POST-HARVEST HANDLING TECHNOLOGIES AND MAIZE FARMERS' INCOME

IN MID-WEST UGANDA, MASINDI AND KIRYANDONGO DISTRICTS

BY

BABRA BALUNGI

JAN15/EMBA/0499U

DEPARTMENT: SCHOOL OF BUSINESS AND MANAGEMENT

SUPERVISOR

PROFESSOR BENON BASHEKA (PhD, FCIPS)

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List of Acronyms

ACE   Area Cooperative Enterprise

APLIS   African Post-harvest Losses Information System

DV   Dependent Variable

EAC   East African Community

ECA   East and Central Africa

EUT   Expected Utility Theory

FAO   Food and Agriculture Organization of the United Nations

IV   Independent Variable

MAAIF   Ministry of Agriculture, Animal Industry and Fisheries

NGO   Non-governmental organisation

PHHS   Post harvest handling and storage

PHHT   Post harvest handling Technology

PHL   Post harvest Loss

SSA   Sub- Saharan Africa

UBOS   Uganda Bureau of Statistics

USAID   United States Agency for International Development

WFP   World Food Program

CHAPTER ONE

INTRODUCTION

1.1 Introduction

This study intends to measure the effects of Post-Harvest Handling Technologies (PHHT) on Maize farmers' income in Uganda. Post- Harvest Handling Technologies in this study will be considered as the independent variable (IV) and shall be measured in form of availability, training and adoption while maize farmer's income is the dependent variable (DV) and will be measured in terms of quantity and quality of grain yield as well as the maize selling price.

In Africa, Post-harvest losses (PHL) remain a persistent challenge. According to the World Resources Institute, approximately 23% of available food in Sub-Saharan Africa is lost or wasted (Global knowledge Initiative, 2014: 9). Undertaking a study to measure the effects of PHHT on income among maize farmers becomes pertinent. Two million African smallholder farmers will have greater income and economic opportunities, improved resilience, and increased food and nutritional security through reduced PHL in food crop value chains by 2020 (Global Knowledge Initiative, 2014: 9).

This proposal is arranged in three main chapters: the introduction, literature review and methodology. The introduction chapter is presented first and covers logically the background to the study, the problem statement, the purpose of the study, the objectives of the study, the research questions, the research hypotheses, the scope of the study, the significance, justification and operational definition of terms and concepts. The background to the study is first presented.

1.1 Background of study

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). 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.

1.1.2 Theoretical Background

This study will use 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, 2012:55). 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.

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: 55). 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 is founded on the conceptualisation 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: 55), post-harvest loss of grain which ranges from 20- 30 % caused by bad practising 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 conducted in Central America found out that completion of training course about post-harvest handling technologies as one of the main determinants of achieving household self sufficiency in maize (Bokusheva et al, 2012: 1). Davis, Hands, and Maki, (1997: 1) stated that decision making of adopting a given post-harvest technology depends on the risks and uncertainty involved. 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). There is a wide range of technologies available that, if adopted, would enable smallholders and larger producers to improve the quality and quantity of grains during post-harvest handling and storage (World Bank, 2011). Reduction in quality of grain lowers the value markets, which are usually informal,

so that farmers lose the opportunity of better incomes (Rural 21, 2013:17). Kaminski and Christiaensen (2014) argued that post-harvest loss increase with higher seasonal price differences.

1.1.4 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, 2011a: 8). 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, 2011a: 10).

1.2 Problem Statement

Providing farmers with the basics in PHHTs helps increase earnings of farmers (ACDI VOCA, 2010). Okoruwa *et al* (2012: 55) emphasized that post-harvest loss of grain caused by bad practising of poor 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 (Dunford, 2015) but encouraging farmers to produce high quality grain and reducing post harvest loses through proper use of post-harvest handling technologies leads to higher income (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 an average of 13.5 % post-harvest losses in SSA (Rural 21, 2013:16). There is no empirical study that has been conducted to show the relationship between post-harvest handling technologies and farmers' incomes. 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 farmers which will be considered in this study and moreover, it was conducted in a different geographical context from Uganda. Atukwase Kaaya and Muyanja (2012) carried out the research about the dynamics of fusarium and fumonisins in maize during storage using the traditional storage structures commonly used in Uganda. This study only considered only storage practices yet, harvesting, drying and threshing can reduce maize quality. Left this way, the situation will only perpetuate the situation of smallholder farmers selling their grain soon after harvest cheaply getting less income and later the price increases (USAID and EAGC, 2013) hence not getting enough incomes. Therefore, there is a need to conduct a study on the effects of post-harvest handling technologies and maize farmer's incomes in Kiryandongo and Masindi District.

1.3 Purpose of the study

The purpose of the study is to investigate the effect of the post-harvest handling technologies on maize farmers' income in Kiryandongo and Masindi District

1.4 Objectives

i.   To determine the effect of availability of post-harvest handling technologies on maize farmers' income in Kiryandongo and Masindi Districts.

ii. To establish the role of training in post-harvest handling technologies on maize farmers' income in Kiryandongo and Masindi Districts.

iii. To assess how adoption of post-harvest handling technologies affects maize farmers' income in Kiryandongo and Masindi Districts.

1.5 Research Questions

i.   How does availability of post-harvest handling technologies affect maize farmers' income in Kiryandongo and Masindi Districts?

ii. How does training in post-harvest handling technologies affect maize farmers' income in Kiryandongo and Masindi Districts?

iii. How does adoption of post-harvest handling technologies affect the maize farmers' income in Kiryandongo and Masindi Districts?

