the researcher knew what was required and how to measure the variables of interest (Sekaren, 2003). It also allows the researcher to collect a lot of information over a short period of time at a low cost and free from bias of the interviewer (Kothari, 2004:101). (Creswell, 1994) advises that a questionnaire to be used must be prepared very carefully so that it may prove to be effective in collecting the relevant information. Therefore, the researcher prepared carefully a questionnaire to collect information about the dimensions of post-harvest handling and maize farmers' income.

3.6.2 Key informant interview guide

Key informant interview is a qualitative, in-depth interviews of people selected for their first-hand knowledge about a topic of interest (Kumar, 1989). A key informant interview guide was used to get information from the key informants. Key informant interview guides were devices that provided information to guide the interview process. This guide has a list of questions that were asked in relation to the themes of study specifically the independent variable (post-harvest handling technologies) and the dependent income (Maize farmers' income).

3.7 Data Quality Control

Data quality controls are measures that are taken to ensure that the information to be collected will represent the sample and is consistent. Quality data control or pre- testing instruments considered two aspects; validity and reliability.

3.7.1 Content Validity of Research Instruments

Validity is the degree to which results obtained from the analysis of data actually represent the phenomenon under study (Oso and Onen, 2008). This is the ability of the instrument to collect truthful and justifiable data. Validity also refers to the accuracy and meaningfulness that are based on the research findings, the measure of the extent to which an instrument measures what it is meant to measure (Mugenda, 1999). The researcher prepared data collection instruments and subjected them to validity tests before finally administering them on respondents. The draft questionnaire was subjected to expert judgment to verify the validity of the questions in line with Lynn (1986) where the researcher will use the Content Validity Index (CVI).

The researcher distributed an initial draft questionnaire to 5 (five) experts in post- harvest technologies in maize. The Content validity was determined by having items on the instrument rated by five (5) experts. The Content Validity Index (CVI) was then determined by the formula and the workings below.

$$CVI = \frac{\text{Number of items considered valid}}{\text{Number of items on the draft questionnaire and the interview checklist}}$$

A CVI of 0.7 and above for any instruments was considered valid for the study in accordance with Amin (2005). All questions deemed not valid was edited or dropped per the recommendation of the experts.

3.7.2 Reliability of the research instruments

Reliability is the measure of the degree to which a research instrument yields consistent results or data after repeated trails (Sekaran, 2003). Reliability also refers to the ability of the instrument(s) to collect the same data consistently under similar conditions. To determine the reliability of the research instruments, a pre-test of the instruments were undertaken in a similar environment using the same tools. The instrument was pretested once with thirty five respondents, and the Chronbach's alpha was used to correlate the scores of the responses.

The formula for Cronbach's Alpha which was used was as follows:

A Cronbach's Alpha = (n/ n-1) (SD^2 - ∑Variance)/SD^2

where: n= Number of items on the test

SD= The Standard Deviation for the set of test scores, and ∑Variance = Summation of the variances of the scores for each of individual item on the test.

A Cronbach's Alpha of above 0.7 showed that the tool was reliable. The higher the reliability coefficient, the higher the reliability of the instrument.

3.9 Procedure of Data Collection

A systematic procedure during data collection was followed by a researcher. The researcher ensured acquisition of a letter to introduce the researcher to farmers' cooperative in Nkoma Sub-county Kamwenge districts to enable him seek the acceptance from management and leadership of the selected parishes to access and interact with proposed respondents. The researcher sought to deliver questionnaires to respondents to whom he explained the objectives of the study, how they were selected and as well sought their consent to participate as respondents and requested to fill the questionnaire. The researcher at a later date collected the filled questionnaires and verified the completeness of responses therein. The researcher also fixed appointments to conduct interviews with key informants and searched for data to support answering the research questions.

3.10 Data analysis

Data analysis is the process of bringing order, structure and meaning to the mass of collected data to obtain usable and useful information. Both quantitative and qualitative data was analyzed using the following different methods of analysis as below:

3.10.1 Quantitative data analysis

The quantitative data was sorted, and edited to eliminate errors so as to ensure completeness, accuracy and uniformity. Coding was then done after editing in an attempt to reduce data from detailed to summarized and understandable forms such as tables, charts and graphs. The data was then entered into the computer and analyzed using Statistical Package for the Social Sciences (SPSS). Data was analyzed using descriptive statistics such as frequencies, percentages and cross tabulations. Interpretations and implications of the generated statistical information was then derived, objective by objective following the data presentation and analysis.

In order for the researcher to measure the degree of association between the Independent variable (Post- harvest handling technologies) and the dependent variable (Maize famer's income), the Spearman rank correlation was used. Spearman rank correlation is the technique of determining the degree of correlation between two variables in case of ordinal data where ranks are given to the different values of the variables. The main objective of this coefficient was to determine the extent to which the two sets of ranking are similar or dissimilar.

This formula was used to calculate the Spearman rank correlation

$r^2 = 6\sum d^2_i / 1- n (n^2 -1)$

Where: r^2= Spearman rank correlation

d_i = the difference between the ranks of corresponding values x_i and y_i

n = number of value in each data set

This was at a significance level of 0.05. A significance level, according to Mugenda (1999) is the probability of obtaining similar results if the study is repeated many times using different but equal random samples. For values of less than 0.05(5%), the hypotheses was accepted and the conclusion was that there was a significant positive relationship between the Independent variable (Post-harvest handling technologies) and the dependent variable (Maize farmers' income). Regression analysis which is "used when the researcher is interested in finding out whether an independent variable predicts a given dependent variable" (Mugenda, 1999) was also used to establish which of the post- harvest handling technologies dimensions was more responsible for maize farmers income by measuring to their net effects on the dependent variable.

