

**FACTORS INFLUENCING UPTAKE OF METAL SILO TECHNOLOGY
AMONG SMALL-SCALE FARMERS: A CASE OF MWINGI CENTRAL
SUB-COUNTY, KENYA.**

BY

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for the Award of Master of Arts Degree in Project Planning and Management of
the University of Nairobi**

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DECLARATION

This research project report is my original work and has not been presented for any award in any other university.

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This research report has been submitted for examination with my approval as the university supervisor.

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DEDICATION

I dedicate this research report to my mum Peninah Wairimu for her great love and support, and giving me a chance to attend school, my husband Raphael Nduati for his guidance and support in achieving this milestone, my twins Ryan Nduati and Lisa Wanjiru for their motivation, support and understanding when I could not spend enough time with them while attending classes.

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ABBREVIATIONS AND ACRONYMS

FAO	Food and Agricultural Organisation of the United Nations
GII	Global Innovation Index
MPPM	Master of Arts in Project Planning and Management
SPSS	Statistical Package of Social Scientists

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ABSTRACT

The purpose of the study was to investigate factors influencing metal silo technology uptake among farmers in Mwingi Central Sub-County, Kenya. The study was guided by the following specific objectives; to determine the influence of farmer characteristics on uptake of metal silos technology among farmers, to identify the influence of farm characteristics on uptake of metal silos technology among farmers and to identify the influence of extension services on uptake of metal silos technology among farmers. The researcher used Statistical Package of Social Scientists (SPSS) to analyse the data. Descriptive statistics were used to analyse the data. The data was presented in tables and interpreted by the researcher and contrasted to the literature review. The study adopted the descriptive research design. The target population for the study are 217 smallholder farmers involved in maize growing activities. The study proposed to adopt multistage cluster sampling, purposive sampling and stratified random sampling. The study selected 30 % of the population in each of the stratum. The sample size for the study was 65 respondents. The results show that among the three independent variables, there was a positive and significant relationship between education and adoption of metal silo technology with a correlation coefficient of 0.039. Similarly there was a positive and significant relationship between extension services and adoption of metal silo technology with a correlation coefficient of 0.005. The most significant relationship was between farm size and adoption of metal silo technology. These findings imply farm size is the factors that are highly correlated with adoption of metal silo technology. The study concludes that the farmers do not adopt the metal silo technology due to the small amount of maize that they harvest which is associated with the size of the farm. The study concludes that the more educated a farmer is, the more likely they know about alternative techniques for grain storage. The study found that farmers had low levels of interaction with extension agents and this led to low access to information on metal silo technology. The study also concludes that informal communication among the farmers was found to be the major source of information on methods of grain storage among the respondents. The study recommends that training should be provided to the farmers that have already adopted the metal silo technology to become change agents of the technology among other farmers in the region. That metal silo technology should be designed to suit the needs of smallholder farmers as majority of the smallholder farmers have small parcels of land and do not have quantities of grain harvested to suit the metal silo technology that is available in the market. That sensitization of the metal silo technology should be coordinated with the county and central government agencies in order to reach a high number of farmers.

CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

Agriculture remains the cornerstone of most of the people and countries of Africa. According to Gitonga, De Groote and Tefera (2015) two-thirds of the people in eastern and southern Africa (ESA) live in rural areas where they make a living from agriculture, often from degraded and marginal lands, with little opportunity to diversify incomes through additional employment in non-farming activities. One of the key constraints to improving food and nutritional security in Africa, however, is the poor post-harvest management that leads to 20-30 % loss of grains, with an estimated monetary value of more than US\$ 2 billion annually and can reach US\$ 4 billion (Zorya, Morgan & Rios, 2011).

The importance of enhancing post-harvest storage and handling of cereals and in particular maize, wheat and rice in Kenya cannot be overemphasized. Storage evens out the seasonal driven supply and hence stabilizes inter-temporal price variation and consequently raises farmers' income (Komen, Mutoko, Wanyama, Rono & Mose, 2006). This is besides its role in reducing food insecurity created by the intermitted supply. Maize is the most important staple crop, but it is produced seasonally, and consumed continuously at farm level. There is therefore the need for on-farm storage, but heavy post-harvest losses occur mainly during harvesting and storage stages. The Cereal Growers' Association (2010) estimates that 30 to 40 % of the total grain production in Kenya is lost due to inefficiencies in post-harvest handling and these impacts negatively on farmer's income, market supply, cereal prices and food security (Nduku, De Groote & Nzuma, 2013).

Safe storage of grains at farm level is very crucial since it directly contribute to food security as it mitigates the impact of dismal and non-consistent harvests. Traditional storage practices in developing countries cannot guarantee protection against major storage pests of staple food crops like maize leading to 20-30 % grain losses, particularly due to post harvest insect pests and grain pathogens (Tefera et al., 2010). There are several technologies that have been introduced to the market to remedy this situation.

Postharvest losses are a permanent reduction to crop harvest that result from one or a combination of factors such as storage pest infestation, rodents and moulding. Postharvest damage (by biotic and abiotic agents) and loss of staple grains due to insect pests, rodents and birds are a common problem in developing countries including Malawi. However, precise information on postharvest losses of grains in Malawi is scanty. Nevertheless, observations indicate that more than 70% of maize stored on the cob is severely damaged by larger grain borer (*Postephanus truncates*) and other associated grain pests after 6 to 8 months of storage (Maonga, Assa & Haraman, 2013).

A possible sustainable solution, the metal silo technology was introduced to the rural farmers who practice subsistence agriculture. The technology ensures safe on-farm grain storage which reduces after harvest crop loss substantially thereby encouraging the farmers to maintain their harvest beyond the low price glut period either for food or to trade later when the prices are higher and therefore gain more from their farming activity (Ndegwa, Groote & Gitonga, 2013). In Central America, empirical findings from the implementation of a similar project in revealed high and reliable profit potential on the side of the artisans (Fishler et al., 2011), the uptake of the business

opportunities provided by the silo making venture to the trained artisan in Kenya is low.

Different studies have described the metal silo and outlined their history and potential (Tefera et al., 2010) have shown that metals silos are highly effective in protecting maize grain from storage pests and that it has a substantial impact on reduction of losses and improving food security. The benefit cost analysis of the metal silos based on average annual production of 720 bags for each household in Kenya, showed that the NPV, IRR and BC ratio all favour investing in the metal silo technology (Kimenju, De Groote & Hellin, 2009).

Uptake of any new technology carries with it an element of risk because of lack of familiarity and experience with the technology (Kambewa et al., 2012). World Bank, (2011) reported that there is low uptake of postharvest technologies in various Sub-Saharan countries. Among other factors explaining non-uptake include lack of extension services (Ndawala, 2005), technology attributes such as demands for extra labour for harvesting, drying, shelling and threshing; the cost, outdoor structures hence prone to theft, especially in periods of acute food shortages (Fisher, 2012), education level (Ndawala, 2005), sex and age (Tchuwa, 2009).

1.2 Statement of the Problem

Despite improved grain production, Kenya loses 30 to 40 % of the total grain output due to inefficiencies in post-harvest handling especially during harvesting and storage (Rembold, Hodges, Benard, Knipschild & Leo, 2011). In spite of the availability of a wide range of storage techniques, significant grain loss occur on-farm in Kenya each year (Komen et al., 2006; Zorya et al., 2011). Bett and Nguyo, (2007) estimate that in the semiarid regions of Kenya, annual maize storage losses range from five to 17 %

which is estimated in monetary terms to be 1.8 million 90 kilogram bags valued at Kshs 8.1 billion. Efficient post-harvest handling, storage and marketing can tremendously contribute to social economic empowerment of rural communities as stipulated in Kenya Vision 2030 (Republic of Kenya, 2007).

Nduku et al. (2013) undertook a comparative analysis of maize storage structures in Kenya. The analysis established that the cost benefit analysis showed that the metal silo was the most profitable maize storage structure. Gitonga et al. (2015) conducted a study on metal silo grain storage technology and household food security in Kenya. This study found that metal silo technology is effective against main maize storage pests and its uptake can significantly improve food security in rural households.

