ADOPTION OF POST-HARVEST HANDLING TECHNOLOGIES (PHHT) AND ITS INFLUENCE ON SMALL-HOLDER MAIZE FARMERS AT AFIENYA IN NINGO PRAMPRAM DISTRICT IN GHANA.

A Research Project Submitted to Van Hall Larenstein University of Applied Sciences in Partial Fulfillment of the Requirement for the degree of MSc Management of Development: Rural Development and Food Security.

BY

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Dedication

To God be the glory for his blessings during my studies. I dedicate this project work to my late mother Felicia Kumadie for her love and inspiration. May she rest in perfect peace. Lastly to my wife Gifty and my children for their prayers, love, patience and encouragement whilst I am away from home. God bless you all.

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List of Acronyms

A C F	Agricultural Cooperative Foundation
AGRA	Alliance for a Green Revolution in Africa
A P H L I S	African Post-Harvest Losses Information System
FAO	Food and Agriculture Organization
FGD	Focus Group Discussion
FAOSTAT	Food and Agriculture Organization Corporate Statistical Database
GSS	Ghana Statistical Service
IFPRI	International Food Policy Institution
KII	Key Informant Interview
MOFA	Ministry of Food and Agriculture
MOD	Master of Development
NGO	Non-Governmental Organization
NIPDA	Ningo Prampram District Assembly
PHHT	Post-Harvest Handling Technology
PHL	Post- Harvest Losses
SSA	Sub Saharan Africa
USAID	United State Agency for International Development
WFP	World Food Program.

Summary

Maize cultivation in Ghana has been ongoing for centuries. Maize production in Ghana, is predominantly done under rain-fed conditions by smallholder farmers. The agro-ecological zones for maize cultivation in Ghana are grouped into four; the coastal savannah, forest zone, transition zone and the Guinea savannah zone. Maize accounts for 50% of the total cereal production in Ghana, with reported post-harvest losses between 5% to 70%. Maize remains an important crop for smallholder farmers and plays a vital role in safeguarding food security in the district. However, the amount of maize that can be used for food in the district is low as result of losses through poor post-harvest management activities. Post-harvest handling technologies might be part of this low productivity. Some farmers use improved technologies, but most don't adopt these technologies while production and market share remain low.

The aim or objective of this study was to identify the determinants of adoption of improved technologies and management practices in the study area. By using a random sampling technique, a total of 25 out of 325 farmers from four zones were selected from the list of farmers by the extension officer for the study area. For the purposes of the study, Individual interviews were conducted with the 25 respondents to gain insights into how they practice PHHT and why they do what they do. Individual interviews enabled the respondents to tell their story in their own way. Focus group discussion were also used as another source of primary source of data collection. Individual interviews supplemented focus group discussion data, and observational data was collected by the researcher to further supplement the FGD data and interview data.

Each of these data collection tools provided opportunities to gain insight about the farming activities of the participants (farmers). The farmers were interviewed with the aid of an interview questionnaire prepared after literature research to help obtain information regarding the farming and postharvest activities associated with maize production. In addition, another interview questionnaire was designed to extract information from other stake holders such as the extension service officer and a key informant. Secondary data was obtained from journals, books published and unpublished documents.

Results of the study indicated that 9 out of the 25 sample respondents were non adopters of improved technologies, 13 respondents were partially adopting some parts or stages of postharvest handling technologies while 3 respondent farmers were fully adopting the improved technologies. Also management practices such as time of harvest, dehusking, transportation, drying shelling, bagging and storage practices by the respondent farmers was found to be poor to reduce post-harvest losses. Farmers stated that because of irregular visits of the extension officer, pest and disease, lack of credit access , farming is becoming unattractive and unable to expand their acreage.

Results after analyzing the data shows that (8) eight variables education or training, contact with extension agents, sex, cost of technology, risk of technology, participation in demonstrations and access to credit were significant and positively affect adoption of improved technologies by smallholder farmers at Afienya in the Ningo Prampram district.

Based on this finding, the study suggests that the NGO, agricultural extension service and stakeholders in agriculture should collaborate in extension service delivery, lobby and recruit more extension agents to the field; that credit facilities be made flexible to maize. That the extension service organize forums for farmers at least twice every farming season to get farmers more motivated .

Chapter 1 Introduction

1.1 Background

Maize (*Zea mays* L.) cultivation in Ghana was introduced in the late 16th century and it got established as an essential staple crop in the southern part of Ghana. Maize is the most widely produced and consumed cereal crop in Ghana and maize production has seen an increasing trend since 1965 (FAO, 2008) . The agro-ecological zones for maize cultivation in Ghana are grouped into four. The Coastal savannah zone, forest zone, transition zone and Guinea savannah zone.The system of maize cultivation differs among these agro-ecological zones. Afienya and for that matter the Ningo Prampram district falls in the Guinea Savannah zone. For this study Afienya is chosen, because of the areas agro-ecological suitability for maize production among eight communities in the district. The community is known for its maize production potentials and the farmers here consider maize production as business (presence of adopter and non-adopters of post-harvest handling technologies.

The district is a newly created district carved out from Dangbe West (now Shai Osudoku) and forms part of the new district and municipalities created in 2012. It covers a total land area of about 622.2 square kilometers. Prampram is the capital. It is 40km from Accra the capital of Ghana. The district is bordered to the north by Shai Osudoku district, to the east by Ada West district, to the south by the Gulf of Guinea and to the west by the Kpone Katamanso district. According to 2010 census by the Ghana Statistical Service (GSS) the population of the district is 70,923 with 33,514 as males and 37,409 being females. It is located at an elevation of 76 meters above sea level

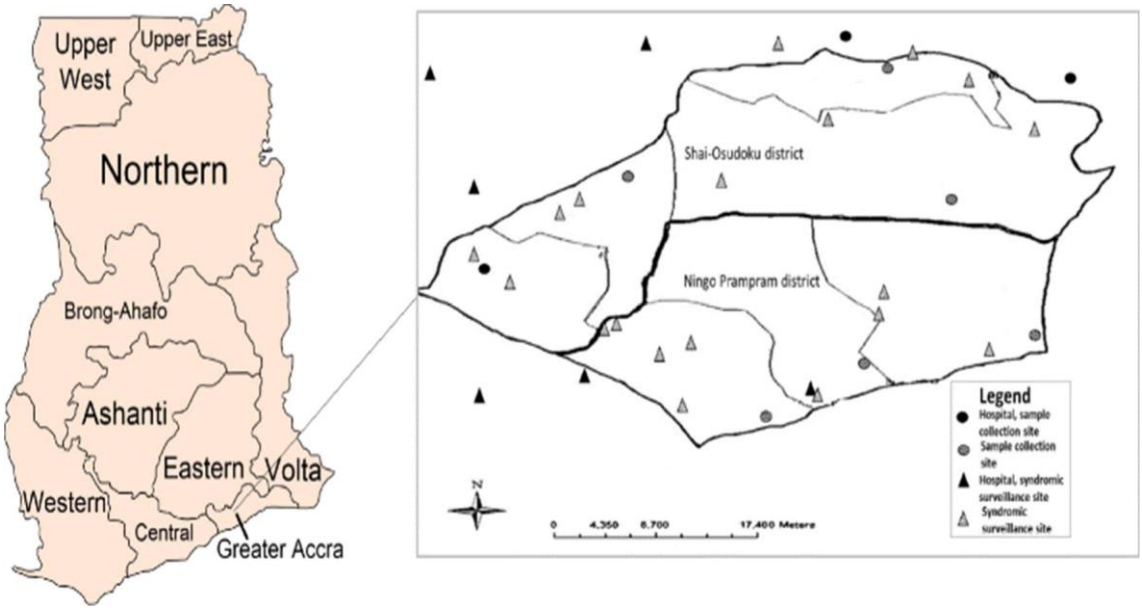

Figure 1: Map of Ghana locating Ningo Prampram district.