1.6 Research Hypothesis

i.   There is a significant positive relationship between availability of post-harvest handling technologies and maize farmers' income in Kiryandongo and Masindi District.

ii. There is a significant positive relationship between training in post-harvest handling technologies and maize farmers' income in Kiryandongo and Masindi District.

iii. There is a significant positive relationship between adoption of post-harvest handling technologies and maize farmers' income in Kiryandongo and Masindi District.

1.7 Conceptual Framework

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┌─────────────────────────────────┐          ┌─────────────────────────────────┐
│     Independent Variable:       │          │      Dependent Variable:        │
│ Post-harvest handling technologies│        │      Maize farmers' income      │
└─────────────────────────────────┘          └─────────────────────────────────┘

┌─────────────────────────────────┐
│   Availability of Post-harvest  │
│     handling technologies       │
│   •  Harvesting                 │
│   •  Drying                     │
│   •  Shelling                   │
└─────────────────────────────────┘
                                              ┌─────────────────────────────────┐
┌─────────────────────────────────┐           │   •  Quantity of maize          │
│   Training in of Post-harvest   │──────────▶│   •  Quality of maize           │
│     handling technologies       │           │   •  Price                      │
│   •  Planning                   │           └─────────────────────────────────┘
│   •  Implementation             │
│   •  Monitoring                 │
└─────────────────────────────────┘

┌─────────────────────────────────┐
│   Adoption of Post-harvest      │
│     handling technologies       │
│   •  Awareness                  │
│   •  Cost of post-harvest method│
│   •  Risks involved             │
└─────────────────────────────────┘
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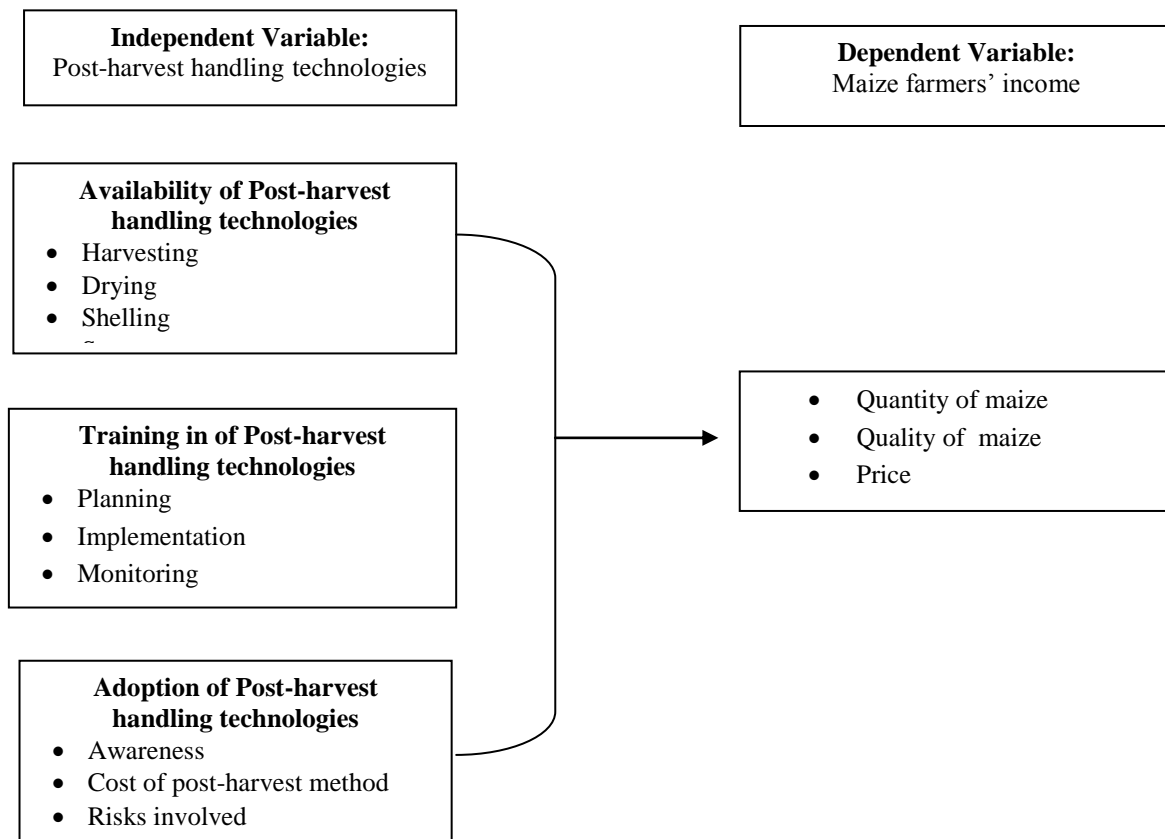
Figure 1.1 Conceptual Framework
Adopted from Okoruwo, et al. (2012) and modified the researcher

Post-harvest loss of grains lowers the income and standards of living of the farmers (Okoruwo, *et al*. 2012:56) due to poor practising of post-harvest handling processes of harvesting, drying, shelling, treatment and storage which reduces the grain not only in quality but also in quantity (Asea. *et al*, 2014). Bokusheva *et al* (2012: 1) in central America found out that completion of training course about post-harvest handling technologies as one of the main determinates of achieving household self- sufficiency in maize. Kaminski and Christiaensen (2014) discovered that post-harvest loss increase with higher seasonal price differences. According to Browning, Halcli, and Webster (2000: 1) under the rational theory, people calculate the likely costs and benefits of any action before deciding what to do like the using a given post-harvest technology and Davis, Hands, and Maki, (1997: 1) highlights that decision making of adopting a given post-harvest technology depends on the risks and uncertainty involved.