However, these studies found that metal silo technology uptake among farmers has been low (Nduku et al., 2013; Gitonga et al., 2015). Slow rates of uptake cause a loss of potential benefit of sustainable practices to growers and the public. This is the main reason why so much attention has been given to try and understand what drives uptake of new technologies among farmers (Pannell et al., 2006; Rogers, 2005). Based on the foregoing, this study hopes to identify the factors influencing uptake of metal silo technology among farmers in Mwingi Sub County in Kenya.

1.3 Purpose of the Study

The purpose of the study was to investigate factors influencing metal silo technology uptake among farmers Mwingi Central Sub-County, Kenya.

1.4 Objectives of the Study

The study was guided by the following specific objectives;

- i. To determine the influence of farmer characteristics on uptake of metal silos technology among small holder farmers.
- ii. To identify the influence of farm characteristics on uptake of metal silos technology among small holder farmers.
- iii. To examine the influence of extension services on uptake of metal silos technology among small holder farmers.

1.5 Research Questions

The study will aim to answer the following research questions;

- i. To what extent do farmer characteristics influence on the uptake of metal silos technology among farmers
- ii. How do farm characteristics influence uptake of metal silos technology among farmers
- iii. What is the influence of extension services on uptake of metal silos technology among farmers

1.6 Significance of the Study

The study hopes to be of significance to grain farmers as it will inform on the factors that influence the uptake and non-uptake of metal silo technology in postharvest preservation of grains in Mwingi Central Sub-County. This information will go a long way in ensuring that farmers do not experience grain loss.

The study will be of significance to metal artisans trained by The Food Agriculture Organisation (FAO) programme to design and build fabricated metal silos. The study

will be of significance as it will recommend for action to increase uptake of the metal silo technology which will promote their enterprise growth.

The study is hoped to contribute to academia and researchers as it will contribute to the body of knowledge on factors influencing technology uptake in the agricultural sector by focusing on uptake of the metal silo technology among grain growers. The study will also be of importance as it will suggest for areas of further research.

1.7 Delimitation of the Study

Most of the farmers targeted were engaged in groups that were formed by FAO to undertake the project it was easy to identify the homes of the group members. The research also used the local data enumerators for ease of translation and at time use of local language. The researcher had an introduction letter from the University, this made it easier to be trusted by the respondent. The technique of questionnaires and observation was mostly used, this method has been tested and succeeded with the past research.

1.8 Limitations of the Study

Accessing the vast Mwingi Sub County through public transport was one of the challenges encountered. The researcher together with data enumerators had to use motor bikes in order to access some of the villages in the interior. Another challenge was the willingness of the respondent to give full and true information in regards to their household matters.

1.9 Assumptions of the Study

The study assumes that the proposed methodologies will be adequate to answer the research questions and achieve the research objectives. The study assumes that the target population will be available, ready and willing to participate in the study. The researcher assumes that the time allocated for this study will be sufficient to undertake the research project.

1.10 Definition of Significant Terms in the study

Extension services – These refer to the educational, training and information sharing services provided to farmers to improve their agricultural output and knowledge. The indicators include frequency of interaction, means of communication and source of information on grain storage.

Farm characteristics – These refer to the farm features that are assumed to influence farmers' decisions to adopt a technology. The indicators included size of farm, type of farm ownership, distance from market, and main type of crop in farm.

Farmer characteristics – These refer to the socio-economic factors of farmers that are assumed to influence their decision to adopt a technology. The indicators included age, gender, marital status, household size, farming experience.

Metal silos – This is a technology which is used to store grains and protect them from pests. A technology that reduces the loss of grain.

Uptake – This refers to the use of metal silo technology among farmers for storing grains after harvest. These refers to the number of farmers adopting the technology.

1.11 Organization of the Study

This chapter of the study introduced the research by providing a background of the study, problem statement, research objectives, and research questions, significance of the study, delimitation, limitations and assumptions of the study. The chapter also presented the definition of significant terms used in the study. Chapter two of the study presented the literature review of the study. Chapter three presented the researcher techniques the study will adopt. These include the research design, target population, sample size and sampling procedures, data collection methods, data collection procedures, validity and reliability of instruments and data analysis and presentation. Chapter four of the study included the data analysis and presentation. Chapter five of the study presented the summary, discussion, conclusions and recommendations of the study.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

This chapter presents the literature review which is based on the research objectives. The topics in the literature review are farmer characteristics and uptake of metal silos technology among farmers; farm characteristics and uptake of metal silos technology among farmers and extension services and uptake of metal silos technology among farmers. The theories for the study are Innovation-Diffusion Model, Adoption Perception Model and the Economic Constraint Model. The chapter also presents the conceptual framework, knowledge gap and summary of literature review.

2.1 Farmer Characteristics and Uptake of Metal Silos Technology among Farmers

Bokusheva, Finger, Fischler, Berlin, Marín, Pérez and Paiz (2012) study on factors determining the uptake and impact of a postharvest storage technology found that the uptake of metal silos is influenced by a group of socioeconomic characteristics of the households such as the household head's age, land ownership, access to extension services and quality of basic infrastructure. Chirwa (2005) found that the farmer and plot level characteristics included in the model, age of the farmer, education of the farmer, size of the plot, land tenure and soil fertility are statistically significant.

Age is an important factor that influences the probability of uptake of new technologies because it is said to be a primary latent characteristic in uptake decisions. However, there is contention on the direction of the effect of age on uptake (Asiedu-Darko, 2014). In line with general literature, farmers' age on technology uptake is found to have a negative effect, older farmers being more reluctant to change or the expected return being lower (Bocquého et al., 2011). Maonga et al. (2013) study

found that Age was significant at 5 % level with a positive sign, and had a probability of increasing uptake of small metallic silos by 3.56 %. However, age squared decreased the probability to adopt the silo technology ($p < 0.05$) by a margin of 0.03 %. Chirwa (2005) found that older farmers are less likely to adopt technology.

This implies that after passing a certain age bracket, probability of adopting new agricultural technologies by farmers tends to decline. This indicates that older farmers are not motivated to adopt new technologies; they become more risk averse and therefore, prone to resist change of the status quo in farming activities (Maonga et al., 2013). Asiedu-Darko (2014) found out that age had a negative influence on the uptake of agricultural technologies in three farming areas in Ghana.

Gender issues in agricultural production and technology uptake have been investigated for a long time. Most of such studies show mixed results regarding the different roles men and women play in technology uptake. Doss and Morris (2001) in their study on factors influencing improved maize technology uptake in Ghana, and Overfield and Fleming (2001) studying coffee production in Papua New Guinea showed insignificant effects of gender on uptake.

Chirwa (2005) found evidence that farmers that belong to female-headed households are unlikely to adopt farming technologies. Gitonga et al. (2015) found that both adopters and non-adopters of metal silo technology were dominated by male headed households. The proportion of aged male decision makers is significantly higher for the adopters (15%) than for non-adopters (7%). The average household size was seven and six persons for adopters and non-adopters, respectively.

Uaiene, et al. (2009) who studied determinants of agricultural technology uptake in Mozambique and found that completion of at least lower primary school implies a

much higher propensity to adopt new technology than lower or zero levels of education. In Nigeria, Atibioko, Ogunlade, Abiodun, Ogundele, Omodara and Ade (2012) study on effects of farmers' demographic factors on the uptake of grain storage technologies This shows that for the farmers that have adopted the technologies their level of education plays an important role which is while the odds in favour of uptake of NSPRI grain storage technologies increased by 1.378 for level of education. Education enhances ability to obtain, use and process information relevant to a technology (Letaa et al., 2014).

2.2 Farm Characteristics and Uptake of Metal Silos Technology among Farmers

The farm characteristics include farm size, farm altitude, land tenure, perception about soil fertility and plot distance from dwelling. Farm size is an indicator of wealth in the household that is often correlated with the ability to acquire information from sources outside the farm (Letaa et al., 2014). Large farm size also reduces the opportunity cost of experimentation, thus the probability to adopt (Sitomwe et al., 2009).