Temperatures in the district is generally high with a monthly mean of about 21degrees centigrade to 29 degrees centigrade. The district experiences a bi-modal rainfall pattern, beginning from April and ends in October-November with annual rainfall between 800-1200 mm. December-April is the warmest months while June to August is the coolest months. Below is a table indicating the climatic conditions of the district.

Table 1: Annual Climatic data for NIPDA

Climatic factor	Minimum	Maximum	Average
Rainfall (mm)	**800**	**1200**	**1000**
Temperature (*C)	**21**	**29**	**25**

Source: Meteorological Service Department, Ghana. 2017

The natural vegetation and climate of the district which experiences rainy and dry spells during the year encourages the production of maize. Although the production of maize has been on the increase it has not lifted the status of socio-economic development of farmers in the area. The improvement of maize production and its post-harvest handling is essential since most farmers solely depend on maize as potential source of income and preparation of all their dishes. It is noteworthy that despite the efforts put into maize farming, its achievement will depend on the level of enthusiasm shown by the farmers in PHHT practices and management of maize.

The topography of the district is gentle without hills which are good for mechanized farming. Farming is the major occupation of the people of Afienya in the Ningo Prampram District and the main crop grown is maize which is inter cropped with pepper, tomatoes and cassava mainly. The most outstanding investment potential on offer in the district revolves around crop and livestock and poultry farming because the topography of the district favors this activity as there is ready access to the needed raw materials such as animal feed. Farmers starts planting their farms with the onset of the major rains that begin in March or April. Soils are generally light in texture and low in fertility, so productivity is low. Almost all household keep some form of livestock e.g. sheep and goats and some cattle.

Maize accounts for over 50% of the cereal production in Ghana, and annual yields have been reported to be growing around 1.1% (Arhin, 2014). However, postharvest handling has been a major challenge. Even though maize has excellent storage qualities, there are many factors contributing to its deterioration which force farmers to sell part of their maize produce for badly needed money at the harvest time (MOFA, 2006). The quantity of maize consumed in a particular year by subsistence farm households in Ghana can be severely affected if there is high postharvest loss. Postharvest loss is complex and difficult to be dealt with completely since it differs with crop, storage condition and structures used for storage. In the developing countries most of the losses occur due to inefficient postharvest handling and storage facilities, which cause food to spoil or deteriorate before it reaches the market or final consumer (FAO, 2011).

According to Evans Nsiah of Pens Food Bank Enterprise ''Food production in Ghana has never been a problem, for almost 70% of the population within the maize growing areas do farming, but how to manage post- harvest is the greatest challenge.'' Information gathered by Evans Nsiah of Pens Food Bank Enterprise during a PHL assessment trip suggest that on-farm PHL are approximmately30% with more of this percentage occurring during the major season due to drying challenges resulting from the short dry spell prior to the minor growing season, land constraints ,poor handling of the maize in the field, delayed harvesting during harvesting during the minor season. Additionally, piling of husked ears, or ears on stalks on the ground in the field for long periods of time after harvest (pre-drying in the field): lack of proper drying of maize which results in molding and increase in aflatoxin levels; physical losses during harvesting , transportation, drying and shelling and bagging. Many of the farmers and stakeholders interacted with indicated that the highest losses occur during harvesting because most farmers attach attention to only storage practices as the main management practice in reducing postharvest losses in maize.

The purpose of this study is to determine the factors influencing the adoption of Post-Harvest Handling Technologies (PHHT) by maize farmers at Afienya in the Ningo Prampram district, Ghana, to understand why smallholder farmers are not adopting PHHT available. PHHT in this study is measured in terms of adoption levels (*harvesting, drying and shelling*). The stakeholders in this study are the Agricultural Cooperative Foundation (NGO) which provides extension advisory services to farmers, organizes training in collaboration with the ministry of food and agriculture as a partner in development. New and modern information on grains and legumes development is sought from the Grains and Legumes board. The researcher works as a link between the farmers the organization and research. The researcher is a field staff from the organization. The organization is ably supported by Agrochemical Suppliers (Inputs) in the prompt inputs delivery to targeted groups. The commissioner is the Agricultural Cooperative Foundation the NGO.

According to a 2016 study by Dr. Bruno Tran, an expert in post-harvest management with the Africa Post-Harvest Losses Information System (APHILS), Ghana losses about 318,514 metric tons of maize annually to post-harvest losses (APHLIS, 2013). The inability of smallholder farmers to adopt innovative methods of post-harvest activities continue to hamper the reduction of this losses. The extension service has the right information for the farmers but dissemination of these appropriate technologies is hampered due to inadequate resources, mobility the research observed.

1.2 Problem Statement

Overtime, adoption of agricultural innovation in developing countries including Ghana has attracted attention because it has provided the basis for increasing production and productivity. Improvements in agricultural productivity would be improved among smallholder farmers through technologies which are developed at the research centers and disseminated to farmers mainly through agricultural extension service *(Stephen et al 2014*). However, integrating these technologies into their farming activities is greatly influenced by socioeconomic, institutions, (tradition and norms), attitude and perceived technology *(Bihon,2015).*

In the study area, maize production has seen a significant production, but the productivity is very low because of lower utilization of improved agricultural technologies such as improved maize variety, poor postharvest management practices, pest and insect infestation among maize producing farmers. Moreover, information given by extension officers to farmers is mainly focused on storage practices to reduce postharvest losses, but there are other practices such as harvesting, drying and shelling that also have great effects on the quality and quantity of maize yield (Okoruwa et al2012)

A study conducted by *Okoruwa et al* (2012) looked at postharvest grain management, storage techniques and pesticide used by farmers in South- West Nigeria. However, it did not look at other aspects of harvesting, drying and shelling which can also can also reduce grain quality and quantity if handled poorly . Thus, research in this area is vital for improving productivity by maize farmers, by understanding the problems related to postharvest handling technologies, adoption levels of PHHT and management practices.

Therefore, with the above-mentioned gaps, the researcher intended to find out the determinants of PHHT in the district and recommend management practices with a view of fulfilling the knowledge gap in the study area.

1.3 Research Objective

To determine the factors influencing the adoption of post-harvest handling technologies (harvesting, drying and shelling) on smallholder maize farmers at Afienya in the Ningo Prampram district and to recommend measures to Agricultural Cooperative Foundation (ACF) to increase the adoption of PHHT.

1.4 Research Question

What are the factors influencing the adoption of PHHT among smallholder maize farmers at Afienya in the Ningo Prampram district?

Sub-Questions

- What is the adoption level of PHHT (*harvest*, *drying and shelling)* among the small holder farmers at Afienya in the Ningo Prampram district?
- What is the awareness level of PHHT at Afienya in the district?
- What is the cost and perceived risks of adopting PHHT?