1.8 Significance of the study

This study will 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 will;

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

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

iii. Contribute to the study of social relationships between Post harvest handling technologies and Maize farmers' income

iv. Contribute to the researcher's academic progress towards earning a of Masters in Business Administration (Project Planning and Management) of Uganda Technology and Management University (UTAMU)

1.9 Justification of the study

Maize is a key staple food in Eastern and Southern Africa, with a highly seasonal production but relatively constant consumption over the year. Farmers have to store maize to bridge seasons, for food security and to protect against price fluctuations (Tefera., 2012). **S**ignificant volumes of grain in developing countries are lost after harvest, aggravating hunger and resulting in expensive inputs such as fertilizer, irrigation water, and human labour being wasted. Qualitative PHL can lead to a loss in market opportunity and nutritional value; under certain conditions, these may pose a serious health hazard if linked to consumption of aflatoxin-contaminated grain, food losses contribute to high food prices by removing part of the food supply from the market (World Bank *et al*., 2011:1). Poor post-harvest handling such as poor drying and improper storage conditions lead to losses due to storage pest and aflatoxin contamination (MAAIF, 2013: 1). Post-harvest losses of grains limit the potential of income of the farmers, threaten food security and exacerbate conditions of poverty among the maize

farmers in the rural areas whose income stream depends on the ability to store excess farm produce and sell it later (Okoruwa *et al*, 2012:56). Therefore, this study intends to determine the effects of post-harvest handling technologies on maize farmers' income to address the problem faced by farmers during the process of Post-harvest handling.

1.10 Scope of the study

1.10.1 Content scope

The study will limit itself to PHHT as the independent variable which will consider three dimensions: PHHT availability, PHHT training and PHHT adoption whereas Maize farmers' income with three dimensions as well namely; quantity of maize, quality and selling price.

1.10.2 Geographical scope

The study will be conducted around mid- west Uganda specifically, Kiryandongo and Masindi District as shown in *Appendix 6*. Bunyoro (mid- western) region is one of the major maize growing sub-regions in Uganda (MAAIF, 2013:1). The 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 Kiryandongo and Masindi districts respectively, this region was selected. One cooperative will be selected each district and a representative farmers will be interviewed. The warehouse operators and officials that provide technical assistance will also be interviewed.

1.10.3 Time Scope

The study will limit itself to the activities different cooperatives or warehouses and farmers from 2015 to 2010. This timeframe is specifically chosen because it's easy to understand the income growth of farmers and farmers can easily remember what has happened in past five years. This time is chosen on the basis that farmers are expected to have gained the experience in maize post- harvest handling technologies and benefited from using them.

1.11 Definition of operational terms and concepts

In the study, the following will be key concepts and terms and shall be 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.

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

<center>**CHAPTER TWO**</center>

<center>**LITERATURE REVIEW**</center>

2.0 Introduction

According to Amin (2005:138), literature review involves the systematic identification, location and analysis of documents containing information related to the research problem. This chapter provides the review of literature on post-harvest handling technologies and income. It includes the theories used as well as the key concepts of the study and their interrelationships.

2.1 Theoretical Review

According Adams (2007:28) a theory is a set of systematically interrelated concepts, definitions and propositions that are advanced to explain and predict phenomena (facts). Theory also explains how some aspect of human behaviour or performance and enables us to make predictions about their behaviours. This study will use Rational Choice Theory and Expected Utility Theory in order to describe, understand, explain and predict Maize farmer's behaviours in response to post harvest handling technologies use.

2.1.1 Rational Choice Theory

The Rational Choice Theory is an economic principle that assumes that individuals always make prudent and logical decisions that provide them with the greatest benefit or satisfaction and that are in their highest self-interest. In the context of the proposed study, farmers are assumed to be rational in their capacity to devise, choose, and put into practice effective means to clear ends such as improving standards of living, income and maximising profit maximization (Okoruwa *et al*, 2009: 55). Rational Choice Theory uses a specific and narrow definition of "rationality" simply to mean that an individual such as a farmer acts to balance costs against benefits to arrive at action that maximizes personal advantage (Milton, 1953) and the idea of this theory was invented by Max Weber in 1920. Traditional smallholder farmers have their reasons for not adopting untried technologies (Mazonde, 1993). Browning, Halcli,

and Webster (2000:1) demonstrates that under the rational theory, that people calculate the likely costs and benefits of any action before deciding what to do. In regard to that farmers will decide the post-harvest handling technology with fewer costs but with high benefits

2.1.2 Expected Utility Theory

The principle of expected utility maximization states that a rational investor such as a farmer, when faced with a choice among a set of competing feasible investment alternatives like choice post-harvest technologies to use, acts to select an investment which maximizes his expected utility of wealth, therefore they will always chose the technology with less investment (Okoruwa O, *et al*, 2009). Expected Utility Theory (EUT) has been the basis for much decision-making theory (Okoruwa O, *et al*, 2009). EUT assumes that the preferences of the decision maker comply with the axioms of ordering, continuity and independence (Starmer, 2000). Davis, Hands, and Maki, (1997: 1) highlights that Expected Utility Theory (EUT) is the way a decision maker (DM) chooses between risky or uncertain prospects by comparing their expected utility values, the weighted sums obtained by adding the utility values of outcomes multiplied by their respective probabilities.

The contribution of Expected Utility Theory (EUT) to the current understanding of decision making in complex situations where risk and human reactions to it are involved needs no enlargement. Maize farmers will use the post-harvest handling technologies with fewer risks but with greater income maximisation. Despite overwhelming evidence against its empirical validity and the proliferation of non-expected utility theories (non-EUTs) in the Field of choice under risk and uncertainty. EUT remains the standard approach to the analysis of economic, social, political, and ethical problems (Liang, 2003) hence will be useful in analysing farmer's problems when they are using different post-harvest handling technologies.