3.10.2 Qualitative data analysis

Qualitative data obtained by using key informant interviews and documentary reviews was sorted, edited and arranged according to themes category by category, based on the study objectives. This further ensured that the information given by the respondents was accurate, complete and consistent. Content analysis was done according to the themes and interpretations made and reported.

3.11 Measurement of variables

The study variable was measured at three levels: Univariate, Bivariate and Multivariate.

3.11.1 Univariate Level

At the Univariate, the researcher gave a full description of a single variable and its attributes. Hence, frequency tables were used to present data and give a descriptive and inferential analysis of the variables.

3.11.2 Bivariate Level

At bivariate level, the researcher established the relationship between the Independent variable (Post- harvest handling technologies) and the dependent variable (Maize famer's income). The bivariate level involved considering two variables at the same time and involved correlation of dimensions of the Independent variable (Post- harvest handling technologies) and the dependent variable (Maize famer's income). This was used to test for the hypothesis of the study.

The decision rule was set at 5% level of significance which was the accepted precision level in socio-economic research.

3.11.3 Multivariate Level

All the independent variables that were tested significant at bivariate level were analyzed using a regression analysis to measure their net effects of independent variable on the dependent variable. This is a typical measurement that established the relationships between the Independent variable (Post- harvest handling technologies) and the dependent variable (Maize famer's income). It was essential to determine the percentage effect or effects of each dimension the Independent variable (Post- harvest handling technologies) to the dependent variable (Maize famer's income).

3.12 Ethical consideration

In conducting research, it was important to remember the power relationship in a research process and how this affects the research. The researcher had the responsibility not to abuse power, and to safeguard other participant's integrity, anonymity and generally treat all involved with respect. As one of the overarching principles of ethics, it was crucial to sound research to do no harm .This position promoted an ethical view that claimed that the value of the research is not worth destroying people or communities in the process. Another consideration in the research was that participation was voluntary and was a conscious decision and informed consent which was a way of ensuring this. This was obtained by the researcher explaining what the study was about, and ensuring the participant's anonymity as well as the participants' possibility of withdrawing during the research.

CHAPTER FOUR

ANALYSIS, PRESENTATION AND INTERPRETATION OF STUDY FINDINGS

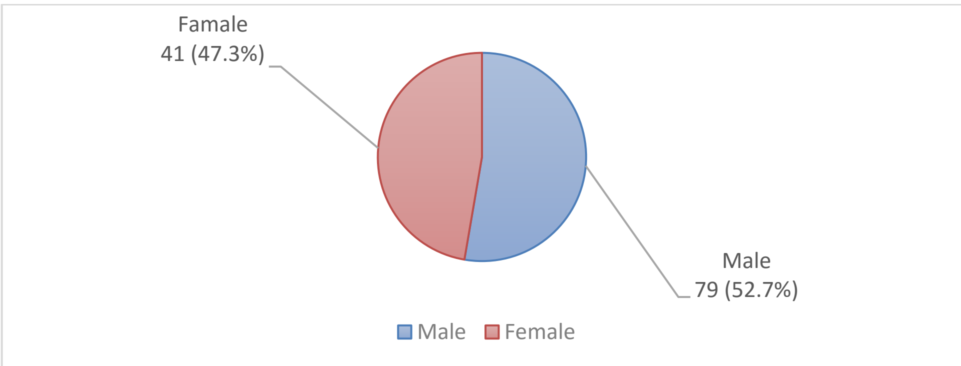
4.1 Introduction

This chapter presented study findings that were in line with the objectives. Quantitative methods of analysis were used to generate descriptive and inferential statistics that aided in the interpretation of the findings. All the 150 questionnaires administered to the respondents were collected giving response rate of 100%. The findings were organized as socio-demographic characteristics, post-harvest handling technologies and practices used by maize farmers, role of training in post-harvest handling technologies on maize farmers' income and effect of the post-harvest technologies and practices on farmers' incomes in the area.

4.2 Socio-economic characteristics of maize farmers

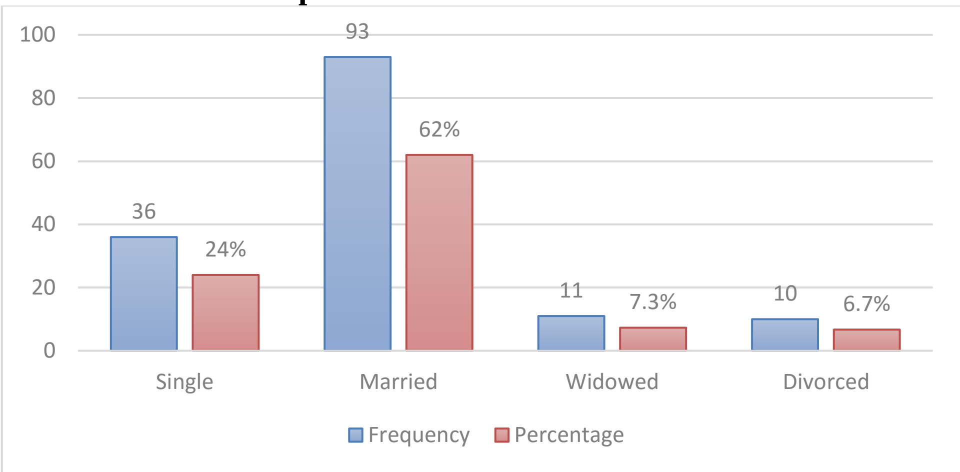
The major demographic characteristics considered included; gender, marital status, education level, age, farming experience and farm size in acres. The purpose for collecting respondent background information was to help the researcher find out their influence on the use of postharvest handling technologies.