1.5 Conceptual Framework

Poor practices of post-harvest handling activities such as harvesting, drying, shelling, treatment and storage reduces grain quality and quantity. Technology adoption depends on whether farmers have the requisite physical (material) and abstract possessions (e.g. education). A lack of assets or possessions renders smallholder farmer not able to adopt technologies.

People calculate the likely cost and benefits of any action before deciding what to do like the usage of a given post-harvest technology. Lack of available knowledge or awareness of PHHT limits its adoption. Farmers will be able to adopt technologies that have a lower risk have a greater appeal to farmers who are naturally risk averse (Meinzen-Dick, 2004).

What might be influencing farmers to adopt and continue the use of newly introduced technology and the rejection of the technology?. Farmers may be aware of improved technologies but may not have the ability or knowledge in the technology. Subsistence farmers might believe in their indigenous knowledge and attach a level level of importance to the traditional method, it is a tradition and heritage and farmers might feel they are ditching their tradition and norms to adapt to new technology

If farmers are aware of an innovative practice especially by observing a neighbor (farmer) who adopts and have good harvests, the likelihood that the (non-adopter) follows the process is high, because he now sees and will believe in the technology transfer but would be considering the cost behind and the likely risks(Bokusheva,et al.2012). Training of farmers on PHHT is a prerequisite to reducing post-harvest losses. Bokusheva, et al., (2012) in central America found out that successful completion of training course on post-harvest handling technologies as one of the main factors of achieving household self-sufficiency in maize. Kaminski and Christiaensen (2014) revealed that post-harvest losses increase with higher seasonal price differences. Farmers will adopt a new technology if they have the capability to adopt and continue the use of that innovation. According to Browing, Haleli, and Webster (2000) under the rational concept, people calculate the likely costs and benefits of any action before deciding what to do like the adoption of a given post-harvest technology. The decision making of adopting a given post-harvest technology depends on the risks and uncertainties involved.

Farmers may have the knowledge, believe and capabilities but if their practices are not in the right way quality and quantity of their harvest may be compromised.

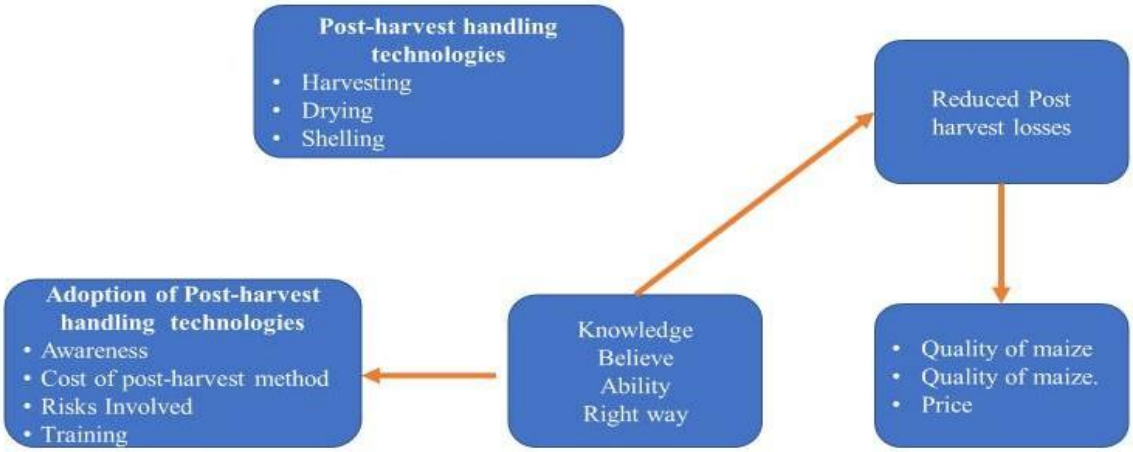

Figure 2: Conceptual Framework adopted from Okoruwa et al and adopted by the researcher

Chapter 2 Literature Review

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

2.1 The Concept of Post-Harvest Handling Technology

The primary role of an effective post-harvest handling system is to ensure that the harvested product reaches the consumer, while fulfilling market and consumers expectations in terms of volume, quality and other product and transaction attributes including nutrition, food security and product safety. Post-harvest technologies include all activities that a farmer carries out after maturity of crops such as harvesting, transporting and drying, shelling, treatment, storage, packaging, transportation and marketing (Zorya, et al., 2011).

2.2 Availability of Post-Harvest Handling Technologies

There are many post-harvest handling technologies that a farmer can use depending on the cost of the technology. Rugumamu, (2009) argued that, the missing link in post-harvest loss reduction in all phases is the availability of appropriate technologies. This study therefore finds out the relationship between availability of appropriate technologies and post-harvest loss among maize farmers. It has also been found out that grains can be damaged during harvesting, threshing or transportation and by a range of insects, pests and molds. Improvements in storage facilities, drying and transportation would reduce or prevent damage and loss (Lama, 2014).

2.3 Harvesting

Harvest is defined as pulling ears from stalks and typically piling the ears until shelling can be done. Farmers harvest maize once the grain reaches physiological maturity (moisture content is 20-30%). At this stage the grain is susceptible to pest attacks and is favorable for mold growth and the associated risk of aflatoxin contamination. Farmers at Afienya however do not harvest at the right time (ill timing) in attempt to prepare the land very early for the minor season. Weather conditions at the time of harvest are critical factor influencing pos-harvest losses. Unstable weather conditions due to climate change leads to damper or cloudier conditions which increases PHL (Zorya, et al., 2011). Key indicators of when a plant is ready to be harvested are; it changes color from green to light brown or yellowish. Right timing of harvest greatly affects the extent of aflatoxin contamination. Allowing maize to dry in the field results in field losses caused by rodents, termites, birds and theft etc.

2.4 Drying

Maize drying is to allow a moving, relatively less humid and dry air takes moisture away from the grain. Farmers at Afienya in Ningo Prampram district in Ghana both small and large scale, rely almost exclusively on natural drying of crops from a combination of sunshine and movement of atmospheric air through the products. Traditional techniques maize farmers use at Afienya and for that matter in rural communities in Ghana are:

- *In-field drying*

The cobs may be stacked in the field to allow for further drying. Further losses are likely to happen due to more scattering and exposure to pest and insects.

- *On-platform drying*

Threshing of grain is mostly preceded by further drying in homesteads. The maize may be hung on racks or placed on purposely constructed platforms. This method has many advantages compared to the in-field drying but the percentage of grain loss is relatively high.

- *On-ground drying*

The grains are typically spread-out on the ground floor to allow drying. The grains which may be on the bare floor could absorb moisture, be contaminated with dirt and foreign materials, and be exposed to rains, insects, pests, livestock and birds. In recent times, people are commonly drying maize on plastic sheets or mats. This practice of ground floor drying is being discouraged because of the following reasons.

. Must keep watch all the time to keep the grain from rain etc.

. Grains can be washed away when there is sudden downpour or be brought under shelter at night or when it is about to rain.

. There is higher risk of contamination from dust, soil, stones, animal droppings, fungal and insect infestation.

. Quantitative losses from birds, poultry and domestic animals are very high.

. The method is time consuming and can be labor intensive when harvest is huge, unfortunately this method is the most practiced by farmers.