The probability of adopting small metallic silo technology was 44.5 % higher for smallholder farmers with access to agricultural extension services than those without extension contact. Barungi et al., (2013) found that the probability of adopting Napier grass in Uganda was 25.6 % higher for farmers with access to extension services than for those without access. Extension services create awareness and enable farmers to get information about improved technologies. Such information is crucial for decision making by farmers in the process of new technology uptake. Farmers must have access to information about improved technologies before they can consider adopting them (Doss, 2003).

Farm size is a usual factor explaining technology uptake, both in theoretical models and empirical models (Bocquého et al., 2011). The size of landholding, and therefore farm size impacts on the household's land use decisions in terms of type and diversity of farm enterprises, as well as cropping systems and patterns (Maonga, 2005). Farm size was therefore expected to have positive effect on uptake of metallic silos.

Security of land ownership has also demonstrated to affect agricultural technology uptake decisions (Kassie et al., 2012; Sserunkuma, 2005). Better tenure security gives farmers ability and incentive to invest in productivity enhancing technologies. Distance to the plot is also an important determinant of uptake because of increased costs of monitoring the technology performance when plot is farther away from the residence. Distant plots have been reported to receive less attention and less frequent monitoring, particularly for maize and legumes which are edible at green stage (Teklewood et al., 2013).

In their study, Gitonga et al. (2015) households that adopted metal silo were significantly closer to the passable road (1.5 km) than non-adopters who on average were 3.1 km away from the road. Adopters were more endowed in land and cultivate an average of 8 acres annually compared to 5 acres cultivated by non-adopters

2.3 Extension Services and Uptake of Metal Silos Technology among Farmers

Access to agricultural extension messages is believed to have positive influence on technology uptake by farmers. Extension improves farmers' awareness of the available new technologies. We expected agricultural extension to play a positive role in the uptake of the metallic silo technology. Generally, farmers with larger financial capabilities are considered to be more prone to technology uptake, especially if the technology requires some important investment (Bocquého, et al., 2011).

Studies (Kaliba et al. 2000; Akudugu et al., 2012) have shown that regular contact with extension staff increases farmers' awareness on availability of new technologies as well as how they can be applied. Long distances to markets, typical of the situation in the study area further contribute to market imperfections and are expected to exhibit a negative effect on uptake of new technologies. Input distribution centres for an improved seed in the villages enhances not only the accessibility of seeds and credit but also provide platforms for information access and markets. Thus it is expected to have positive influence on uptake of new improved bean varieties. Similarly, agricultural credit/ loan services in the villages enhance credit access and hence it is also expected to have a positive influence on uptake (Letaa et al., 2014).

Ndawala (2005) argues that among other factors explaining non-uptake include lack of extension services. Matita and Dambolachepa (2015) conducted a study on uptake of improved postharvest management Technologies and found that extension services beyond production are among other factors that affects utilization of improved storage structures for maize. Provision of credit services coupled with extension services on post-harvest management could facilitate uptake of appropriate post-harvest technologies and practices among farmers.

Uaiene et al. (2011) agrees that contact with extension agents is expected to have a positive effect on uptake based upon the innovation-diffusion theory. Such contacts, by exposing farmers to availability of information can be expected to stimulate uptake. A positive relationship is hypothesized between extension visits and the probability of uptake of a new technology. Access to information has also been found to have a significant influence on technology uptake among farmers. This includes the different sources of information that are available to farmers. Letaa et al. (2014) found that possession of modern Information and Communication devices (ICTs) such as

mobile phones, television sets and radio also had positive and significant influence on technology uptake.

2.4 Theoretical Framework

To explain uptake behaviour and determinants of technology uptake, three paradigms are commonly used: the innovation-diffusion model, the uptake perception and the economic constraints models (Maonga et al., 2013).

2.4.1 Innovation-Diffusion Model

The underlying assumption of the innovation-diffusion model is that the technology is technically and culturally appropriate but the problem of uptake is one of asymmetric information and very high search cost (Maonga et al., 2013). According to Chirwa (2005) the innovation-diffusion or transfer of technology model, is which technology is transferred from its source to the smallholder farmer through an intermediary such as an extension system, and the diffusion of the technology depends on the characteristics of the farmer.

2.4.2 Adoption Perception Model

Uaiene et al. (2009) states that the adopters' perception paradigm on the other hand, suggests that basically the perceived attributes of the technology determine uptake behaviour of farmers. This means that even with full farm household information, farmers may subjectively evaluate the technology differently than scientists (Ashby & Sperling, 1992). Thus, understanding farmers' perception of a given technology is crucial in the generation and diffusion of new technologies and farm household information dissemination" (Uaiene et al., 2009). The model assumes that the characteristics of (the technology and the underlying agro-ecological, socio-economic

and institutional circumstances of farmers play a central role in the uptake of technology (Chirwa, 2005).

2.4.3 Economic Constraint Model

According to Aikens et al. (1975); Smale et al. (1995); Shampine (1998), the economic constraint model contends that input fixity in the short run, such as access to credit, land, labour or other critical inputs limits production flexibility and conditions technology uptake decisions". The economic constraint model takes the view that farmers have different factor endowments and that the distribution of endowments determines the uptake of technology (Chirwa, 2005).

2.5 Conceptual Framework Description

Figure 1 shows the conceptual framework of the study which indicates the relationship between the independent and dependent variables. The independent variables are farmer characteristics, farm characteristics and extension services influence on the dependent variable which is uptake of metal silo technology.