2.2 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).

2.2.1 Availability of Post-harvest Handling Technologies

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 is the availability of appropriate technologies. Therefore this study would like find 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).

2.2.1.1 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 aflatoxin 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).

2.2.1.2 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).

2.2.1.3 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.

2.2.1.4 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 aI.,* 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).

2.2.2 Training in Post-harvest Handling Technologies

The overall goal of the PHHS training is to empower smallholder farmers to improve the quality of their cereal grains and pulses in order to help them improve their incomes from sales to higher quality markets (WFP, 2012).   The results of the study conducted in Central America found out that completion of training course about post harvest handling technologies as one of

the main determinants of achieving household self sufficiency in maize (Bokusheva et al, 2012: 1). A good training process should be moving to a more detailed presentation of a range of learning approaches, materials and processes. Advanced planning, including a training needs assessment, development of learning outcomes, design of the training programme, selection of participants including associated gender aspects, decisions on the venue and field sites are covered. These are followed by notes on evaluating, scaling out and up, and follow up of the PHHS learning (WFP, 2012). Rugumamu (2012: 73) argued that lack of specialized training in the post-harvest component of the crop management cycle and lack of a lead farmer/practitioner with a coordinator hinder rapid and efficient transfer of appropriate technologies.

Various methods can be used to extend information and advice either to groups or to individual farmers. Farmers learn best when taught using informal techniques. Open discussions facilitated by the extension worker enable the experiences of a group to be put forward as well as allowing those that have used a particular technology to describe it and to offer their opinions. Flip charts with prepared diagrams can be used to illustrate a message. Visual aids illustrate the problems and solutions. Posters may be used as visual aids during discussions but can be pinned up around the village to provide a permanent reminder of a message (FAO, 2009).

There is no better way to explain how something works than by showing it in operation and observing the processes involved which is well explained through demonstrations. Sometimes a decision tree can be used to analyse the problems step-by-step, giving solutions for different scenarios that the farmers may face (FAO, 2009). The goal of every trainer or extension worker's job to ensure that the quality and quantity is not lost and this can only be achieved by revisiting the farm at intervals, talking to the farmer and collecting samples to assess the progress of any damage and quality (FAO, 2009).

2.2.3 Adoption of Post-harvest Technologies

The factors affecting technology adoption 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, 1993). Meinzen-Dick (2004), 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 it's the 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., 2004). 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., 2004). Browning, Halcli, and Webster (2000: 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., 2004). Those technologies that have a lower risk have a greater appeal to smallholders who are naturally risk-averse (Meinzen-Dick et al., 2004). Davis, Hands, and Maki, (1997: 1) highlights that decision making of choosing a given post-harvest technology to use depends on the risks and uncertainty involved.

2.3 The Concept of Maize farmer's income

2.3.1 Quantity and Quality of Yield

Reduction in quality of grain lowers the value markets, which are usually informal, so that farmers lose the opportunity of better incomes (Rural 21, 2013:17). USAID (2013) mentioned that smallholder production is characterized by low volumes and poor (inconsistent) quality that are the result of weak post-harvest handling practices and insufficient/inadequate storage.

Uganda lacks an authoritative price determination point (Ahmed, 2012) for instance a central commodity exchange or futures market, national maize quality standards, and a legal and regulatory framework covering grain warehousing and handling operations (NRI/IITA, 2002). 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). Infection of maize grain by storage fungus results in discoloration, dry matter loss, chemical and nutritional changes and overall reduction of maize grain quality (Chuck-Hernández *et al*., 2012). If inadequately dried the conditions are favourable for moulds and fungi to grow, which can result in a significant decreases in grain quality and quantity (Rees, 2004). Since the majority of producers are small scale farmers, maize is often sold by producers in small quantities of poor quality at low prices (PMA, 2009). To produce high quality grain, it is essential that farming households do their post-harvest handling in a proper and timely manner (WFP, 2012).

2.4 Empirical Studies

Suleiman *et al* (2013) conducted a research on determining the effects of deterioration parameters on storage of maize and concluded that, for the proper storage of maize grain, environmental factors such as temperature and moisture content must be controlled. Such factors are the major influences of maize deterioration, because they affect molds, insects, and other pest, which can result in huge losses of maize grain in a very short time. To avoid mycotoxin contamination, maize should be monitored regularly to assure safe storage conditions. They also concluded that In order to maintain high quality maize for both short- and long-term storage, maize must be protected from weather, growth of microorganisms, and pests. This study did not consider the farmer's knowledge or accessibility to such information which will considered in the proposed study.

Kimatu *et al* (2012) carried out research to determine the significant role of post-harvest management in farm management, aflatoxin mitigation and food security in Sub-Saharan Africa

and they concluded that proper post-harvest management, especially the use of the small scale metal silo, contributes to better quality of grains, less pesticide usage and can accelerate agribusiness, therefore directly contributing to rural development and poverty reduction. However, he concluded that not much effort has being invested in reducing post-harvest food losses especially in staple cereals like maize and legumes, even after many studies have shown that it offers an essential way of increasing food availability and income without the need of other resources hence creating a need of carrying out the proposed study.