- *The use of chemicals*

Farmers sometimes tend to the use of chemical control methods despite the associated issues. This method is rarely practice by smallholder farmers because of lack of knowledge of its management.

a. The use of fumigants and contact insecticides

Gaseous fumigants and residual contact insecticides are mostly used to control insects in stored grain, (Obeng-Ofori, D. 2011). The dried grains are fumigated and then packed into bags for storage. Fumigants are reported not having residual effect but can penetrate through attacks or bulk product killing all life stages of insects. The major drawbacks in the use of fumigants are that they do not protect against grain re infestation, they are extremely poisonous and could result in death if not well handled (Danilo,2003). Proper drying reduces microbial activity especially of molds that may produce Mycotoxins (such as aflatoxin).

2.5 Shelling

The most recommended way to store maize is in a shelled form. Shelling or threshing is a process that frees the grain from the cob, seed head or pod. In many rural areas of developing countries including Ghana, the maize kernels are shelled mostly by using the fingers. Shelling by hand typically takes weeks. The shelling becomes painful and cause injuries to fingers when the kernel is hard to shell. In situations where the harvest is very huge, shelling is commonly done by loading sacks with the maize cobs and the loaded sacks are beaten with sticks. The beating may result in physical damage to the grain making the grains more susceptible to pest and molds and cause germ damage (FAO,2009). The use of small-scale hand-cranked or powered maize shellers are often unaffordable or difficult to obtain by smallholder farmers at Afienya. Farmers are not able to purchase hand shellers even if they are available and still believe in their traditional way of shelling. According to APHLIS (2013), most broken grain comes from poor post-harvest handling during shelling or threshing and may also be a consequence of pest attack and fungal contamination.

2.6 Storage

The main objective of grain storage is to maintain the quality of the produce for a long time (Okoruwa, 2009). Due to inadequate storage practices and facilities small holder farmers in the district and for that matter Ghana loss up to 40% of their harvest to insect, pest, mold and moisture. Traditionally, maize is stored in mud lined grain silos, in any instance farmers should consider the difficulties of storing maize at optimal conditions and balance humidity, the moisture content of the grain and the potential for pest infestations (Meridian Institute, 2005). Much as most farmers do not have storage space and containers, they struggle to protect the crop from mice and other pests. In other instances, farmers must dispose of their harvest early to avoid spoilage hence depriving them of higher income in the future when prices are high due to poor storage facilities. In Ghana, maize is stored in different locally constructed storage structures such as granaries, mud silos, cribs and commercial stores or living rooms for a period of 2-6months.

2.7 Adoption of Post-harvest Handling 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), argue that the main factors affecting technology adoption among smallholder farmers in Sub-Saharan Africa are assets, vulnerability and institutions. Therefore, this study would like to focus on dimension cost of the technology to be used in terms of its affordability to farmers, the level of awareness as well as 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 by smallholder farmers (Meinzen-Dick et al.,2004). Browning, Halcli and Webster (2001) states that people calculate the likely cost and benefits of any action before deciding what to do like the usage of a given post-harvest technology. Vulnerability factors deal with the effects of technologies on the level of exposure of farmers to economic, and social risks (Meinzen-Dick et al., 2004) Lack of available knowledge or awareness of PHHT limits adoption. Farmers would adopt technologies that have a lower risk have a greater appeal to smallholder farmers who are naturally risk averse (Meinzen-Dick, 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 uncertainties involved.

2.8 Training in Post-harvest Handling Technologies

The overall goal of extension service on the PHHT training is to equip smallholder farmers with knowledge 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). Available knowledge will create awareness in smallholder farmers at Afienya to shift from their existing practices for an improvement to maximize the returns on their investment, 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). A good training process should be moving to a more detailed presentation of a range learning approaches, materials and processes. Advanced planning, including a training needs assessment, development of learning outcomes, designed of the training programme, selecting 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 PHHT learning (WFP, 2012). Rugumamu,(2009), argued that lack of specialized training in the post-harvest component of the crop management cycle and lack of a lead farmer or 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.

2.9 Quantity and Quality of Yield

Reduction in quality of grain lowers the market value, which are usually informal, so farmers lose the opportunity of better incomes. USAID (2013) indicated that smallholder production is characterized by low volumes (quantity) and (inconsistent) quality that are the result of poor post-harvest handling practices and insufficient and inadequate storage. Temperature and moisture content of the grains are the two key features affecting the quality of the grain, dry matter losses, allowable storage times and overall storage management of the grain (Lawrence & Maier, 2011). Infection of maize grain by storage fungus results in discoloration, dry matter loss, chemical and nutritional changes and overall reduction of maize grain quality and quantity. If inadequately dried, the conditions are favorable for molds and fungi to grow, and results in a significant decrease in quality and quantity. To produce high quality grain, it is imperative on smallholder farmers to do their post-harvest handling practices in a proper and timely manner (WFP, 2012). Quantity of maize grain reduces as a result of grain scattering and grains left in the field. Spillage due to transport of harvest from the field to homestead. Reduction in quantity can also be observed during drying when maize is dried in the open, livestock theft and contamination with their urine, bio-deterioration and moldiness. Activities of shelling may scatter, spill and cause the breakage of maize grain depending on the method used thus reducing the quantity and quality of grain. Transport of maize to the markets may see spillage if not bagged and packed properly causing a reduction in quantity of maize.

CHAPTER 3: Methodology

3.1 Study Area Description

The population of the Ningo Prampram district according to Population and Housing Census 2010 is 70,923 representing 1.8 percent of the region's total population. Males constitute 47.3 percent; female represent 52.7 percent. About 58.3 percent of the population live in rural localities. The district has a household population of 68,521 with a total number of 14,627 households. About 66.8 percent of the population aged 15 years and older are economically active while 33.2 percent are economically inactive of the employed population.

In the district ,33.7 percent of the households are engaged in agriculture. In the rural localities, 43.5 percent of households are agricultural households while in the urban localities 22.9 percent of the households are into agriculture. Most households engage in agriculture in the district. 84.8% are involved in crop farming with chicken as the dominant animal reared.

The district has 107 public schools made up of 32 junior high schools ,2 senior high schools and 31 pre-schools. It has 15 health facilities out of which 10 are public health facilities and the remaining 5 are private. The economy is largely rural. The predominance of rural population reflects in the occupational distribution of agriculture as the dominant occupation.

3.2 Research Strategy and Design

Research strategy

To answer the questions of the research several research methods were used. The researcher adopted qualitative research method in order to obtain in-depth information and a thorough understanding of the factors influencing the adoption of PHHT. Qualitative strategy was adopted as it regards participants' perspectives as necessary, limits the imposition of ideas on participants and contributes to an in-depth study for richer information and understanding of human experience and action.

Out of a list of 325 farmers in the region which are registered at the extension service, 25 were randomly selected from four different zones and might be having different land sizes. It includes (6) six females and 19 males for interviewing. 25 of 325 were selected because this was representative of the sampled population.

All the farmers selected were male headed households. There were no female headed households in maize farming, but they were into vegetable farming therefore the researcher had to rely on the six females that are into a male headed household.

The study area is 21 kilometers from researchers' residence, so initially the researcher decided to go there with a motorbike but because of my leg problems and intermittent rains, my brother in law's car was hired.

I planned to have at least a thirty minutes interview with each respondent but could not because it took time for farmers to understand clearly the questions. The researcher have to restructure the questions as he continues with subsequent interviews and so it took 80 minutes and more later.