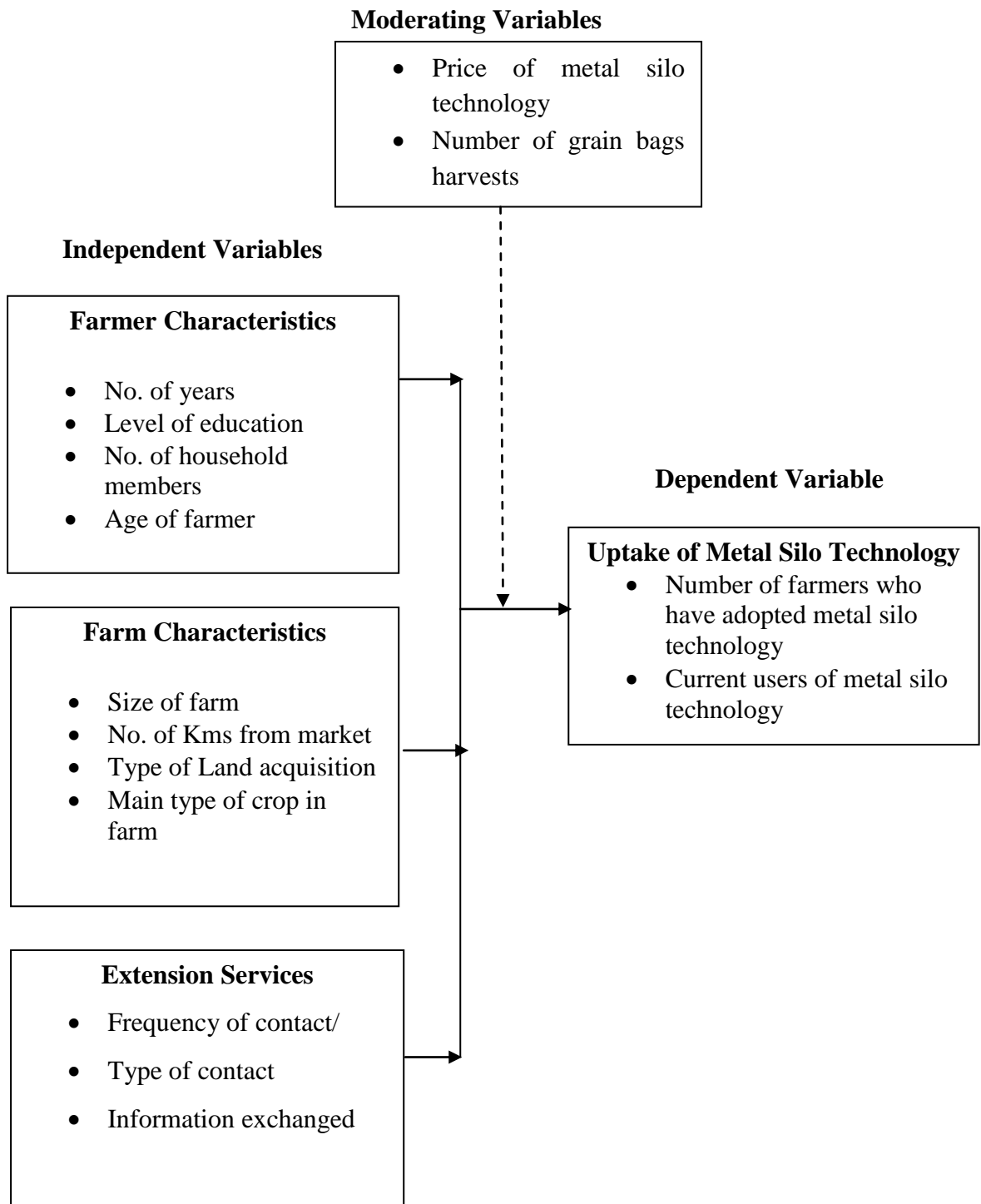


Figure 1.1: Conceptual Framework

Source: Researcher (2015)

2.6 Knowledge Gap

The literature review implied the existence of a plethora of literature on factors influencing uptake of agricultural technology in developing countries. These factors were discussed in terms of farmer characteristics, farm characteristics, and extension services. However, despite this evidence the literature reviewed lacks empirical evidence on the influence of farmer characteristics, farm characteristics, and extension services on uptake of metal silo technology in Kenya. The study will therefore seek to fill this knowledge gap by exploring the influence of farmer characteristics, farm characteristics, and extension services on uptake of metal silo technology among grain farmers in Kenya by focusing on Mwingi Central Sub-County.

2.7 Summary of Literature Review

The literature review presented published and unpublished research works on the relationship between farmer characteristics, farm characteristics, extension services and uptake of agricultural technology. The theoretical framework and conceptual framework is presented along with the knowledge gap the study intends to fill. The next chapter of the study presents the research methods that the researcher will adopt to achieve the study objectives.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This chapter presents the research techniques that the researcher adopted to achieve the study's research objectives. These include the research design, target population, sample size and sampling procedures, data collection methods, data collection procedures, validity and reliability of instruments and data analysis and presentation.

3.2 Research Design

According to Noum, (2007), research design is the scheme, outline or plan that is used to generate answers to research problems. The study adopted the descriptive survey research design. This design involves collection and gathering of data from a specified population on a specific subject. The design was a cross-sectional survey design which involves collection of data at a defined timeframe. The main aim of descriptive research is to provide an accurate and valid representation of (encapsulate) the factors or variables that pertain / are relevant to the research questions.

3.3 Target Population

The population includes all elements that meet certain criteria for inclusion in a study (Burns & Grove, 2011). The target population of the study were the small-scale farmers in Mwingi Central Sub-County, Kenya. The target population for the study were 217 smallholder farmers in Mwingi Central Sub-County. This population was drawn from the pilot project of metal silo technology by Gitonga (2013).

3.4 Sampling Procedures and Sample Size

The study adopted multistage cluster sampling. According to Arulmozhi and Muthulakshmi (2009) multistage samples are used primarily for cost or feasibility

reasons where the population under investigation has been organized into different clusters.

In the first stage, purposive sampling technique was used to select Mwingi Central Sub-County. In the second stage, cluster sampling was used to select the five villages; these are Mwingi, Nguni, Kivou, Mui and Nuu. In the third stage, stratified random sampling procedure was used to identify study respondents of which small holder farmers were selected from five clusters which comprise the five villages. The researcher chose 30 % of the target population from each of the strata as suggested by Mugenda and Mugenda (2003) that 10 % - 30 % of the target population is adequate for research.

Table 3.1: Sample Distribution

Villages	Population	Percent (%)	Sample
Mwingi	39	30	11
Nguni	42	30	13
Kivou	38	30	11
Mui	43	30	13
Nuu	55	30	17
Total	217		65

Source: Kitui Villages County Bill (2014)

3.5 Data Collection Methods

The study adopted quantitative methods of data collection by use of questionnaire and observation techniques. Data gathering is the precise, systematic gathering of information relevant to the research sub-problems, using methods such as interviews, participant observation, focus group discussion, narratives and case histories (Burns & Grove 2003). In collecting data, a researcher can choose either or both quantitative and qualitative approaches. Quantitative approaches are more amenable to large

volumes of data whereas qualitative approaches emphasise on richness in data. The study proposes to adopt quantitative methods of data collection.

3.5.1 Questionnaires

The study adopted the questionnaire as the primary tool for data collection. A questionnaire is a list of questions with a set of open-ended or close-ended responses which the respondent is expected to choose as a form of measurement for a variable. The advantage in using the questionnaire is that it is cheaper and fast to administer to a rather large population. The questionnaire consisted of three sections which included questions about the farmer characteristics, farm characteristics and extension services. The questionnaire contained both open-ended and close-ended questions items and Likert scale items.

3.6 Pilot Study

The researcher undertook a pilot study in order to test the reliability and validity of the research instrument. Pre-testing or pilot study was carried out to ensure that the questions are relevant, clearly understandable and make sense before the research tools are finally administered to participants. The pre-testing aimed at determining the reliability of the research tools including the wording, structure and sequence of the questions (Karuoya, 2014).

3.7 Validity and Reliability of Instruments

Validity refers to the extent to which research instrument measure what they were intended to measure. On the other hand, reliability refers to the extent to which an instrument is capable of attaining similar results if administered to a different population.

3.7.1 Split-half Method

The split-half reliability test is an alternative approach which involves correlating scores on one random half of the items on the test with the scores on the other random half. That is, just divide the items up into two groups, compute each subject's score on the each half, and correlate the two sets of scores. This will involve computing an alternate forms estimate of reliability after producing two alternate forms (split-halves) from the single pilot test. The researcher will then calculate the Cronbach's Alpha to determine the reliability of the measurement scales. Cronbach's Alpha that are less than 0.6 are generally considered to be poor, those in the 0.7 range to be acceptable, and those over 0.8 to be good; the closer the reliability coefficient gets to 1.0, the better (Islam et al., 2011). The reliability of the instrument was established at 0.69 which is acceptable.

3.7 Data Collection Procedures

In order to have a fluid data collection process, the researcher will write up a cover letter which was administered along with the questionnaire. This contained information on purpose of the study, assurance for confidentiality and anonymity of the research respondents and contact information of the researcher. The researcher applied for a letter of authorisation from the University of Nairobi, Department of Extra-Mural Studies to collect data for the study. The researcher also applied for a permit from the National Commission of Science Technology & Innovation (NACOSTI).

3.8 Data Analysis and Presentation

Data analysis is a mechanism for reducing and organising data to produce findings that require interpretation by the researcher (Burns & Grove, 2003). The researcher used Statistical Package of Social Scientists (SPSS) to analyse the data. Descriptive

statistics was used to analyse the data. This generated quantitative reports through tabulations, percentages, and measure of central tendency (Cooper & Schindler, 2003). The data was presented in tables and interpreted by the researcher.