Okoruwa *et al* (2009) also conducted a research on Post harvest grain management storage techniques and pesticides use by farmers in South-West Nigeria. The factors which significantly influencing farmers' choice of storage techniques and pesticides used including quantity of grains harvested, cost of pesticide and cost of investment, price of grains, gender of farmers, education, capital invested and cost of pesticides were analysed. The study was conducted only for a total of 192 grain crop farmers who were randomly sampled through the multi-stage sampling approach. This study focused on adaptation of agriculture technologies as a whole but this study will focus on only adaptation of post-harvest technologies in relation to household income. Due to the fact that this study was conducted Nigeria with different ecological conditions and with different sample size, the proposed study here will be conducted in Uganda with a sample size if 220 respondents focusing on understanding the effects of Post-harvest handling technology availability, adoption and training on maize farmer's income.

Kaaya and Kyamuhangire (2006) conducted a research about the effect of storage time and agro-ecological zone on mold incidence and aflatoxin contamination of maize from traders in Uganda. They found high temperature to be a major factor influencing aflatoxin contamination and fungal growth. They also revealed that temperature and water activity (aw) influence not only rate of fungal spoilage, but also the production of Mycotoxin. This information is very important but they did not consider other aspects of post harvest other than storage like drying,

threshing and storage which will be considered in this study. This study will also focus on the training process of maize farmers which was not looked at during this study.

Kaaya *et al* (2012) carried out the research about the dynamics of fusarium and fumonisins in maize during storage using the traditional storage structures commonly used in Uganda and concluded that storage of maize in traditional storage structures for more than 4 months results in significant decrease in fumonisin levels. This study only considered one post-harvest technology which is storage but there are other technologies that can reduce maize quality like harvesting, drying and threshing which will be looked at in this study.

2.5. Synthesis and Gap Analysis

Most of the studies that have been conducted in Uganda have considering storage practices as the main post harvest handling technology used but there other practices that have a great effects on the quality and quantity of maize grain such as harvesting, drying and shelling which will be considered in this study. Additionally, this studies conducted in Uganda and internationally do not consider the training aspects of maize farmers which is a variable under investigation in this proposed study hence this study is very important to point out this missing gaps.

CHAPTER THREE

METHODOLOGY

3.0 Introduction

Kothari (2004:8) defined research methodology as a way of systematically solving a research problem. This involves various steps that will be followed by the researcher during the study. The chapter provides the research design, the study area, and the target population, sampling procedure, methods of data collection and Data Collection Instruments, Data Quality Control (Validity & Liability), measurement of the Variables and data Analysis

3.1 Research Design

According to Kothari (2004:31), 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, 1996:74). This study will use a cross-sectional survey design which will adopt mixed methods. A cross-sectional study predominantly uses questionnaires or structured interviews for data collection with the intent of generalizing from a sample to a population (Creswell, 2003). Under the aspect of mixed methods, the researcher will combine quantitative and qualitative research techniques and methods to provide the best understanding of a research problem (Creswell, 2003:12). Mixed methods employs strategies of inquiry that involve collecting data either simultaneously or sequentially to best understand research problems(Creswell, 2003:18). Quantitative research employs numerical indicators to ascertain the relative size of a particular phenomenon and involves counting and measuring of events as well as performing the statistical analysis of a body of numerical data (Smith, 1988). Qualitative approaches on the other hand are concerned with expression of attitudes, opinions and feelings. They allow a researcher to solicit information that cannot be expressed in numerical format, making it possible to obtain non-numerical information about the phenomenon under study to aid establish patterns, trends and relationships from the information

gathered (Mugenda & Mugenda, 1999). The quantitative method will be administered by the used of questionnaire while the qualitative methods will use key informant interviews and documentary reviews.

3.2 Study population

According to Amin (2005: 235), a target population is the population to which the researcher ultimately wants to generalise the results. The target population for this study will be 290 respondents including; farmers from the two selected area cooperative enterprise with a target population of 150 for Nyamahasa ACE where five famers will be selected randomly from 30 producer organisation under this cooperative and 120 active lead farmers will be selected from Masindi District Farmers Association that are supported by RECO Industries and USAID production for improved nutrition project, warehouse operators to which the cooperatives are affiliated with a population of 4 respondents, officials who provide technical support to these cooperative with a respondents of 8 and two officials from specific organisations that support the quality aspect of maize production in Uganda as well as two agricultural officials each from masindi and Kiryandongo districts hence having a population of 4 respondents.

3.3 Sample size

A sample is a subset of a population selected to represent characteristics of a population (Nesbary, 1999). The study will be conducted on representative sample of 220 respondents. An optimum sample is one which fulfils the requirements of efficiency, representativeness, reliability and flexibility (Kothari, 2004:57). Amin (2005:238) emphasize that a researcher must determine the sample size that will provide sufficient data to answer the research problem. Using a sample is important to reduce costs, time and has a high degree of accuracy (Amin, 2005: 238-239).The sampling process will be guided by the table below.

Table 3.1 Sampling Procedure

SN	Category	Population	Sample	Sampling procedure
1	Farmers			
	a) Nyamahasa ACE (Kiryandongo district)	150	108	Random sampling
	b) Masindi District Farmers Association (Masindi District)	120	92	Purposive sampling
	Sub Total	*270*	*200*	
2	Warehouse operators	**4**	**4**	Purposive sampling
3	Two training officials from organisations that provide technical support to the cooperative organisations	**8**	**8**	Purposive Sampling
4	Two officials from Uganda Commodity Exchange	**2**	**2**	Purposive Sampling
5	Two officials from Eastern Africa Grain Council Uganda Office	**2**	**2**	Purposive Sampling
6	Two agricultural officials each from Masindi and Kiryandongo Districts	**4**	**4**	Purposive Sampling
	Grand Total	**290**	**220**	

The sampling procedure will be guided by the table above. The researcher will conduct the study on a sample of 220 respondents. 108 famers will be randomly selected from Nyamahasa ACE in Kiryandongo district and 92 active lead farmers from Masindi District Farmers Association supported by RECO Industries and USAID production for improved nutrition project. Two organisations that provide technical support to farmers to these cooperatives will be selected that have a population of 8 staff members but only two members providing training services to farmers will be selected purposively. Two warehouse operators that are affiliated to these cooperatives will be purposively selected. Two officials will be selected from Uganda Commodity exchange, Eastern Africa Grain Council and Uganda Grain Council.