After the individual interviews two focus group discussions was planned with the extension office. Semi-structured interviews were to be administered with farmers (*adopters*) and *(non-adopters)* to know about their experiences in respect with PHHT.

3.3 Research Design

The researcher employed a qualitative approach to gain an understanding of the underlying reasons, ideas opinions. The researcher sourced for information or data from desk study extensively on the term '' Post-harvest handling technologies and its influence on smallholder farmers on google scholar, web of science, reading reports, books and articles . Since it is a people centered research a checklist with questionnaire was used to obtain data from the respondents. The data was collected through a case study strategy to gain in depth knowledge of the research problem. The researcher adopted observation to triangulate what the respondents say and what really is on the ground. This observation involves asking question on the assets of the respondents.

3.4 Method

Afienya was selected purposively based on the community's proximity to researchers' location and its agro-ecological suitability for maize production (among eight communities in the district), where farmers consider maize farming as a business (presence of adopters and non-adopters of improved PHHT). The sampling frame (complete village household lists) was identified in collaboration with a community leader and the extension agent of the area of study. Information for the case study was gathered from randomly selected farmers, extension service department of MOFA in the Ningo Prampram district, Ghana Grains Development Board and the Statistics Service of Ghana. Farmers that were selected were all part of Afienya community but from four different zones, made up of 25 farmers out of 325 farmers list.

Individual Interviews

The researcher spent the first (2) two days in the study area before completing the scheduled interview as respondents could not be located on the first visit, so it was necessary to return several times to the same house before an interview could be conducted. When it was not possible to locate a farmer even after repeated visits, replacement was selected at random from the farmers list. It was however revealed that the scheduled time coincided with the registration for the Ghana citizenship identity card issuance in the district. Farmers in the community rushes there early in the morning to avoid long queues which usually takes a long time to get registered. The time required to complete each interview varied from 45 minutes to 1 hour depending on the response of the respondents farming activities so must restructure the questions with subsequent interviews.

The interview did not follow any formal pattern and exhibited flexibility that created a conversational background that enabled the farmer the willingness to open to me. It offered researcher the opportunity to ask extra questions on unknown issues that cropped up during the session.

For assessing the level of adoption of improved PHHT of maize, respondent farmers were grouped into four categories such as none, high, medium, and low adopter based on average, frequencies and percentages of farmers land proportion covered by the improved technology. A higher percentage indicates a higher level of adoption, while a lower percentage indicates a lower level of adoption of a technology. Adoption level was categorized as zero percent (no adopter), (70-100%) as high, (50-69%) as medium, and <50% as low adopter. Out of the 25 farmers interviewed 9 (36%) were non adopters of PHHT, 7((28%) were low adopters, 6 (24%) were medium adopters and 3(12%) high adopters. Six (6) female farmers with initials D.S, K.F, D.D, A.S, A.B, and K.K and (19) nineteen males were interviewed.

Focus Group Discussion

Two focus group discussions was schedule in collaboration with the extension officer. The first FGD was at a plant clinic organized for farmers from four zones in the district at the district assembly hall at Prampram. The district directorate was present with four zonal extension officers. The researcher was invited and met farmers after the plant clinic on the 29th of June 2019 at 11:00 hours to 12:30 hours. Attendant farmers were not all maize farmers, therefore after the clinic, the researcher separated sole maize farmers from the others. However, most of the farmers did not want to leave after the meeting as they were curious to know what the researcher was going to tell the selected maize farmers. The researcher in consultation with allowed farmers to stay but would not be contributing in the discussions.The farmers were used as another primary source of data collection. FGD's were chosen as the primary source of data collection because the data collected comes from interactions with different category of farmers and gives the researcher an insight into the ways in which meaning is made within the context of the group. The time required to complete each interview varied from one hour to two hours depending on the response of the respondents farming activities and or the respondent's familiarity with the PHHT.

The second FGD was held on the 25th of July 2019 at Mobole, the researcher wanted to know from adopters and non-adopters of PHHT the factors influencing the adoption of PHHT in the study area. In selecting farmers for the FGD, the researcher after contacts with a key informant (community leader) and the extension officer, it was found out that only 3 farmers, large scale farmers that are practicing all stages of PHHT, in the study area and are high adopters, so the researcher chose all of them so that diverse experiences and opinions could be shared and collected amongst all category of adopters. The researcher, then randomly selected 7 other farmers who are not adopting or partially adopting. Individual interviews were also done with selected key informants in order to corroborate or dispute the information collected from both the semi-structured interviews and the focus group discussions.

Observation. The researcher wanted to observe the method of harvesting, drying and shelling but could not see these activities. Maize fields were not fully matured for harvesting, drying and shelling as at the time of visit. However, to be more precise, the researcher visited 9 farmers field to acquaint himself with stages of maturity. The researcher therefore had to rely on information given by the farmers from their past practices, information from the extension agent and one key informant and observed storage structures of the smallholder farmers and other assets available..

Key informants

Two key informants were interviewed. A community leader and a warehouse attendant. Although the farmers are not patronizing the warehouse the attendant provided useful information on harvesting and drying and explained that the small holder farmers are not patronizing the warehouses because of the cost involved and the size of their harvest. He added that it is only the maize aggregators who buy from smallholder farmers and store. The warehouse is currently under renovation. a level of secondary school education.

In all 25 smallholder farmers, 1 extension agent and two key informant was interviewed in order to corroborate or dispute the information collected from both the semi-structured interviews and the focus group discussions.

The interview was done with the smallholder being the main agent to effect change in the post-harvest practices and management in maize production, while the stakeholders act as the catalyst for improvement.

Table 2: illustrates farmers location, sex , age and farm size

Farmers Initial	Location	Sex	Age	Farm Size (Acreage)
D.S	Mobole	Female	40	< 5
K. F	Mobole	Female	43	< 5
J. A	Afienya	Male	39	< 5
E. A	Afienya	Male	35	5- 10
B. O	Afienya	Male	35	< 5
D.M	Adjimador	Male	36	5 -10
A.M	Adjimador	Male	29	< 5
B. B	Mobole	Male	37	< 5
O.M	Ablekuma	Male	23	5-10
A. G	Mobole	Male	37	10 -15
D.D	Afienya	Female	31	10 -15
A. S	Afienya	Female	30	10 -15
A.H	Adjimador	Male	32	10 -15
A. B	Ablekuma	Female	40	10 - 15
D.A	Adjimador	Male	34	10 - 15
C.D	Adjimador	Male	47	10 - 15
E. E	Mobole	Male	44	10 - 15
E. T	Mobole	Male	54	10 - 15
I.K	Mobole	Male	46	10 - 15
B. T	Afienya	Male	38	10 - 15
K. K	Adjimador	Female	41	10 - 15
N. P	Adjimador	Male	44	10 - 15
M.D	Ablekumah	Male	52	< 30
Z. Y	Afienya	Male	54	< 30
M.B	Afienya	Male	58	< 30

Individual interview with a maize farmer , son and the extension officer on the farm

3.5 Limitations of the research

- It took the researcher two days to get to the targeted respondents, this was as a result of the researcher's scheduled time coincided with the registration of Ghanaians for a citizenship card in the district.
- The researcher initially planned a thirty minutes interview with respondents but in the field, interviews took forty-five minutes to an hour depending on the response of the respondents farming activities, so researcher has to restructure his questionnaire for subsequent interviews.
- The researcher initially thought of observing the activities of harvesting, drying and shelling but as at the period of the study maize farms are still not matured for harvesting. The researcher had to rely on interviewing respondents about how, why and when they do these activities.
- Budget constraints coupled with the researcher's health (leg problem) pose a delay sometimes, had to always depend on in-law's car for field visits.
- Only male headed households were interviewed as female headed households are not into maize farming, perhaps the findings and results might have change.