Figure 1: Distribution of respondents by gender



Result in figure 1 above showed that (52.7%) of the respondents were male, and 47.3% female. There was an observed difference between participants by gender where male dominated the study than female. This is perhaps justified by the fact that maize is a laborious crop that requires more of energy. This energy is provided by men than women.

Figure 2: Marital status of the respondents



Findings in figure 2 above indicate that more than a half (62%) of the respondents were married, 24% never married, 7.3% separated and 6.7% divorced. The dominance of married respondents in the study is due to their commitment in farming activities to meet food needs of their families.

Table 1: Descriptive Statistics

Classification	N	Minimum	Maximum	Mean	Std. Deviation
Age in years	150	18	70	36.96	14.036
Years spent in school	150	0	18	10.68	4.430
Experience in maize growing and postharvest handling	150	1	18	7.71	3.138
Valid N (listwise)	150				

As shown in table 1 above, mean age distribution of the respondents was 36 years with a minimum of 18 and a maximum 70. A big portion of the respondents were aged 18 to 70 years. Average number of years in school were ten (10) with a minimum of zero and maximum of 18. Average years of experience in maize growing and postharvest handling were 7 with a minimum of 1 and maximum of 18 years. The above data indicates that maize farming attracted relatively young farmers of active age averaging 37 years. This implies that maize farming is an attractive enterprise to the young people of good education with a mean of approximately 11 years of schooling.

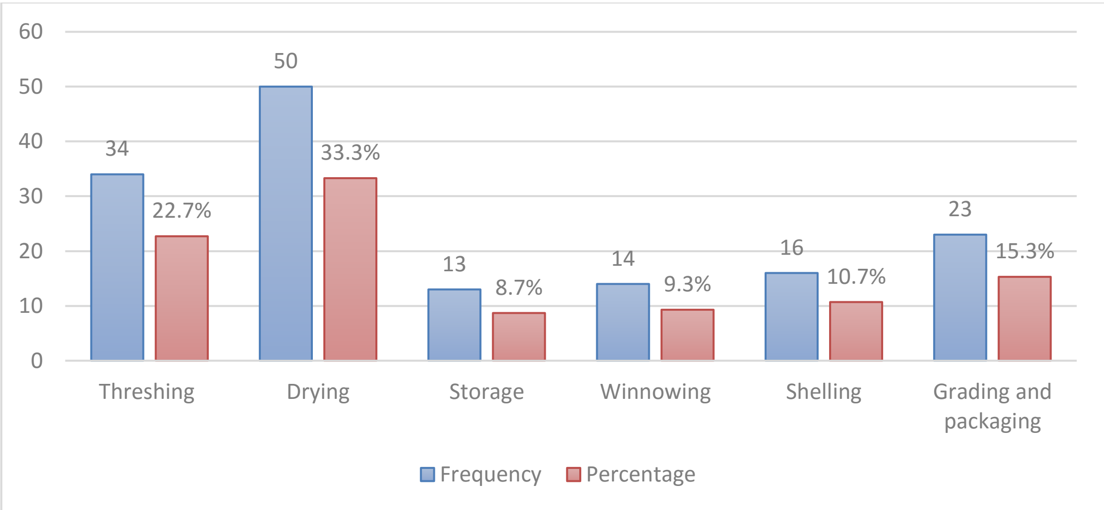
Table 2: Descriptive Statistics of acreage and harvest per acre

Classification	N	Minimum	Maximum	Mean	Std. Deviation
Maize acreage per season	150	1	23	2.97	5.043
Tons of maize per acre	150	1	14	2.89	2.587
Valid N (listwise)	150				

As shown in table 2 above, average land distribution among maize farmers were 2.9 acres with the smallest holder owning a minimum of an acre and the biggest holder owning a maximum of 23 acres. Average tons of maize generated in acre of maize were 2.89 with a minimum harvest of a ton and maximum of 14 tons. The data indicates that maize is produced by small scale farmers.

4.3 Post-harvest handling technologies and practices on maize farmers' income in Nkoma sub-county, Kamwenge District

Figure 3: Post- harvest handling technologies and practices



As shown in figure 3 above, 33.3% of the respondents mentioned drying as the most used post-harvest handling technology/practice at, 22.7% threshing, 15.3% grading and packing, 10.7% shelling, 9.3% winnowing and 8.7% storage.