Table 3.2: Operationalisation Table

Objectives	Variables	Indicators	Measurements	Measurement Scales	Tools of analysis
To determine the influence of farmer characteristics on uptake of metal silos technology among farmers	<u>Independent Variable</u> Farmer characteristics <u>Dependent Variable</u> Uptake of metal silo technology	Gender, age, education, marital status, household size and farming experience	No. of years/ level of education/ no. of members/ no. of years	Interval Ordinal Interval Nominal	Mean Standard Deviation
		Use of metal silo technology in grain storage			
To identify the influence of farm characteristics on uptake of metal silos technology among farmers	<u>Independent Variable</u> <u>Market factors</u> Farm characteristics <u>Dependent Variable</u> Uptake of metal silo technology	Size of farm Distance/location of farm Land acquisition/form of ownership	No. of acreage Location No. of Kms Lease, own, rent	Interval Nominal Interval Nominal	Mean Standard Deviation
		Use of metal silo technology in grain storage			
To identify the influence of extension services on uptake of metal silos technology among farmers	<u>Independent Variable</u> Extension services <u>Dependent Variables</u> Uptake of metal silo technology	Frequency of contact/ type of contact/ information exchanged	No. of times Days/weeks/months/ Face to face/phone	Interval Ordinal Nominal	Mean Standard Deviation
		Use of metal silo technology in grain storage			

CHAPTER FOUR

DATA ANALYSIS, PRESENTATION AND INTERPRETATION

4.1 Introduction

This chapter presents the results from the data collection which is presented in line with the study objectives. The data is presented in tables and also by the researchers own interpretation.

4.2 Response Rate

The research was in a position to gather a total of 62 finished questionnaires that were used in the analysis of data from the aforementioned sample size. It brought about an implication that the response rate stood at 95 percent which is within the recommended figure by Nulty (2008) that a response rate of above 50 percent is tolerable.

4.3 Background Information

4.3.1 Gender

The literature review showed that gender has been shown to play a role in the adoption of agricultural innovations. In this study, the researcher sought to determine the gender of the respondents.

Table 4.1 Gender

Gender	Frequency	Percent
Male	38	61.3
Female	24	38.7
Total	62	100.0

Table 4.1 depicts that the large number of the participants were male as they represented 61.3 percent while female represented 38.7 percent. The outcomes depict

that the majority of those who took part in the research were male. The same could be attributed to the fact that the technical field is dominated by men.

4.3.2 Age

The variable of age has been found to be a determinant in adoption of innovation in the agriculture sector. The study sought to determine the age categories of the sample size.

Table 4.2: Age

Age	Frequency	Percent
20-30	9	14.5
30-40	24	38.7
40-50	11	17.7
51 years and above	18	29.1
Total	62	100.0

In terms of their age, Table 4.2 shows that 14.5 percent were 20-30 years, 38.7 percent were 30-40 years, 17.7 percent were 40-50 and 29.1 percent were 51 years and above.

4.3.3 Marital Status

The marital status of the respondents was significant for the study to establish as an indicator of decision making dynamics in the household which can influence adoption of agricultural innovations.

Table 4.3: Marital Status

Marital Status	Frequency	Percent
Single	21	33.9
Married	36	58.0
Widow/widowed	5	8.1
Total	62	100.0

Table 4.3 indicates that married respondents formed the highest number (58.0 percent) when it came to the marital status while the single accounted for the second highest number with 33.9 percent. Maonga et al. (2013) admit that the issue of marital status is very tricky in technology uptake. It is not known how being married or otherwise influences the farmers' decision to adopt a new technology.

4.3.4 Education Level

The variable of education level is an important variable in agricultural innovations adoption. The study sought to measure the influence of education on adoption of metal silo technology.

Table 4.4: Education Level

Education level	Frequency	Percent
Primary	15	24.2
O' level	22	35.5
Diploma/certificate	12	19.4
Higher diploma/degree	9	14.5
Masters	3	6.4
Total	62	100.0

Table 4.4 shows the findings in terms of respondents' education, the results show that 24.2 percent were primary, 35.5 percent were O' Level, 19.4 % were diploma/certificate, 14.5 percent were higher diploma/degree and 6.4 % were masters. The findings suggested that the highest proportion of the respondents had secondary level of education and only a minority had college level education. Studies have suggested, the higher the education level the more likelihood of uptake of technology.

The researcher asked respondents whether they had attained any form of training on grain storage and farmers in the sample indicated no. According to Bukosheva et al.

(2012) training allows farmers to obtain new knowledge and thus become more aware of possibilities for more efficient utilization of their resources as well as farm organization. Second, training courses present an important communication channel for disseminating information about new technological solutions available on the market, and therefore play an important role in improving farmers' access to relevant markets and production factors.

4.3.5 Household Size

The household size variable has been found to be a determinant to influence adoption or non-adoption of agricultural innovations. In this study it was assumed that the size of the household would act as an indicator for farm characteristics and its influence on adoption or non-adoption for metal silo technology.

Table 4.5: Household Size

Household size	Frequency	Percent
Less than 3 members	9	14.5
3-5 members	42	67.8
More than 6 members	11	17.7
Total	62	100.0

Table 4.5 shows that a household size of between 3 to 5 members formed the highest proportion of the respondents while those of more than 6 members were the least. This can be attributed that the households were more observant when it came to family planning and economic hardships could not allow for a larger household. The findings suggest that majority of the household had an average number of five members. This finding is similar to the average household size of households in Kenya which stands at 4.22 (Mwaura, Muluvi & Mathenge, 2013).

4.3.6 Farming Experience

The farmer experience is an important factor for adoption and non-adoption of metal silo technology as they may have devised strategies for grain storage.

Table 4.6: Farming Experience

No. of years farming	Frequency	Percent
Less than 1 year	4	6.5
2-5 years	14	22.6
6-10 years	18	29.1
More than 11 years	26	41.8
Total	62	100.0

Table 4.6 shows that farmers with the highest level of experience formed the larger part of the sample population. In other words, individuals with more than 11 years formed a percentage of 41.8. On the other hand, farmers or individuals with less than a year of farming formed the least percentage of 6.5. Therefore, it can be concluded that those sampled preferred farming to make a living and for other purposes.

4.4 Influence of Farm Characteristics

This section intends to gather information of the respondents in reference to the various attributes or characteristics.

4.4.1 Farm Size

The size of the farm may necessitate a farmer to adopt the metal silo technology if they harvest a large number of grain and are more likely to lose it if they do not have adequate storage facilities.

Table 4.7: Farm Size

Farm size	Frequency	Percent
Less than 1 acre	26	41.8
1-2 acres	19	30.8
3-4 acres	10	16.1
More than 5 acres	7	11.3
Total	62	100.0

Despite the sampled population representing a considerable number of farmers, it is evident from Table 4.7 that they had little parcels of land. For instance, respondents with less than 1 acre formed the highest proportion (41.8 percent) and contrastingly, those with more than 5 acres formed a proportion of 11.3 percent which was the least. The size of landholding, and therefore farm size impacts on the household's land use decisions in terms of type and diversity of farm enterprises, as well as cropping systems and patterns (Maonga, 2005).

4.4.2 Type of Farm Ownership

The type of farm ownership may influence a farmer to adopt or not adopt an innovation due to investment decisions.

Table 4.8 Type of Farm Ownership

Farm ownership	Frequency	Percent
Self-owned	31	50.0
Leasing	10	16.1
Inherited	21	33.9
Total	62	100.0

Table 4.8 shows that 50 percent (highest proportion) of the respondents owned farms, 16.1 percent leased (formed the least proportion) while 33.9 percent inherited farms.

From the findings, it can be concluded that a larger number of the residents owned lands while those who did not own leased.

Studies suggest that a larger share of owned land in farm cropland also has a significant impact on the investment decision. On the one hand, farms that possess a larger portion of their cropland are wealthier and thus might more easily afford a metal silo than less wealthier farms (Bukosheva et al., 2012).

4.4.3 Distance from Market

Table 4.9: Distance from Market

No. of Kms	Frequency	Percent
Less than 1 Km	6	9.7
1-2 Kms	27	43.5
3-4 Kms	12	19.4
More than 5 Kms	17	27.4
Total	62	100.0

Table 4.9, indicates that a large proportion of the respondents (43.5 percent) walked or rather covered a distance of between 1 to 2 kilometres to the market. On the other hand, 9.7 percent covered less than a kilometre to the market while 19.4 percent covered between 3 to 4 kilometres and those covering more than 5 kilometres accounted for 27.4 percent of the population. The longer the distance to the market place, the more likelihood that farmer will incur losses. Majority of the maize is sold soon after harvest. The metal silo technology would be useful for storage to sell after a longer period which will fetch farmers a better price.