Chapter 4: Results

In this chapter, the findings of the study are presented. The data from the study were structured according to the research questions. 25 out of 325 farmers from four different zones, with different land sizes and six females in different adopter categories were interviewed.

4.1 What is the adoption level of Improved PHHT of Maize in the Study Area

Results from the study on the existing technology adoption level on the maize production is presented in table 3 below.The researcher categorized the levels into four levels of adoption categories of improved PHHT of maize production in Afienya in the Ningo Prampram district. Adoption categories were determined by the level of adoption of post-harvest handling technologies. These are non-adopter, low adopter, medium adopter and high adopter of improved maize technologies in the study area. Non-adopters were found to be (9)36% out of the total respondents and zero percent covered by improved PHHT of maize production. The Low adopters were (7) 28% and less than 50% of farmland covered by improved PHHT of maize. Medium level adopter farmers also were (6) 24% . The high- level adopters were (3)12% .The high level of adopters is very low in percentage, this evident during a focus group discussion (FGD 2) only (3) three out of the 25 were practicing PHHT. Out of the (6) six female farmers, two are not adopting any form of PHHT, three are low adopters and one medium adopter, partially adopting some technology. Both adapters and non-adopters mentioned various reason for not adopting PHHT.

Table 3: Adopter category levels

Adopter Category	**Adopter level**	**Frequency**	**Percentage**
Non adopter	0%	9	36
Low adopter	< 50%	7	28
Medium adopter	51-69%	6	24
High adopter	70-100%	3	12
Total		25	100

Source: Author (2019).

4.2 What is the awareness level of PHHT in the district?

As farmers adopt or not adopt could also have to do with the awareness level. (reference). Researcher asked the farmers if they were aware of PHHT. It was found out from the interview that farmers were all aware of PHHT so researcher asked further why not adopting. In the focus group discussion this was discussed, all the farmers (non-adopters, low adopters and medium adopters indicated that *they are aware of the innovative practices but due to their land size, cost of the technology and sometimes risk involved they are unable to adopt the new technologies.*

Another farmer with initial D.A said '' *I am aware of the technologies but when I try the improved maize variety ''agric'', I lost about half of my harvest due to insect attack. I have vowed not to plant any ''agric'' maize, our local variety is hardier, I will keep to that and safe my family from food insecurity*''.

Table 4: Illustrating the awareness level of PHHT

Adopter Category	Awareness level	Practicing/Not practicing	Percentage
Non adopter	Aware	Not practicing (9)	36 %
Low adopter	Aware	Partial Practice (7)	28%
Medium adopter	Aware	Not practicing all (4)	16%
High adopter	Aware	Practicing (5)	20%
Total		25	100%

Source: Author (2019)

Cost of Technology

Results from the interviews revealed that even though awareness levels of PHHT is high, farmers gave various reasons like cost of the technology, risks associated as the main reason and which cut across all interviews. Non adopters' farmers explained that they see the harvest of adopters as compared to theirs but have no choice than to keep to their traditional methods since the application of the improved technologies comes with additional cost which they cannot afford for now.

All category of adopters expressed the same sentiments of financial constraints, as the main reasons for not adopting all the stages of PHHT. The high adopters with initials M.D, Z.Y, and M.B corroborated their story and said had it not been the assistance from the banks they would not have been able to adopt any technology. They however said the overhead charges form the banks are quite high.

Findings from the study indicated that out of the 25 farmers interviewed, adoption levels of 9 respondents was 0%., although they are aware of the PHHT, they are not practicing it because of cost and risk involved. 7 respondents were found to be less than 50% and are low adopters, they hardly practice a technology. 6 respondents partially adopt PHHT and 3 respondents are innovators. They are adopting every stage of the PHHT. Two female respondents were found to be non-adopters, three are low adopters and one a medium level adopter, partially adopting some of the technologies.

Extension

Results from the respondents as regards the frequency of contact with the extension agent in a quarter reveals that non adopters hardly see the extension staff in three months. Low and medium adopters averagely had 5 times extension agents visit. Low and medium adopters also stated that, frequency of extension agents' visits is not encouraging and not motivational, that the technologies come with added cost and possible risks, regular visits would facilitate the implementation of this technologies with their supervision. High adopters were found out to have extension service all the time they needed their service, always available to them, this might be because of their influence and resources available to them, they extension agents tend to visit them more a low adopter bemoaned.

Knowledge: Farmers with initials D.S, D.M, A.M and A.H also said, *they are very much aware of the technologies but lack extension advice since the officer hardly come to them , that the extension officer only visits the influential farmers, a situation they feel bitter about''.*

Medium adopter with initial E.T emphasized that, '*unless extension service is efficient, effective service would elude them, because the area covered by the extension agent is wide hence his inability to reach all farmers. They need to be mobile to reach us all*" he noted.

From the findings and results obtained from interviews, it is evident that almost all categories of farmers are aware of PHHT at Afienya community, but are not knowledgeable .The adoption levels are rather very low as shown in the table 4 **.**

Table 5: illustrates source of finance, Information, Labour and Head of Household

Farmers Initial	**Category**	**Source of Income**	**Source of Info.**	**Source of labour**	**Head of Household**
D.S *	Non-Adopter	Personal	Own Source	Household	Man
K. F *	Non-Adopter	Personal	Own Source	Household	Man
J. A	Non-Adopter	Personal	Other Farmers	Household	Man
E. A	Non-Adopter	Personal	Personal	Household	Man
B. O	Non-Adopter	Relatives/ Friends	Own source	household	Man
D.M	Non-Adopter	Personal	Own Source	HH/Relatives	Man
A.M	Non-Adopter	Personal	Own Source	Household	Man
B. B	Non-Adopter	Personal	Own source	Household/Relatives	Man
O.M	Non-Adopter	Relatives/Friends	Other farmers	Household/Relatives	Man
A. G	Low Adopters	Personal	Other Farmers	Household	Man
D.D *	Low Adopters	Personal	Own Source	Household/Relatives	Man
A. S *	Low Adopters	Personal	Own Source	Household/Relatives	Man

A.H	Low Adopters	Personal	MOFA/ Own Source	Household/Relatives	Man
A. B *	Low Adopters	Personal	Own Source	Household	Man
D.A	Low Adopters	Personal	MOFA/Own	Household	Man
C.D	Low Adopters	Personal	Own Source/Others	Household/Relatives	Man
E. E	Medium Adopters	Traders	Others/MOFA	Household/Friends	Man
E. T	Medium Adopters	Traders/Personal	Other Farmers	Household/Relatives	Man
I.K	Medium Adopters	Personal	Own Source/MOFA	Hired /Household	Man
B. T	Medium Adopters	Personal/Friends	MOFA	Household/Relatives	Man
K. K *	Medium Adopters	Personal	Own source/MOFA	Household/Relatives	Man
N. P	Medium Adopters	Personal/Traders	Other Farmers	Household/Relatives	Man
M.D	High Adopters	Rural Bank/Personal	MOFA	Hired	Man
Z. Y	High Adopters	Rural Bank/Personal	MOFA/Own source	Hired	Man
M.B	High Adopters	Rural Bank/Personal	MOFA/ Own Source	Hired	Man

Source: Author (2019) * female

FGD 1 : *Photo of farmers after the plant clinic at assembly hall at Prampram*

From the interviews gathered the most important reasons indicated by the farmers for not wholly adopting although they are aware of the improved technologies were the risk involved, sex, cost of the technology, insect-pest, inadequate extension service and education and storage problems are the major problems related to adoption of improved or innovative practices of maize production in the study area. The results from the study show that all the respondents are aware of PHHT but are either practicing or not practicing all aspects of the technology.