These results are complemented by the key informant stating that; "*Farmers find it very hard to shell their maize for example farmers from Kamwenge district particularlyin Nkoma sub-county use a mechanical sheller but the cost of hiring this sheller is a bit expensive where they charge sh3,000* *to shell 100 kg and sometimes causing breaking of the maize grain. Therefore, it's important to provide a quality and cheap sheller at sub- county level".*

Another key informant said: "*Farmers in this area lack quality shellers to use while shelling their maize. The shellers cause a lot of grain breakage leading to a high post-harvest loss. Therefore, there is a need for the government and other development partners to provide quality shellers that farmers can hire at a low cost*". These results show that shelling is also a major challenge to farmers. Although, they use a mechanized sheller, the cost of hiring a sheller is still high and sometimes causes grain breakage.

Table 3: Methods used in drying maize

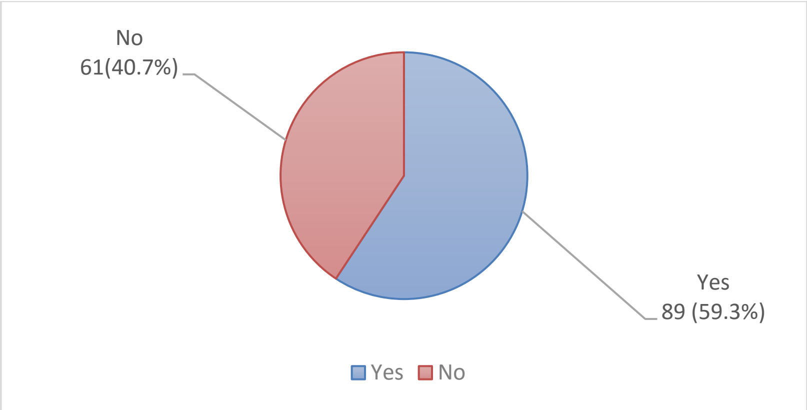
	Responses	Frequency	Percent	Cumulative Percent
Valid	Sun drying on grass	28	18.7	18.7
	Sun drying on bare soil	59	39.3	58.0
	Sun drying with a drying yard	25	16.7	74.7
	Solar drying	18	12.0	86.7
	Tarpaulin	20	13.3	100.0
	Total	150	100.0	

According to the results in table 3 above, 39.3% mentioned sun drying on bare soil as the commonly used method for drying maize, 18.7% sun drying on grass, 16.7% sun drying with a drying yard, 13.3% tarpaulin and 12% solar drying.

In an interview conducted with agricultural extension agents, it was revealed that; *"drying especially when farmers dry on a bare soil it leads to high post- harvest losses. Farmers in Nkoma Sub-county were advised to build cribs for drying. In fact those are one the conditions put in place by the association to buy their maize. In most cases, farmers lack enough money to construct strong and big cribs. Some farmers complain about thieves and pest damage".*

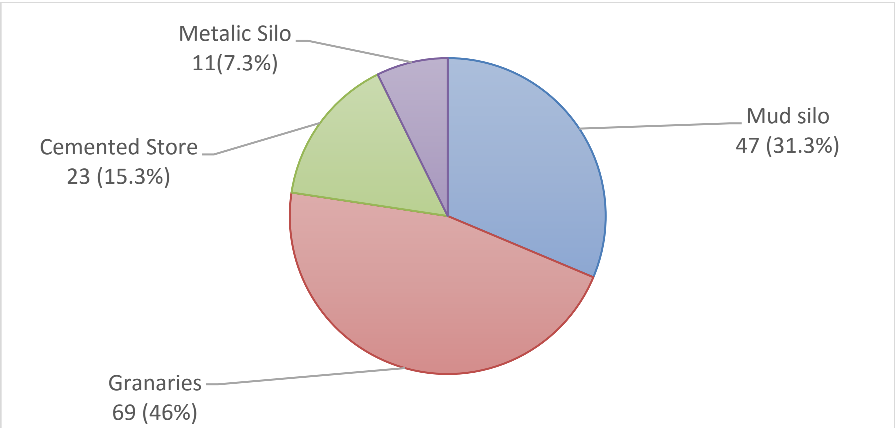
Another community stake holder was quoted saying: "Farmers in Nkoma sub-county, Kamwenge district use tarpaulins but farmers find it very hard to get quality tarpaulins to use. Provision of artificial driers like solar and electrical driers will help a lot in reducing post-harvest loss"

Figure 4: Whether respondents had maize store



When asked whether they owned a maize store, 59.3% replied yes while 40.7% said no.

Figure 5: Type of store owned



As shown in figure 5 above, most (46%) of the respondents used granaries, 31.3% mud silos, 15.3% cemented stores and 7.3% metallic silos.

One key informant said: "*Most farmers do not have quality and enough storage facilities. When their maize is shelled, it's immediately taken to the warehouse for further cleaning, drying and storage. The biggest challenge is that farmers lack money to use while storing their maize. The* *major problem with warehouse operators is lack of genuine fumigants where by most of them are fake causing the storage pests to develop resistance to them*".

Another key informant said: "*Most farmers in Nkoma sub-county have their small stores called granaries but with little space to accommodate all the harvested maize. With a provision of village collection centre with a good store where farmers can store their maize as they are waiting for the prices to go up and sell is important. Farmers also need to be trained more in storage pest management*".