3.4 Sampling techniques

The study will use 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, 2004:15: Amin, 2005:244). Simple random sampling will be used to select farmers in the selected cooperatives 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 (Kothari, 2004:15). Purposive sampling will be utilized to select warehouses operators, officials providing technical support and officials from Uganda Commodity exchange, Eastern Africa Grain Council and Uganda Grain Council, districts agricultural leaders because these are people expected to have knowledge on the phenomenon under investigation.

3.5 Data collection methods

Data collection methods are specific approaches that will be applied to obtain information on the research problem (Kothari, 2004:95). The study will employ 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 shall use primary data collection methods by obtaining information for the directly from the respondents hence being original. Survey questionnaires will be used to collect quantitative data directly from farmers and key informant interview will be used to collect qualitative data directly from warehouse operators and all officials from supporting organisations. Questionnaires comprising of both open and closed ended questions will be 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 will supplement the primary methods and is expected to provide the researcher with an opportunity to gain more information about the phenomenon. The researcher will review the average maize production status of each farmer as well as the quality aspects. The researcher will review the different training materials of the organisation in the different regions selected. Document reviews assist the researcher gather information for a bottomless appreciation of the subject under investigation as well as validate the findings from the other data collection methods (Kumar, 1996).

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 to be used during this study will include; questionnaires, key informants interview guide and documentary review checklists.

3.6.1 Survey Questionnaire

A questionnaire will be used to facilitate the quantitative data collection. According to Amin (2005:269) 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 will be chosen to collect this type of data because it is an efficient data collection mechanism especially when the researcher knows what is required and how to measure the variables of interest (Sekaren, 2003; Creswell, 1994). 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). Kothari (2004: 100) 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 will prepare carefully a questionnaire to collect information about the dimensions of post harvest handling and maize farmers' income.

3.6.2 Key informant interview guide

A key informant interview guide will be used to get information from the key informants. Key informant interview is a qualitative, in-depth interviews of people selected for their first-hand knowledge about a topic of interest (Kumar, 1989). Key informant interview guides are devices that provide 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).

3.6.3 Document review checklist

A Document review checklist will be used for carrying out the documentary review. This is an instrument which will contain a list of all documents reviewed that are relevant to the phenomena under study. The researcher will develop a list of different documents to be reviewed including documents that have information on average maize production status of each farmer as well as the quality aspects. All the documents that are related to the independent variable (post harvest handling technologies) and the dependent income (Maize farmers' income) will be reviewed.

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 will consider two aspects; validity and reliability.

3.7.1   Validity of Research Instruments

Validity is the degree to which results obtained from the analysis of data actually represent the phenomenon under study. This is the ability of the instrument to collect truthful and justifiable data (Oso and Onen, 2008). 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 & Mugenda, 1999: Amin 2005: 285). The research will prepare research instruments and subject them to validity tests before finally administering them on respondents. The draft questionnaire will be 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 will distribute an initial draft questionnaire to 5 (five) experts in post- harvest technologies in maize. The Content validity will be determined by having items on the instrument rated by five (5) experts. The Content Validity Index (CVI) will then be determined by the formula and the workings below.

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

A CVI of 0.7 and above for any instruments will be considered valid for the study in accordance with Amin (2005). All questions deemed not valid will be 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 (Amin, 2005) To determine the reliability of the research instruments, a pre-test of the instruments will be

undertaken in a similar environment using the same tools. The instrument will be pretested once with thirty five respondents, and the Chronbach's alpha will be used to correlate the scores of the responses.

The formula for Cronbach's Alpha to be used is follows:

$$\text{Cronbach's alpha} = \left[\frac{n}{n-1}\right] \left[\frac{SD^2 - \sum Variance}{SD^2}\right]$$

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 will show that the tool is reliable. The higher the reliability coefficient, the higher the reliability of the instrument (Amin, 2005:295)

3.9 Procedure of Data Collection

A systematic procedure during data collection will be followed by a researcher. The researcher will ensure acquisition of a letter to introduce her to farmers cooperative in Masindi and Kiryandongo districts from UTAMU to enable her seek the acceptance of the management and leadership of the selected institutions to access and interact with proposed respondents. The researcher will seek to deliver questionnaires to respondents to whom he will in detail explain the objectives of the study, how they will have been selected and as well seek their consent to participate as respondents and request them to thus fill the questionnaire. The researcher will at a later date collect the filled questionnaires and verify the completeness of responses therein. The researcher will also fix appointments to conduct interviews with key informants and will review selected documents to search 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 will be analysed following different methods of analysis as below:

3.10.1 Quantitative data analysis

The quantitative data will be sorted, and edited to eliminate errors so as to ensure completeness, accuracy and uniformity. Coding will then be done after editing in an attempt to reduce data from detailed to summarized and understandable forms such as tables, charts and graphs. The data will then be entered into the computer and analyzed using Statistical Package for the Social Sciences (SPSS). Data will be analyzed using descriptive statistics such as frequencies, percentages and cross tabulations. Interpretations and implications of the generated statistical information will then be 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 will be 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 is to determine the extent to which the two sets of ranking are similar or dissimilar (Kothari, 2004).