A female farmer (non-adopter) with initial D.S said ‘’ *I wish I have my own land to do my own farm as a business , but our culture and tradition does not favour women to own such land s ,I would have been in serious maize business’’, she bemoaned .*

Most farmers interviewed said they were used to cultivating the local variety of maize, upon interaction with them, it was revealed that “the local variety provides security against huge yield losses because , it is very tolerant to harsh climatic and poor soil conditions, the farmers claimed.

Harvesting: Asked at a forum group discussion, why farmers (non-adopters, low adopters and medium adopters) mostly do not dehusk maize on the plant at harvest;

Farmer with initial D.A said ‘’*our local varieties are hardier than the ‘’agric’’ improved varieties from the extension service which is more susceptible to insect infestation and attack*’’ hence, he keeps to their normal known traditional variety.

The extension service officer in charge of the area pointed out that '' *most farm households attach a bit of importance to the traditional method , it is a tradition and heritage thing and most farmers feel they are ditching their tradition and norms to adapt an improved storage''.* For example, he cited a scenario that interest me, "he said *there is a traditional maize meal, (a delicacy called 'kenkey') which is made from fermented maize dough, by which the dough is been wrapped in dried husk of the maize before it is boiled to be ready for consumption, some farmers believe if they practiced an improved method of storage, they will lose their maize husk and will find it difficult to get access to husk to prepare their delicacy.* The officer further said ''*we have been advising farmers to store the husk separately after dehusking when switching to an improved method of storage so that it can be used for food preparation purposes but most farmer still prefer to practice the traditional harvesting method in order to have their maize husk intact to be used to prepare their local traditional delicacy ('kenkey').*

Source: Author (2019) Photo of Ghanaian local traditional delicacy Kenkey

The picture of the maize meal made from maize dough that is been wrapped in the maize husk ready to be boiled for consumption as shown above.

All the 8 female farmers collaborated the story. The female farmers affirmed that; *the husks are an additional source of income.* The husks are finely sorted, bagged and sold to women in the kenkey business, their traditional dish. The farmers claimed insect attack on the husks of local varieties are minimal than the improved varieties.

When asked how they cart or transport their harvest to their homestead; almost all the non-adopters and low adopters responded similarly, that their household and relatives assist in the activities of harvesting and carting to the homestead. Farmer with initial JA said, "*I and my family always work overtime during the land preparation and harvesting period, we leave home for the farm as early as 6am and work till 6pm in the evening, we carry harvested maize by headload".*

Only one farmer ET (medium adopter) stated that "he hired four people during harvesting and hires a truck to cart to homestead immediately since he always wanted to harvest early to prevent matured dry maize from lodging". Apart from this farmer, majority of the farmers stated that they depend on their household, friends and relatives for every farming operation due to reliability coupled with financial constraints because they don't have much to pay for labor cost and the difficulty in mobilizing

of labor. The high adopters with initials M.D, Z.Y and M.B stated that they hired labour for all their farming activities due to the size of land they crop.

Drying: Drying of maize in the study area is primarily by spreading whole ears or shelled grains on the ground to air dry after harvest. Only 5 farmers (2 low adopters farmers A.H and C.D and 3 medium adopters I.K, E.E and B.T) have the locally constructed narrow cribs which is used as drying and storage structure.

During focus group discussion, farmers were asked their methods of drying the maize and why their chosen methods. Farmer with initial A.G said '' *I normally dry my maize on tarpaulin but can be time consuming, labour intensive when is huge''.* Another farmer with initial B.O and D.D said '' *we spread -out our harvest on the bare floor to dry, we can't afford to buy tarpaulin. We lost substantial amount of maize from rains when there is sudden down pour''.*

One farmer with initial B.T stated that *"the fear of loss as results of pest and insect attack; I am forced to sell about half of my produce at the district market in November when the maize is fully dry". Another farmer with initial DM also stated that "ideally I would love to store my maize throughout the whole year so that my family will have enough maize to consume all year, but due to the occurrence of high insect infestation, the family are left with very little or nothing between the month of June-July and are force to rely on other starchy food crops such as cassava''.*

A female farmer with initial AS lamented that *''These are the major factors (risk and cost involved) that prevents me from expanding the size of my farm and could go a long way of affecting the food sufficiency of our household throughout the whole year''.* All the farmers interviewed said they dry with the sunshine. Harvested maize is spread on tarpaulin and dry in the open air. Farmers also said it is labour intensive and a threat to quantity of maize loss and the quality of maize, households must keep an eye on the drying maize because of unpredictable weather conditions, unexpected rains in that period and nuisance of domestic animals. Farmers (low adopters) with initial A.G and A.B said *''we plant only half of our land size (3 hectares) with maize for major season , we plant on a larger scale in the minor season just because we don't have tarpaulins to spread our maize for drying in the major season. In the minor season we leave our maize in the field to dry properly before harvesting''* although it comes with it associated problems.

It has been found out that most farmers interviewed do not keep maize to dry on the farm for some time now due to the demand for fresh maize which is a delicacy. According to almost all the low and medium adopters, affirmed that this new strategy is to have quick money to pay off some of their responsibilities and get money to start preparation for the minor season maize which is more productive. Farmers with initial A.S and K.K also said '' *since we don't have space and to avoid spoilage due rains, insects, pest and sometimes losses from birds, poultry and domestic livestock we had to cut large part and sell fresh''.* This indicates that the cost of production and the possible risks makes it difficult to adopt improved technologies are still practicing their indigenous methods.

Focus Group Discussion 2

Shelling; During the FGD, farmers were asked how they shell their maize for storage, all the respondents except the high adopters said ''*mostly maize kernels are shelled by using the fingers. Shelling the maize by hand sometimes takes weeks depending on the harvest. The shelling becomes painful and cause injuries to fingers when the kernels are hard to shell''*, . Farmers further said in situations when the harvest is huge shelling is commonly done by loading sacks with the maize cobs and the loaded sacks are beating with sticks. When asked whether they are aware of physical damage to the grains making the grains more vulnerable to pests and molds as result of the beatings; farmers said they are aware but have no other choice. Farmer with initial K.K said '' *simple tools developed by the engineering service department to make it possible to shell maize several times faster than by the fingers are now unavailable.* According to the farmers interviewed, some individuals are owning shellers that they render services to farmers, some operate in the act of barter trading, where they take one bag out of the total ten shelled bags. ''*But we cannot depend on them all the time because there is a long list of farmers waiting for their services, so we resort to beating the maize in sacks*'' farmers with initial O.M and E.E explained.