4.2 The factors affecting the use of maize post-harvest handling technologies on maize farmer's income in Nkoma sub-county, Kamwenge district

Table 4: Whether there were factors affecting the use of maize post-harvest handling technologies

	Responses	Frequency	Percent	Cumulative Percent
Valid	Yes	150	100	100
	No	00	00	100.0
	Total	150	100.0	

On whether there were factors affecting the use of maize post-harvest handling technologies among maize farmers, 100% of the respondents replied yes while neither of the respondents said no.

Table 5: Factors affecting the use of maize post-harvest handling technologies on maize farmer's income

	Responses	Frequency	Percent	Cumulative Percent
Valid	Infrastructural facilities	28	19	19
	Price fluctuation of maize grains	17	11	30
	Human and financial capital	50	33	63
	Excessive field heats and lack of on-farm storage facilities	25	17	80
	Knowledge on post-harvest handling practices	30	20	100.0
	Total	150	100.0	

Regarding the factors affecting the use of maize post-harvest handling technologies on maize farmer's income, 33% of the respondents revealed human and financial capital, 20% revealed knowledge on post-harvest handling practices, 19% of the respondents said that infrastructural facilities affect the use of maize post-harvest handling technologies which has thus affected income among maize farmers, 17% reported excessive field heats and lack of on-farm storage facilities and 11% reported price fluctuation of maize grains.

In an interview conducted with one of the key informants, it was revealed that; "*most of the farmers access no or less extension training programs because extension agents are few compared to the number of farmers captured at sub-county level and this leaves most of the farmers untrained on the use of effective maize post-harvest handling technologies which mostly render maize farmers to post-harvest losses thus affecting their household income*".

4.3 Effect of post-harvest technologies and practices on household income

Table 6: Model Summary for the relationship between post-harvest technologies/practices and household income

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.614[a]	.432	.312	2.292

The results in table 6 above summarized the regression model used in the analysis. A direct strong correlation of .614 was observed between post-harvest handling technologies/practices and household income. The R Square of .432 was an indication that application of post-harvest handling technologies/practices contributed to 43.2% increment in household income. An Adjusted R Square of .312 implied that applying post-harvest handling technologies/practices accounted for 21.2% variation in household income generated.

Table 7: ANOVA results for the perceived effect of post-harvest technologies/practices on household income

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	50.692	2	10.138	1.931	.002[a]
	Residual	11942.922	148	5.251		
	Total	11993.614	150			

a. Dependent Variable: household income

As shown in Table 7 above, the effect of post-harvest technologies/practices on household income was significant at 2 and 148 degrees of freedom since the p-value of .002 was less than 0.05. The effect of each post-harvest technology/practice on household income was further executed through multiple regression as presented in table 8 below;

Table 8: Multiple regression output for the effect of post-harvest technologies/practices on household income

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	6.900	.659		10.479	.000
	Threshing	.005	.000	-.073	-1.391	.165
	Drying	5.027	.031	.130	2.252	.002
	Storage	9.156	.783	.412	3.223	.000
	Winnowing	4.003	.201	.137	2.605	.010
	Shelling	.000	.001	.036	.689	.491
	Grading and packaging	5.125	.131	.230	2.785	.001
a. Dependent Variable: Income						

As shown in table 8 above, six post-harvest technologies/practices were set as predictors of household income in the area. Only four were significant including; drying, storage, winnowing, grading and packaging. Results of analysis presented a significant association between maize drying and household income at 5% level of significance. The Coefficient (β = 5.027 at p= .002) implied that as maize being dried increased by a unit, household income increased by 5 shillings.

Similarly, maize storage had a significant effect on household income generated at 5% level of significance. The Coefficients (β = 9.156 at p= .000) for storage implied that a unit increase in the maize stored for a specified period, increased household income by 9 shillings.

Another statistically significant association was observed between maize winnowing and household income at 5% level of significance. The Coefficient (β = 4.003 at p= .010) indicated that a unit increase in the kilograms of maize winnowed, increased household income generated by 4 shillings.

Lastly, a significant association was further observed between grading and packaging, and household income generated at 5% level of significance. The Coefficient (β = 5.125 at p= .001) reveals that a unit increase in the kilograms of maize graded and packaged, increased household income generated by 5 shillings.

These results were supplemented by the key informant who said: "*maize post-harvest handling technologies would increase farmer's income if majority have what it takes to invest in postharvest technologies and again due to wider area coverage, most of the farmers do not get access to extension training programs on how best they can use post-harvest handling technologies which also affect their income at household level*"

CHAPTER FIVE

DISCUSSION, CONCLUSIONS AND RECOMMENDATION

5.1 Discussion of findings

The discussion was arranged in line with the study objectives that include; post-harvest handling technologies and practices on maize farmers' income, role of training in post-harvest handling technologies on maize farmers' income and the effects of the post-harvest technologies and practices on the incomes of maize farmers in the study area.