This is a formula to be used by the researcher to calculate the Spearman rank correlation

$$r^2 = \frac{6\sum d_i^2}{1 - n(n^2-1)}$$

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 will be at a significance level of 0.05. A significance level, according to Mugenda and 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 will be accepted and the conclusion will be 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 & Mugenda, 1999.p.135) will also be used to establish which of the post- harvest handling technologies dimensions is more responsible for maize farmers income by measuring to their net effects on the dependent variable.

3.10.2 Qualitative data analysis

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

3.11 Measurement of variables

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

3.11.1 Univariate Level

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

3.11.2 Bivariate Level

At bivariate level, the researcher will establish 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 will be used to test for the hypothesis of the study. The

decision rule will be set at 5% level of significance which is an accepted precision level in socio-economic research.

3.11.3 Multivariate Level

All the independent variables that will be tested significant at bivariate level will be analysed using a regression analysis to measure their net effects of independent variable on the dependent variable. This is a typical measurement that tries to establish relationships between the Independent variable (Post- harvest handling technologies) and the dependent variable (Maize famer's income). It is 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 is important to remember the power relationship in a research process and how this affects the research. The researcher will have 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 is crucial to sound research to do no harm .This position will promote an ethical view that claims that the value of the research is not worth destroying people or communities in the process. Another consideration in the research is that participation will be voluntary and should be a conscious decision and informed consent which is a way of ensuring this. This will be obtained by the researcher explaining what the study is about, and ensuring the participant's anonymity as well as the participants' possibility of withdrawing during the research.

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APPENDICES

Appendix 1: Draft Questionnaire
Introduction

You are humbly chosen to participate in a study to determine the effects of post-harvest handling technologies on maize farmers' income. 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 technologies. 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

Babra Balungi, KOPIA Uganda Center

Telephone: +256 771 844 101

Email: bbalungi@gmail.com

	A. Background Information					
1	Respondent's Sex *(please tick or circle)* 1 = Female 2 = Male					
2	Your age group *(please tick or circle)* 1. (19 years or less) 2. (20 – 29 years old) 3. (30 – 39 years old) 4. (40 – 49 years old 5. (50 years or more)					
3	Years of Experience *(please tick or circle your answer)* 1. (5 years or less) 2. (5 –10 years old) 3. (10 - 15 years old) 4. (15 – 20) years old 5. (20 years or more)					
4	Location	1. Masindi District		2. Kiryandongo District		
5	What is your maize acreage per season? 1. Less than 1 2. 1 up to 2 3. More than 2 up to 3 4. More than 3 up to 4 5. More than 4 up to 5 6. More than 5					
	B. Availability of Post-harvest handling technologies					
	Apply where Appropriate, Using the scale of **(1= Strongly Disagree, 2= Disagree, 3= Not sure, 4= Agree, 5= Strongly Agree)**, please tick or circle your answer to indicate the extent to which you agree with the following statements.					
6	There is availability of post-harvest handling technologies in this region	1	2	3	4	5
7	What is the most post- harvest handling technologies that you need to improve your quality and quantity 1. Harvesting 2. Drying 3. Shelling 4. Storing					
8	What characteristics do you consider to harvest					

	1. Light brown colour of the plant 2. Light brown colour of the plant					
	3. Others (Please specify)					
9	I always use a clean container during the harvesting time	1	2	3	4	5
10	What are the methods you using during drying your maize?					
	1. Sun drying using a tarplin 2. Sun drying on bare soil					
	3. Sun drying with a drying yard 4. Solar drying					
	5. Electric drying 6. Others (Please specify)					
11	It is very difficult to dry maize	1	2	3	4	5
12	What method are you using to shell maize?					
	1. Using hands 2. Using a hand Sheller 3. Using a electric Sheller					
	4. Others (Please specify)					
13	It is very difficult to shell maize	1	2	3	4	5
14	What type of storage bags are you using? Insert the possible options					
	1. Natural fibre/ Sisal 2. Polypropylene (PP) 3. Others (Please specify)					
15	Do you have a store? Yes/ No					
	If yes, which type of store do you have?					
	1. Mud Silo 2. Granary 3. Metallic silo					
	4. Cemented store 5. Others (Please specify)					
16	It is difficult for me to store my maize	1	2	3	4	5
C. Training in post-harvest handling technologies						
17	I have ever received a post harvest handling technology training for the pas t five years	1. Yes		2. No		
18	There was a planning meeting to discuss about how the training would be implemented	1	2	3	4	5
19	There was a consultation to find out our needs	1	2	3	4	5
20	We agreed for the appropriate time to have a meeting	1	2	3	4	5
21	I benefited from the training of post harvest technology use	1	2	3	4	5
22	The farmers that were invited for the workshop came	1	2	3	4	5
23	The venue where the training was commenced was adequate	1	2	3	4	5
24	At the end of the training there was discussion to evaluate and give feedback of how the training was conducted	1	2	3	4	5
25	What method was used during the training					
	1. Demonstration 2. Use of charts 3. Meeting					
	4. Others (Please specify)					
26	After the training, there was a team that visit me to find out how I am using the technologies and the problem faced	1	2	3	4	5
27	Name only two organisations that trained you on post harvest handling technologies?					
	1.					