4.4.4 Main Type of Crop in Farm

The metal silo technology is appropriate for grain storage, therefore the study sought to establish the type of crops among the sampled farmers.

Table 4.10: Main Type of Crop in Farm

Type of crop	Frequency	Percent
Maize	27	43.4
Beans	5	8.1
Maize/Beans	10	16.1
Green grams	12	19.4
Cow peas	8	13.0
Total	62	100.0

Most of the respondents from the table 4.10 reveals that they grow maize and a smaller proportion (8.1 percent) grow beans. It can thus be concluded that maize is the staple food among the respondents.

4.4.5 Number of Bags Harvested

Table 4.11: Number of Bags Harvested

No. of Bags	Frequency	Percent
Less than 5	29	46.7
5-10 bags	14	22.6
More than 10 bags	19	30.7
Total	62	100.0

Table 4.11 reveals that most of the respondents' harvested less than 5 bags (46.7 percent) 5 to 10 bags were the least harvested. It can be attributed to poor rainfalls or farming techniques.

4.5 Influence of Extension Services and Uptake of Metal Silo Technology

This section intends to gather information of the respondents in reference to the extension services. The study assumed that contact with extension service has an influence on uptake or non-uptake of metal silo technology.

4.5.1 Contact with Extension Officers

The frequency of contact with extension officers is an indicator of access to information for the framers. Extension officers play a significant role in the provision of information on emerging agricultural technologies.

Table 4.12: Frequency of Contact with Extension Officers

Frequency of contact	Frequency	Percent
Never	17	24.2
Rarely	18	29.1
Sometimes	21	33.9
Often	3	6.4
Always	3	6.4
Total	62	100.0

In regard to contact with extension officers, Table 4.12 shows that a large proportion (33.9 percent) contacted them sometimes, 29.1 percent rarely contacted them. Least proportion of the proportions often and always (6.4 percent) contacted the extension officers. It indicates that few either did not trust extension officers or were constrained by other factors like distance, cost among others. Access to agricultural extension messages is believed to have positive influence on technology uptake by farmers. Extension improves farmers' awareness of the available new technologies. The study results show that frequency of contact with extension officers was low. Maonga et al. (2013) found that the probability of adopting small metallic silo technology was 44.5% higher for smallholder farmers with access to agricultural extension services than those without extension contact.

4.5.2 Source of Information on Grain Storage techniques

The study investigated the sources of information on grain storage. This was important for the study so as to identify the effectiveness of existing information and communication channels for grain storage.

Table 4.13: Source of Information on Grain Storage techniques

Source of information	Frequency	Percent
Television	4	6.5
Radio	7	11.3
Extension officer	6	9.7
Other farmers	45	72.5
Total	62	100.0

Table 4.13 shows that the respondents (farmers) mostly (72.5 percent) relied on their colleagues or simply other farmers for information on grain storage. Few placed their trust on other sources. For instance, only 6.5 percent relied on the television for information, 9.7 percent on extension officers and 11.3 percent on radio.

Majority of the farmers indicated that they get their information from other farmers; this point to the significance of networks in the uptake of metal silo technology. Onasanya, Adedoyin and Onasanya (2007) study on communication factors affecting the uptake of innovation at the grassroots level found that informal communication among farmers is a key determinant to uptake of technologies.

4.5.3 Type of storage used

The study sought to determine the type of grain storage techniques adopted among the farmers to also determine their appropriateness in reducing post-harvest losses for the farmers.

Table 4.14: Type of storage used

Type of storage	Frequency	Percent
Traditional grain store	8	13.0
Polypropylene lined bags	11	17.7
Hermetic storage	22	35.5
Metal silo	21	33.9
Total	62	100.0

In terms of the type of storage used, most of the respondents (33.9 percent) utilised metal silos for storage purposes. Few relied on traditional grain store (13 percent), a competitive number of the respondents utilised hermetic storage (35.5 percent) and 17.7 percent used polypropylene lined bags as shown in Table 4.14.

The results show that majority of the respondents used hermetic storage technique. According to Atibioke et al. (2012), this is the use of air tight containers to store grains. This is usually used to keep enough quantities to be used by the house hold. Grains to be stored in air tight containers should be adequately dried to the level that will prevent mould growth. Containers used include plastic drums, used oil drums, pots and polythene bags. Grains are stored in polypropylene lined bags to prevent insect infestations. This is used where quantities involved are small. This finding is attributed to the size of farms of the respondents and the small yields from these farms. These technologies have been proven and have been in use by farmers for some time (Gitonga, 2012).

The findings also show that respondents were using traditional grain stores. Gitonga et al. (2015) advice that Traditional storage practices in Africa countries cannot guarantee protection against major storage pests of staple food crops like maize. The lack of suitable storage structures for grain storage and absence of storage

management technologies often force the smallholders to sell their produce immediately after harvest (Gitonga et al., 2013).

4.5.4 Incurrence of Post-Harvest Losses

It was relevant to establish whether there was incurrence of post-harvest losses among the sampled farmers to determine the need for adoption of metal silo technology.

Table 4.15: Incurrence of Post-Harvest Losses

Post-harvest losses	Frequency	Percent
Yes	42	67.7
No	20	32.3
Total	62	100.0

Table 4.15 above shows that a larger proportion of the respondents experienced post-harvest losses (67.7 percent) while the remaining (32.3 percent) did not experience post-harvest losses. The losses can be attributed to poor farming techniques practiced by some of the respondents and vice versa for those who never experienced post-harvest losses. In the semi-arid regions of Kenya, annual maize storage losses range from five to 17 percent which is estimated in monetary terms to be 1.8 million 90 kilogram bags valued at Kshs 8.1 billion. Majority of these post-harvest losses are attributed to storage pests like the common weevil and the Larger Grain Borer (LGB) (Nduku et al., 2012).

4.5.5 Control Methods

The study was interested in knowing the control methods that farmers adopted to reduce grain losses in their farms.

Table 4.16: Control Methods

Loss control methods	Frequency	Percent
Pesticides	22	35.5
Traditional methods	24	38.7
Disposing	10	16.1
Metal silos	6	9.7
Total	62	100.0

In an effort to avert losses, respondents utilised a number of techniques. Table 4.16 shows that 38.7 percent used traditional means, a comparative large proportion (35.5 percent) relied on pesticides to control losses. Least number of the respondents (9.7 percent) used metal silos to control losses while 16.1 percent of the respondents preferred disposing. Thus, it can be concluded that they were not reliant on advanced methods of controlling losses.

4.5.6 Causes of Post-Harvest Losses

Table 4.17: Causes of Post-Harvest Losses

Farm Ownership	Frequency	Percent
Weevils	21	33.9
Aflatoxin	31	50.0
Poor drying/storage techniques	10	16.1
Total	62	100.0

From table 4.17, 50 percent of the respondents' farms were infested by aflatoxins, 33.9 percent of the respondents attributed farm ownership to weevils while 16.1 percent of the respondents' farms were due poor drying or storage techniques.

4.6 Uptake of Metal Silo Technology

This section presents and discusses the uptake or the non-uptake of the metal silo technology among the sampled farmers.

4.6.1 Knowledge of Metal Silo technology

Farmers' knowledge of an agricultural technology is a significant determinant to their adoption of this technology.

Table 4.18: Knowledge of Metal Silo technology

Knowledge of Metal Silo technology	Frequency	Percent
Yes	14	22.6
No	48	77.4
Total	62	100.0

In terms of knowledge of metal silo technology, the study revealed that a large proportion of the respondents (77.4 percent) had no knowledge of the metal silo technology. On the other hand, a smaller proportion (22.6 percent) had knowledge of the metal silo technology as shown in Table 4.18.