5.1.1 Post-harvest handling technologies/practices and maize farmers' income

The study came out with different post-harvest handling technologies and practices used by maize farmers in in Nkoma sub-county, Kamwenge District such as; threshing, drying, storage, winnowing, shelling, grading and packing. Drying was the commonly used post- harvest handling technology/practice in the area reported by 3.3% of the respondents. Most farmers in the area relied exclusively on natural drying by combining sunshine and movement of atmospheric air through the product. Maize was dried on bare soil with others drying on grass, yards, solar dryers, and tarplins. Grains were dried in manner that damage is minimized and moisture levels are lower than those required to support mold growth during storage (usually below 13-15%). This is necessary to prevent further growth of fungal species that may be present on fresh grains. The length of time needed for full drying of grains depends considerably on weather and atmospheric conditions. This finding is in agreement with Kaaya and Kyamuhangire, (2006) who argued that grains should be dried in such a manner that damage to the grain is minimized and moisture levels are lower than those required to support mold growth during storage (usually below 13–15 percent). They noted that majority of the farmers in Uganda dry the maize on bare ground and lack appropriate facilities to establish whether the maize has attained the recommended moisture content for storage. There are three types of drying; sun drying, solar drying and mechanical or electrical drying and the choice of a famer to use a given method of drying depends on the cost and maize quantities.

More so, 22.7% of the respondents reported threshing as another post-harvest handling technology used by farmers in the area. For some grains, like millet and sorghum, threshing is always delayed for several months after harvest and the unthreshed crop stored in open cribs. In the case of maize, the grain is stored on the cob with or without sheathing leaves for some months, or the cobs may be shelled and grain stored. Some machinery suitable for small small-scale operation exists such as: maize shellers. These machines ease the exercise of threshing for most households, though they are hired at a cost. This study finding is in line with FAO, (2009) which stated that shelling or threshing is a process that frees the grain from the cob, seed head or pod. This process involves the removal of maize husks to check for damage. During this process, a lot of care is needed in order to avoid breakage of grain as a way of reducing risk of pests. Shelling (hand-threshing) can be done with a hand-held sheller or using hands. This process should be carefully done because it can assist in the development of insects that may actually be seen during the storage season.

A fraction (15.3%) cited grading and packing as part of the post-harvest handling technologies and practices adopted by farmers in the area. One of the most important processes in packaging and marketing of maize is sorting and grading. Grading is done to categorize cereals, based on colour, size, stage of maturity, or degree of dryness. The two processes are vital in maintaining postharvest shelf life and quality of harvested maize. Sorting is done to limit the spread of infectious microorganisms from bad cereals to other healthy ones during postharvest handling of maize.

Proper packing and packaging technologies are critical in minimizing mechanical injury during the transit of produce from garden and storage areas. Causes of PHL during packing and grading stages are: lack of national standards and poor enforcement of standards, lack of skill, awareness, and financial resources. This finding is comparable to findings by Lawrence and Maier, (2010) who revealed that packaging is one of the important aspects to consider in addressing postharvest losses in cereals, fruits and vegetables. It is enclosing food produce or product to protect it from mechanical injuries, tampering, and contamination from physical, chemical, and biological sources. Packaging as a postharvest handling practice in agricultural production is essential in putting the produce into sizeable portions for easy handling. However, using unsuitable packaging can cause damages resulting in losses. Some common packaging materials used in most developing countries include wooden crates, cardboard boxes, woven palm baskets, plastic crates, nylon sacks, jute sacks, and polythene bags.

Bokusheva et al, (2012) argued that grading is also the process of categorising cereals, fruits and vegetables on the basis of colour, size, stage of maturity, or degree of ripening. The two (grading and packaging) processes are vital in maintaining postharvest shelf life and quality of harvested tomatoes. Sorting limits the spread of infectious microorganisms from bad fruits/cereals to other healthy ones during postharvest handling of tomatoes. Grading also helps handlers to categorize products in a given common parameter which enables easy handling.

Respondents equating to 9.3% further highlighted winnowing/cleaning as a common post-harvest handling practice applied by farmers. This process is usually done prior to storage or marketing if the grain is to be sold directly. For the majority of the smallholder, this process is done manually. It is relatively ineffective from a commercial perspective, since grain purchased from smallholders frequently requires screening to remove stones, sand, and extraneous organic matter. There is little incentive for smallholders to provide well-cleaned grain for marketing; as a result profits from sales are limited. During winnowing, broken grain is removed with the husks and is also more susceptible to certain insects (e.g. flour beetles and weevils). This finding is comparable to the findings by Kimatu et al, (2012) who argued that cereals especially, maize grains, can be prone to aflatoxin contamination, particularly when they come into contact with infested soil during harvesting, threshing, and drying, therefore during this process, farmers should ensures that maize should not get into contact with soil and water.

Lastly 8.7% of the respondents mentioned storage as a post-harvest handling technique for maize. Storage is the art of keeping the quality of agricultural materials and preventing them from deterioration for specific period of time, beyond their normal shelf life. Different crops are harvested and stored by various means depending on the end utilization. Whether the seed will be used for new plantings the following year, for forage being processed into livestock feed, or even for crops to be developed for a special use, the farmers aware of harvesting and storage requirements toward a quality product. After determining the prescribed use for the crop, timing for harvest and storage is of important consideration. This study finding is in line with Okoruwa et al, (2012) who argued that the main objective of grain storage is to maintain the quality of the produce for a long time. Traditionally clay-lined maize grain silos are used for storage in Africa. In each instance, subsistence farmers take into account the difficulties of storing maize at optimal conditions and balance humidity, the moisture content of the kernels, and the potential for pest infestations.