	2.					
28	What was/were the topic or topics that you were trained in? 1. Harvesting and drying 2. Grain storage systems/facilities 3. Quality standards and grading 4. Others (Please specify)						
D. Adoption of Post-harvest handling technologies							
29	What is the most factor limiting you to use these technologies 1. Awareness 2. Costs 3. Risks 4. Sustainability 5. Others (Please specify)						
30	There is enough information on how to use these technologies	1	2	3	4	5
31	Most of farmers in my village know the post-harvest technologies of maize	1	2	3	4	5
32	The cost of these technologies is affordable to me	1	2	3	4	5
33	I always have the money to use these technologies	1	2	3	4	5
34	The cost of using post harvest technologies is less than the amount I obtain from the sale of maize	1	2	3	4	5
35	We have ever discussed about the risks involved in using post-harvest technologies	1	2	3	4	5
36	We have ever discussed about ways of controlling of mitigating the risks involved in using post-harvest technologies	1	2	3	4	5
37	I have implemented the ways controlling the risks involved in these technologies	1	2	3	4	5
38	I am using these technologies because I saw an opportunity of improving my quality, quality, price and income	1	2	3	4	5
39	Because of easily available post-harvest handling technologies, the amount of my maize increased	1	2	3	4	5
40	Because of acquiring training post-harvest handling technologies, the amount of my maize increased	1	2	3	4	5
41	Because of adopting or using post-harvest handling technologies, the amount of my maize increased	1	2	3	4	5
42	Because of easily available post-harvest handling technologies, the quality of my maize improved	1	2	3	4	5
43	Because of acquiring training post-harvest handling technologies, the quality of my maize improved	1	2	3	4	5
44	Because of adopting or using post-harvest handling technologies, the quality of my maize improved	1	2	3	4	5
45	I am satisfied with the amount of maize sold in regard to the amount expected	1	2	3	4	5
46	My customers have ever complained about the quality of maize that I sell	1	2	3	4	5

47	What is the grade of your maize? 1. Grade 1 2. Grade 2 3. Not known					
48	There is mouldy maize in my sales	1	2	3	4	5
49	My customers have ever complained about the high levels of moisture content	1	2	3	4	5
50	There is broken maize in my sales	1	2	3	4	5
51	There is diseased maize in my sales	1	2	3	4	5
52	I am not comfortable with price I sale my maize	1	2	3	4	5
53	The payment for the sale of maize is not timely	1	2	3	4	5
54	According to the total cost invested in production of maize, I have benefited	1	2	3	4	5
55	I have been able to provide my family with basic needs for past five years	1	2	3	4	5
56	I have been able to get any property from the savings or money obtained from maize	1	2	3	4	5

Thank you very much for your valuable time and contribution to the study. Please be assured that the information will be used for academic purposes only.

End

Appendix 2: Draft interview checklist for interviewing key informants

You are humbly chosen to participate in a study to determine the effects of post-harvest handling technologies on maize farmers' income. 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 technologies. 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

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Telephone: +256 771 844 101

Email: bbalungi@gmail.com

Questions

A.   Introduction to the interview

1. Name of interviewer
2. Name of the interviewee
3. Location
4. Stating the purpose and objectives of the study
5. Highlighting confidentiality and anonymity
6. Assuring respondent that s/he could drop the interview at any stage s/he felt
7. Highlighting the rights of the proposed interviewee and clarify on benefits
8. Request for consent to interview

B. Post-harvest Handling technologies

1. In your own opinion do you think the farmers' understand the importance of using post harvest handling technology?
2. What do you think is most difficult stage post- harvest that leads to the highest losses?
3. In your opinion, what do you think about the training of post harvest handling technologies are effective?
4. Are the farmers adopting the post harvesting handling technologies? Yes/No explain your answer
5. What do you think is the most factor limiting the adoption of post-harvest technologies?

C. Income

1. What do you think is the average production of maize per each farmer?
2. What do you think is the grade of the maize sold in this region?
3. What do you think is the most parameter that is reducing the quality of maize?
4. What do you think is the average selling price of maize in this region?
5. Do you think maize farmers are able to provide the basic needs to their family or buy a property?

Appendix 3: Draft document review checklist

Review the following sample documents to ascertain the elements of post harvest handling technologies therein.

1. Cooperatives or warehouses records on the averages prices, quantity and quality
2. Maize production of Kiryandongo and masindi district
3. Organisations training programs
4. EAC maize grain standards
5. Related documents to my study

Appendix 4: Work plan and time frame

Activity	Duration	End Date
Proposal writing and Approval	2 months	January 2016
Data collection	1month	February 2016
Data analysis	2 weeks	March 2016
Report writing	1 month	March 2016
Submission of final Dissertation	1 week	April 2016

Appendix 5: The Sampling table

N	S	N	S	N	S
10	10	220	140	1200	291
15	14	230	144	1300	297
20	19	240	148	1400	302
25	24	250	152	1500	306
30	28	260	155	1600	310
35	32	270	159	1700	313
40	36	280	162	1800	317
45	40	290	165	1900	320
50	44	300	169	2000	322
55	48	320	175	2200	327
60	52	340	181	2400	331
65	56	360	186	2600	335
70	59	380	191	2800	338
75	63	400	196	3000	341
80	66	420	201	3500	346
85	70	440	205	4000	351
90	73	460	210	4500	354
95	76	480	214	5000	357
100	80	500	217	6000	361
110	86	550	226	7000	364
120	92	600	234	8000	367
130	97	650	242	9000	368
140	103	700	248	10000	370
150	108	750	254	15000	375
160	113	800	260	20000	377
170	118	850	265	30000	379
180	123	900	269	40000	380
190	127	950	274	50000	381
200	132	1000	278	75000	382
210	136	1100	285	1000000	384

Note.—N =Population size. S = Sample size. Source: Krejcie and Morgan (1970.p.608).

Appendix 6: Map of Uganda showing Masindi and Kiryandongo district

KEY

△ Districts chosen