This implies that there is a lack of dissemination of information on the metal silo technology among the sampled farmers. The Food and Agricultural Organisation (FAO) conducted a sensitization exercise on metal silo technology. However, this exercise did not cover the region in totality which could explain the lack of knowledge on the metal silo technology.

4.6.2 Uptake of Metal Silo Technology

The researcher intended to find the numbers of farmers who adopted the metal silo technology. Respondents were asked to indicate yes or no to adopting the technology.

Table 4.19: Uptake of Metal Silo Technology

Uptake of metal silo technology	Frequency	Percent
Yes	21	33.9
No	41	66.1
Total	62	100.0

From Table 4.19, sixty six percent of the respondents did not adopt metal silo technology in the storage of their grains while 33.9 percent adopted the metal silo technology. Thus, a smaller number of the respondents had adopted metal silo technology compared to the non-adopters. This implies that there is need for more sensitisation on the technology and also to establish the reasons for non-uptake.

4.6.3 Benefits of Metal Silo Technology

Table 4.20: Benefits of Metal Silo Technology

Benefits of Metal silo technology	Frequency	Percent
Reduced storage costs	6	28.6
Household wellbeing	3	14.3
Increase in grain sold	7	33.3
Reduced workloads	5	23.8
Total	21	100.0

In regard to the benefits of metal silo technology, the results indicate that 28.6 percent of the respondents believed that metal silo technology helped in the reduction of storages costs, 23.8 percent believed that it reduced workload. Past studies have shown that Households indicated that use metal silo technology reduces women’s workload due to the absence of daily shelling and removal of grains, which reduces gender inequalities (Bukosheva et al., 2012).

Thirty three percent of the respondents believed that metal silo technology increased the quantity of grain sold. Fourteen percent believed that metal silo technology benefitted household wellbeing as presented in Table 4.20. In past studies, Gladstone, Austuias and Hruska (2002) noted that about 60 percent of the farmers surveyed were found to still have maize grain in their silos at the beginning of the next harvest in comparison with only 29 percent of the non-users.

4.6.4 Reason for Non-uptake

The study sought to determine the reasons for non-adoption of metal silo technology. It was assumed that identifying these reasons would assist in enhancing metal silo technology among small-scale grain farmers.

Table 4.21: Reason for Non-uptake

Post-harvest losses	Frequency	Percent
I have not seen it	23	56.1
High cost	7	17.1
I have not seen how it works and its benefits	9	22.0
Not interested	2	4.8
Total	41	100.0

The study findings (Table 4.21) show that a larger percentage of the respondents (56.1 percent) pointed out that they had not seen the technology as the reason for not adopting it. Some (17.1 percent) believed that the high cost was the reason for them not adopting it. Others (22.0 percent) pointed out that they had not seen how it works and its benefits as the reason for non-uptake. 4.8 percent of the respondents were not interested and hence the reason for non-uptake.

The high cost of the metal silo technology was cited. However, the researcher further probed the respondents to quote the price of the metal silo and majority of them did not know the price of the metal technology. Similarly, Maonga et al. (2013) interrogated farmers on the reasons for non-uptake of metal silo technology in Malawi and found that 18.8 % (25 respondents) of the sampled households were not sure about the cost of the metallic silos.

4.7 Correlation Analysis

Correlation is a number between +1 and -1 that determines the degree of association between two variables. In addition, a positive correlation coefficient implies that there is a positive association while a negative correlation coefficient implies that there is an inverse or negative relationship.

Table 4.22: Correlation Analysis

		Education	Farm size	Extension services	Adoption of metal silo technology
Education	Pearson Correlation	1			
	Sig. (2-tailed)		.000	.000	.000
Farm size	Pearson Correlation	.277*	1		
	Sig. (2-tailed)	.000		.000	.000
Extension services	Pearson Correlation	.175	.255*	1	.931**
	Sig. (2-tailed)	.000	.000		.000
Adoption of metal silo technology	Pearson Correlation	.039	.069	.005	1
	Sig. (2-tailed)	.000	.000	.000	

** . Correlation is significant at the 0.01 level (2-tailed).

The results show that among the three independent variables, there was a positive and significant relationship between education and adoption of metal silo technology with a correlation coefficient of 0.039. Similarly there was a positive and significant relationship between extension services and adoption of metal silo technology with a correlation coefficient of 0.005. The most significant relationship was between farm size and adoption of metal silo technology. These findings imply farm size is the factors that are highly correlated with adoption of metal silo technology.

4.8 Discussion of Findings

4.8.1 Farmer Characteristics and Uptake of Metal Silos Technology among Farmers

Among the farmer characteristics which included age, gender, marital status and education level, the findings show that education of farmers has a significant relationship with the adoption of metal silo technology. These findings corroborate with Maonga et al. (2013) who found that formal education of household head also had a consistently positive relationship to adoption of small metallic silo technology. The effect was stronger for higher levels of education. Thus, education is a strong determinant of adoption of small metallic silo technology in Malawi and was highly significant at 1% level. This finding is consistent with Uaiene, et al. (2009, p.18) who studied determinants of agricultural technology adoption in Mozambique and found that “completion of at least lower primary school implies a much higher propensity to adopt new technology than lower or zero levels of education.

4.8.2 Farm Characteristics and Uptake of Metal Silos Technology among Farmers

The study measured farm characteristics such as distance from market, size of farm, form of farm ownership and main crop produced. The results show that farm size is the most significant factor associated with metal silo technology. Farm size is a usual factor explaining technology uptake, both in theoretical models and empirical models (Bocquého et al., 2011). The size of landholding, and therefore farm size impacts on the household's land use decisions in terms of type and diversity of farm enterprises, as well as cropping systems and patterns (Maonga, 2005). Farm size was therefore expected to have positive effect on uptake of metallic silos. Increasing the size of farmland for grain production improved the probability of adopting the small metallic

silos by 15.4%. Farm size was a proxy for quantity of grain production especially with regards to smallholder farming where use of high productivity inputs such as fertilizer is constrained by its prohibitive cost. This finding implies that in the absence of improved land productivity, smallholder farmers with large pieces of farmland have increased chance to produce large quantities of grain; therefore, they have higher probability to adopt the small metallic silos.

4.8.3 Extension Services and Uptake of Metal Silos Technology among Farmers

The study measured the influence of extension services to metal silo technology adoption. The indicators for this variable were frequency of contact, form of communication with extension officers and source of information on grain storage facilities. The findings further revealed that there was a positive and significant relationship between extension services and adoption of metal silo technology. Access to agricultural extension messages is believed to have positive influence on technology uptake by farmers. Extension improves farmers' awareness of the available new technologies. These results agree with Maonga et al. (2013) who found that probability of adopting small metallic silo technology was higher for smallholder farmers with access to agricultural extension services than those without extension contact. Barungi et al. (2013) found that the probability of adopting Napier grass in Uganda was 25.6% higher for farmers with access to extension services than for those without access. Extension services create awareness and enable farmers to get information about improved technologies. Such information is crucial for decision making by farmers in the process of new technology adoption. Farmers must have access to information about improved technologies before they can consider adopting them.

CHAPTER FIVE

SUMMARY OF FINDINGS, CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

This chapter presents the discussion, conclusion and recommendations of the study based on the study findings. The summary of findings summarises the findings of the study and the relationship of each indicators on the objectives of the study. The conclusion presents the conclusions made by the researcher in terms of the research objectives and recommendations of the study as per the research objectives.

5.2 Summary of Findings

Metal silo technology has been acknowledged as a storage technique for grain and its effect on reducing grain losses for farmers. The technology has been introduced in Asia and Latin America and recently in Sub-Saharan Africa (SSA). However, there have been few rates of adoption and uptake of the metal silo technology among farmers in Kenya.