5.1.2 Factors affecting the use of maize post-harvest handling technologies on Smallholder maize farmer's income

Regarding the factors affecting the use of maize post-harvest handling technologies on Smallholder maize farmer's income, 26% of the respondents revealed human and financial capital to many maize farmers. This finding is in agreement with Newman & Mullins, (2010) who in their study reported that most adoption studies have attempted to measure human capital through the farmer's Education, age, Gender, and household size. Authors further explained that education of the farmer has been assumed to have a positive influence on farmers' decision to adopt the practices.

Study respondents revealed excessive field heats and lack of on-farm storage facilities. This was reported by 25.3%. this finding concurs with Janet and Richar, (2010) who explained that field heat of harvested crop is usually high, and should be removed as quickly as possible before any postharvest handling activity (Field heats also give rise to a sudden increase in metabolic activity and prompt cooling after harvest to reduce the metabolism is very important.

The study results established that16.7% reported knowledge on post-harvest handling practices. This finding is consistent with Mutabazi, (2019) who stated that farmers do not know the proper time to harvest and best postharvest technologies to use to reduce post-harvest losses. The same author further explained that therefore farmers do not understand the concept of sorting and grading grains by color and size to derive the most value from the product.

The study results also revealed infrastructural facilities as a major factors that limit farmers from adopting to postharvest handling technologies in Suam Sub County. This finding is consistent with FAO, (2018) who reported that power, water, roads and agricultural infrastructure (mechanization) are either inadequate or non-existent in several production areas (FAO, 2018). This makes the processor provide some of these by himself thereby increasing the cost of production and reducing competitiveness.to take it to scale for widespread manufacture.

5.1.3 Effect of the post-harvest technologies and practices on the incomes of maize farmers in the study area

The study findings show that there was an observable significant effect of specific post-harvest technologies/practices on household income generated. Among the six post-harvest technologies/practices set as predictors of household income, four were significant including; drying, storage, winnowing, grading and packaging. Maize drying presented a significant association between with household income at 5% level of significance. It was discovered that a unit increase in maize dried by a kilo, increased household income by 5 shillings. Postharvest drying contributes to reducing poverty by enhancing income earning opportunities for poor people, and by providing time-saving processed foods to the urban poor. This provides income opportunities for smallholders and for landless laborers, which tend to be among the poorest strata in rural settings. This finding is in agreement with Kaaya and Kyamuhangire, (2006) who argued that grains should be dried in such a manner that damage to the grain is minimized and moisture levels are lower than those required to support mold growth during storage (usually below 13–15 percent). Shelf life can be extended by maintaining a commodity at its optimal temperature, relative humidity and environmental conditions.

Similarly, storage had a significant effect on household income generated at 5% level of significance. A unit increment in the kilograms of maize stored for a specified period, contributed to an increase in household income by 9 shillings. This finding concurs with Bokusheva et al, (2012) who stated that improved storage technologies, such as biological pest control or controlled atmosphere storage reduce postharvest food losses. Reducing losses increases the amount of food available for consumption. The project dealing with biological control of the larger grain borer reduces losses in on-farm storage for smallholders, and thus enhances food security.

A statistically significant association was observed between winnowing and household income at 5% level of significance. A unit increase in the kilograms of maize winnowed contributed to a direct increase in household income generated by 4 shillings. This finding is comparable to findings by Rugumamu (2012) who revealed that reduced wastage during storage reduces food and income losses for farmers. In the case of tropical fruit, improved storage technology opens up new markets for products from developing countries and thus creates income opportunities and reduces poverty. In addition, processed convenience foods reduce the amount of time the poor, and especially urban women, have to spend preparing meals. Improved processing that leads to more nutritious foods thus frees up time for other activities such as wage work, contributing to poverty reduction.

Lastly, a significant association was observed between grading and packaging, and household income generated at 5% level of significance. The Coefficient for this case revealed that a unit increase in the kilograms of maize graded and packaged, increased household income generated by 5 shillings. This finding is in line with Zablotowicz, et al., (2009) who stated that systematic sorting or grading coupled with appropriate packaging and storage, will extend shelf life, maintain wholesomeness, freshness, and quality, and substantially reduce losses and marketing costs. Sorting is done to separate poor produce from good produce, and further classify the good produce based on other quality parameters like size. They further mentioned that proper packing is essential to maintain the freshness of leafy vegetable. Packaging should be designed to prevent premature deterioration in product quality, in addition to serving as a handling unit. Use clean, smooth and ventilated containers for packaging. This is a very important factor in cutting down losses in these crops during harvesting, transportation, marketing and storage. Use containers that are appropriate for the crop.

5.3 Conclusions

Based on the findings, the study made the following conclusions;

The study concluded that there are different post-harvest handling technologies and practices used by maize farmers in in Nkoma sub-county, Kamwenge District such as; threshing, drying, storage, winnowing, shelling, grading and packing. Drying on bear soil is the commonly used technology/practice in the area.

The study concluded that there were factors affecting the use of maize post-harvest handling technologies on Smallholder maize farmer's income. These were; price fluctuation of maize grains, human and financial capital, excessive field heats and lack of on-farm storage facilities and knowledge on post-harvest handling practices.

The study further concluded that specific post-harvest technologies/practices had an effect on household income generated. Technologies/practices such as; drying, storage, winnowing, grading and packaging presented a significant association with household income.

5.4 Recommendations

The study recommended the following;

There should be provision to farmers with materials to use or hire at a relatively cheap cost, for instance polyethylene, tarpaulins, tractors with harvesters and trailers, shellers, artificial driers using solar or other electricity, store and village collection centres with all these quality equipment to use.

The trainings should be conducted nearer to the farmers maybe at sub-county level, provision of enough training materials like charts in local languages, use of more local languages during the trainings so that farmers can easily understand, increase on the time allocated for these trainings and more practical sessions during the trainings, involvement of some farmers during the planning stage so that the trainings are directed towards the actual farmers' needs.

Efforts should be made towards increasing awareness of the importance of post-harvest handling technologies so that post-harvest losses are reduced in Nkoma sub-county and increase maize farmers' income.

Farmers should form strong cooperatives that can easily access agricultural financing and be able to hire the post-harvest equipment at a low cost.

5.5 Areas for further research

The study recommends further research on; the factors limiting the adoption of post-harvest handling technologies/practices in Nkoma Sub-county.

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APPENDICES

APPENDIX 1: QUESTIONNAIRE FOR RESPONDENTS

Dear Sir/Madam, am **Ayebazibwe Ubard,** a student of Bishop Stuart University, Mbarara pursuing Master's degree in Agriculture and Rural Innovations and conducting a research study on "**Effects of Post-Harvest Handling on Maize Farmers' Income in Nkoma Sub-County, Kamwenge District".** The study is purely for academic reasons and you are kindly requested to honestly fill this questionnaire by providing your true answers to all questions. There is no pledged compensation for participating in this study. However, your thoughts will certainly contribute to the body of knowledge of post-harvest handling. At all stages of the study, there will be no mention of your personal identity details.

Therefore, you are kindly requested to answer the questions as instructed and for more information feel free to contact.

Instructions: (Please tick or circle or fill in the blank spaces where necessary)

Section A: Bio-data of the respondent

1. Respondent's Sex

a) Female ☐

b) Male ☐

2. Your age in years…………………………………………………..

3. Marital status

a. Single ☐

b. Married ☐

c. Widowed ☐

d. Divorced ☐

4. Years spent in school…………………………

5. Years of Experience in maize growing and post-harvest handling……………………………years

Section B: Post-harvest handling technologies and practices on maize farmers' income in Nkoma sub-county, Kamwenge District\

6. What is your maize acreage per season in (acres)?..acres

7. How many tons of maize do you harvest per acre?...tones

8. Are you aware of post-harvest handling technology?

a. Yes ☐

b. No ☐

If yes, what is it?……………………………………………………………..

……………………………………………………………………………….

9. What is the most post- harvest handling technologies that you need to improve your quality and Quantity of maize

a. Harvesting ☐

b. Drying ☐

c. Storage ☐

d. Shelling ☐

e. Grading and packaging ☐

Any other specify ………………………………………………………………………………...

……………………………………………………………………………………………………

10. What methods do you use during drying your maize?

a. Sun drying using ☐

b. Sun drying on bare soil ☐

c. Sun drying with a drying yard ☐

d. Solar drying ☐

e. Taplin ☐

Others (Please specify)………………………………………………………………

11. Do you have a maize store?

a. Yes ☐

b. No ☐

If yes, which type of store do you have?

a. Mud Silo ☐

b. Granaries ☐

c. Cemented store ☐

d. Metallic silo ☐

Others (Please specify)…………………………………………………………..

SECTION C: Factors affecting the use of maize post-harvest handling technologies on Smallholder maize farmer's income

12. Could there be factors affecting the use of maize post-harvest handling technologies?

a. Yes ☐

b. No ☐

13. If yes, mention the factors?

………………………………………………………………………………………………..

. ……………………………………………………………………………………………..

………………………………………………………………………………………………..

………………………………………………………………………………………………..

Section D: Effects of the post-harvest handling technologies and practices on the incomes of maize farmers

14. Are you aware that there are effects of post-harvest handling technologies and practices on maize farmer's income?

a. Yes ☐

b. No ☐

If yes, what are the effects of post-harvest handling technologies and practices?

a. Minimizes the need to produce more food to cover the losses due to lack of post-harvest handling ☐

b. Post-harvest handling techniques enhances quality of maize produce ☐

c. Proper post-harvest handling helps to extend shelf life of maize grains ☐

d. Reduces the incidence of fungal infection through post-harvest treatments ☐

Any other specify…………………………………………………………………..

APPENDIX 11: AN INTERVIEW GUIDE FOR RESPONDENTS

1. What is your age?....................
2. What is your age?....................
3. What is your marital status?...........................
4. What is your level of education in years?.............................
5. What is your maize acreage per season in acres?
6. Are you aware of post-harvest handling technology?
7. What is the most post- harvest handling technologies that you need to improve your quality and Quantity of maize?..................................
8. What methods do you use during drying your maize?.............
9. Do you have a maize store?...............................
10. If yes, which type of store do you have?...................
11. Have you ever attended extension training on post-harvest handling of maize in your area?
12. If yes, which training aids did extension workers use during training on post-harvest handling?
13. How has extension training on post-harvest handling of maize helped you on improving your income?...................................
14. Are you aware that there are effects of post-harvest handling technologies and practices on maize farmer's income?...
15. If yes, what are the effects of post-harvest handling technologies and practices on maize farmer's income?...