The purpose of the study was to investigate factors influencing metal silo technology uptake among farmers Mwingi Central Sub-County, Kenya. The study was guided by the following specific objectives; to determine the influence of farmer characteristics on uptake of metal silos technology among farmers, to identify the influence of farm characteristics on uptake of metal silos technology among farmers and to identify the influence of extension services on uptake of metal silos technology among farmers.

The researcher used Statistical Package of Social Scientists (SPSS) to analyse the data. Descriptive statistics were used to analyse the data. The data was presented in tables and interpreted by the researcher and contrasted to the literature review. The study adopted the descriptive research design.

The target population for the study were 217 smallholder farmers involved in maize growing activities. The study adopted multistage cluster sampling, purposive sampling and stratified random sampling procedures. The study selected 30 % of the population in each of the stratum. The sample size for the study was 65 respondents.

The study found that the majority of farmers had less than one acre of land and the type of ownership was self-owned for the majority of respondents, inherited or leased. Majority of the respondents farms were 1-2 Kms away from the main road and market. Maize was the major type of crop grown and maize and beans was the second most popular crops that farmers practiced. Majority of the farmers' harvested less than 5 bags followed by those who harvested more than 10 bags.

In terms of contact with extension services, the respondents indicated that they had contact with extension officers sometimes, rarely and never. The major source of information for farmers in the metal silo technology was from other farmers as the results showed that 72.5 % indicated other farmers as source of grain storage. In terms of the grain storage techniques, the study found that 35.5 % used hermetic storage and 33.9 % used metal silo technology, polypropylene lined bags (17.7 %) and traditional grain storage (13.0 %). Majority of the staff indicated suffering grain losses. Traditional methods and pesticides use was the most popular methods of controlling pests among the farmers. Aflatoxin was cited as the most cause of post-harvest losses compared to weevils and poor drying/storage techniques.

In terms of knowledge metal silo technology, 77.4 % did not know about metal silo technology compared to 22.6 % who knew about metal silo technology. The results show that 33.9 % had adopted metal silo technology compared to 66.1 % who did not. The benefits of metal silo technology were Increase in grain sold, reduced storage

costs and reduced workloads. The most common reason for non-uptake was that respondents have not seen the metal silo technology followed by not knowing how it works and its benefits

5.3 Conclusion

5.3.1 Influence of farmer characteristics on uptake of metal silos technology among farmers

The study concludes that education level is a significant factor in uptake of technology among smallholder farmers. The study concludes that the more educated a farmer is, the more likely they know about alternative techniques for grain storage. The study concludes that gender and marital status have no influence on uptake of technology. The study also concludes that farming experience has a significant influence on uptake of metal silo technology. The experience of grain storage among farmers is a determinant to seek alternative forms of storage to help reduce losses.

5.3.2 Influence of farm characteristics on uptake of metal silos technology among farmers

The study concludes that the main type of crop grown by the sampled farmers was maize followed by beans. The majority of the farmers harvested less than 5 bags of maize in each season. The study concludes that the farmers do not adopt the metal silo technology due to the small amount of maize that they harvest which is associated with the size of the farm. The larger the size of the harvest the more likely a farmer will adopt the metal silo technology in order to avoid incurring losses through storage of maize.

5.3.3 Influence of extension services on uptake of metal silos technology among farmers

In Kenya, maize prices are low just after new harvest while they hike several times high prior to the new harvest. The study concludes that communication is an important factor to the uptake of metal silo technology. The study found that farmers had low levels of interaction with extension agents and this led to low access to information on metal silo technology. The study also concludes that informal communication among the farmers was found to be the major source of information on methods of grain storage among the respondents

5.4 Recommendations

Based on the study findings, the study makes the following recommendations;

1. The study recommends that training should be provided to the farmers who have already adopted the metal silo technology to become change agents of the technology among other farmers in the region.
2. The study recommends that metal silo technology should be designed to suit the needs of smallholder farmers as majority of the smallholder farmers have small parcels of land and do not have quantities of grain harvested to suit the metal silo technology that is available in the market.
3. The study recommends that sensitization of farmers on the metal silo technology should be enhanced to reach majority of the smallholder farmers. Sensitization of the metal silo technology should be coordinated with the county and central government agencies in order to reach a high number of farmers.

5.5 Suggested areas for further studies

There are various factors that influence the uptake of metal silo technology

- 1 The study only looked at uptake of the metal silo in Mwingi Sub County which is relatively small. The size is sufficiently large for accomplishing the goal of explanation and understanding. The data obtained was valuable for provided insight into the influence of uptake of metal silo in Mwingi. To increase validity and reliability, a study should be tested among larger scale farmers in other regions
- 2 Due to time constraint, not all performance indicators were included in this research. This leaves room for future research. Other studies should be done based on performance indicators not covered by this study, for example, non-financial measures like innovativeness and market standing.

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APPENDICES

APPENDIX 1: COVER LETTER

Anne Kimani

P.O. Box 24045-00100

Mobile No: 0720822541

Email: akimani80@gmail.com

Date:

Dear Respondent,

Re: Request to Participate in Data Collection

I am a student at the University of Nairobi pursuing a Master of Arts in Project Planning and Management. As a requirement for my studies, I am undertaking a study on *FACTORS AFFECTING UPTAKE OF METAL SILO TECHNOLOGY IN KENYA: A CASE OF MWINGI CENTRAL SUB-COUNTY, KENYA*. As a maize farmer you have been selected/identified to participate in the study by answering the attached questionnaire. The study is purely for academic purposes and is voluntary. The information provided will be held in confidentiality by the researcher and will only be used for analysis. The information should also be provided anonymously and does not require your identification. The final report can be shared with you through the contact information of the researcher provided. Thank you in advance.

Yours Sincerely,

Anne Kimani

M. A. Student

University of Nairobi

APPENDIX 2: QUESTIONNAIRE FOR SMALLHOLDER FARMERS

Please (✓) where appropriate

Section 1: Farmer Characteristics

1. Gender of household head
 - Male []
 - Female []

2. Age of respondent
 - 20-30 years []
 - 30-40 years []
 - 40-50 years []
 - 51years and above []

3. Marital status
 - Single []
 - Married []
 - Divorced []
 - Widow/Widowed []

4. Education level of respondent
 - O' Level []
 - Diploma/Certificate []
 - Higher Diploma/Degree []
 - Masters []
 - Doctorate []

5. Household size
 - Less than 3 members []
 - 3-5 members []
 - More than 6 members []

6. Experience in farming
 - Less than one year []
 - 2-5 years []
 - 6-10 years []
 - More than 11 years []

Section 2: Farm Characteristics

7. Size of the farm

- Less than an acre []
1-2 acres []
3-4 acres []
More than 5 acres []

8. Type of farm acquisition/form of ownership

- Self-owned []
Leasing []
Cooperative []
Inherited []
Other (*Specify*)

9. Distance from trade/market centre

- Less than 1 Km []
1-2 Kms []
3-4 Kms []
More than 5 Kms []

10. Which is the main type of crop in the farm?

- Maize []
Beans []
Sorghum []
Others []

10. On Average how many bags do you harvest per season?

.....

Section 3: Extension Services

11. Frequency of contact with extension service providers

- Never []
Rarely []
Sometimes []
Often []
Always []

12. Source of information on grain storage

- Mobile phone []
Television []

- Radio []
- Extension officer []
- Other farmers []
- Other (*Specify*)

13. Type of maize storage used in farm

.....

13. Have you incurred any post-harvest losses?

- Yes []
- No []

If yes what are the methods you used to control the losses?

- Pesticides []
- Traditional methods []
- Disposing []
- Metal Silos []
- None []

15. What are the common causes of post-harvest losses in this area

- Weevils []
- Aflatoxins []
- Poor drying []

Section 4: Adoption of Metal Silo Technology

16. Do you about metal silos and its use

17. Have you adopted the use of metal silo technology and how did you acquire?

- Yes []
- No [] (Skip to Question 16)

18.If yes, for how long have you been using the metal silo technology?

.....

19.What are some of the benefits of using the metal silo technology?

.....

why have you not adopted the metal silo technology?

.....

Thank You for Your Participation