The farmers at the discussion stated that the use of industrial maize shellers and small-scale hand-cranked or pedal-powered maize shellers are often unaffordable or difficult to obtain by subsistence farmers. '' *Simple tools that have been developed by the engineering department of agriculture to make it possible to shell maize several times faster than by the fingers are no longer in the system,* a female farmer with initial KK lamented.

Hand shelling in rural Ghana

Locally made hand shellers@ MIT (Accessed on 29th July 2019).

Farmers were also asked, at what stage of the PHHT (harvesting, drying and shelling) is maize loss most?

Sixteen (16) respondents (non and low adopters) 64% said most losses occur during the harvesting stage through stealing or intentionally leaving maize on the fields for gleaning later. Three (3) 12% of respondents low adopters stated that most of their maize is lost through the drying process by sudden rainfalls this is as a result of them not having larger tarpaulin, nuisance from domestic animals. On shelling, six (6) 24% respondents (3 medium and 3 high adopters) said they loss maize at the shelling stage as the shellers in an attempt to shell more bags do not take time and speed up the process, maize is thus spread out wide outside the radius.

4.3 What is the cost and risk involved in PHHT?

Results from the interviews revealed that assets, vulnerability, and institutions affect or influence technology adoption. Almost all the categories of farmers focus on dimension cost of the technology to be used in terms of its affordability and associated risks. Farmer with initial A.S (low adopter) said *'' I was a big time farmer, carries out all the innovative practices but due to rising cost of production, uncertainties of the rains, landlords disturbance I failed on two consecutive season, I am now bankrupt''* he lamented. Awareness level is high, but adoption levels vary greatly. A medium adopter farmer with initial E.T lamented that '' *chiefs and landlords are selling productive lands to estate developers. Our farmlands are continuously reducing, meanwhile cost of production and postharvest management technologies come with a cost so they have no choice than to keep to their traditional methods sometimes* ''.

According to Muzari (2012), technology adoption depends on whether farmers have the requisite physical (material) and abstract possessions (education). A lack of assets or possessions will limit

technology adoption (Meinzen-Dick et al., 2004) Browning, Halcli and Webster (2001: 1) states that people calculate the likely cost and benefits of any action before deciding what to do like the using of a given post-harvest technology. Vulnerability factors deal with the effects of technologies on the level of exposure of farmers to economic and social risks. Those technologies that have a lower risk have a greater appeal to smallholder farmers who are naturally risk averse and highlights that decision making of choosing a given post-harvest technology to use depends on the risks and uncertainties involved (Meinzen-Dick et al.,2004). This answers the third and fourth questions of the possible cost and risks involved in adopting a given technology.

Based on the field study, farmers need to be motivated by the frequency of extension agents visits to follow extension agent advisory service, training, and awareness to scaling up a wider area of improved maize PHHT for all smallholder maize growers in to study area. This result is consistent with the finding of (Rehman et al., 2016) at Bangladesh

Table 6: illustrates Sex, land size, level of education, contact with Extension Agent per month

Adopter Category	**Sex**			**Land size**	**Level of education**	**Contact with ext. officer/quarter**
	M	**F**	**Total**			
Non-Adopters	4	2	6	<5	Basic	once
Low Adopters	2	2	4	5-10	Basic	4 times
Medium Adopters	10	2	12	10-15	MSLC	6 times
High Adopters	3	0	3	>30	Diploma	Always available
Total	19	6	**25**			

Source: Own source (2019)

Chapter 5: Discussion

Based on the findings which are presented in chapter four this chapter discusses all themes mentioned in chapter four in line with the research questions.

5.1 Sex of Household Head (SEX)

All the 25 smallholder farmers are male-headed households. Sex of household head, i.e., being male-headed household has a positive and significant relationship with the probability of adoption of improved maize variety. Out of the 25 farmers interviewed (6) 24% were women. Casual observation suggests that roughly the same number as men work in the maize fields in Afienya community, so at first glance the number of women farmers in the same sample seems rather low. However, the relatively low proportion of women farmers probably stems from the fact that in the district, women do not enjoy independent access to land and other resources equal to that of men, so many women end up working in the field of their husbands or male relatives. Interview with the 8 female respondents revealed that their land holdings are less than 5 acres. The females remarked that they must assist their husbands to finish with their activities on the land of their husbands before they can cultivate their land with vegetables . Female farmer with initial KF said '' *Our husbands are poor with little or no education and have less land. I don't know but we rarely have extension service, we have no new knowledge, we observe what our neighbours or other farmers do. We sometimes copy wrongly and fail in our attempts to adopt.* Another female farmer with initial DS said '' *I wish to have my land to do my own farm for my business, but our culture and tradition does not favor women to own land, I would have been in maize business serious''.* The positive sign implies that male-headed households tend to adopt the varieties more than their female counterparts. This may be due to relatively better access of male-headed households to information and agricultural resources than females' household heads. The result is in line with the finding of similar studies (Isaiah et al, 2013).

5.2 Education Level of Small-holder farmers.

As expected, education level of household head has a positive and significant relationship with the probability of adoption of improved maize. It has been observed during interview with farmers that all the non-adopters and low adopters had only primary education and have land holdings less than 10 acres. However, their indigenous knowledge is intact, they will not abandon, they keep to their tradition and norms. The high adopters have moderate education and keeps record of all their farming activities. It is evidence in their approach to practices. They have a higher frequency of contact with extension service than other adopters. This implies that the educated farmers are more likely to adopt improve maize variety than those who are not educated. This may be due to relatively educated farmers have more access to information and they become aware of new technology, and this awareness enhances the adoption of technologies at any cost. Rugumamu (2012:73) argued out that lack of education and specialized training in the post-harvest component of the crop management cycle and lack of lead farmer with a coordinator hinders rapid and efficient transfer of appropriate technologies.

5.4 Livestock Holding

As expected, the variable has a positive and significant relationship with the probability of adoption of improved post-harvest handling technology. The study revealed that high adopters also have large stock of livestock (cattle and small livestock sheep and goats) and poultry. The medium adopters keep local poultry some sheep and goats. Those who have cattle regardtheir livestock holdings as prestige in the community and would hardly sale for farming activities. This implies that a farmer who has number livestock will be more likely to adopt improved maize variety. This may be due to relatively having more livestock offer a means for a better propensity to hire labour and are more entrepreneur. also, farmers who have many livestock might consider their asset base as a mechanism of ensuring any risk associated with the adoption of improved PHHT and management practices.

5.6 Use or Access to Credit (Credit)

There is a major problem associated with the finance of agricultural activities in Ghana especially when it comes to subsistence farmers. Banks find it difficult to assess the ability of subsistence farmers to repay credits because bankers find it very difficult to ascertain the personal integrity of most subsistence farmers. There are two main forms of credit or finance detected in the study area. They are formal/institutional and informal/ non-institutional source of credit where finance is been outsourced by farmers. Both types of credit source play a major role in the finance of agriculture, particularly just at the beginning of every growing season. However, the informal source has been the most outsourced and reliable finance facility that has gone a long way in assisting subsistence farmers as I observed from the study. Table 4 above illustrates the sources of finance for subsistence farmers interviewed , from the table, institutional source of credits were outsourced from banks while non-institutional credit was provided by traders (traders who buy the maize directly from farmer, transport it to the city and sell), friends and relatives. From the study, formal credit source accounted for 18.75% while the informal finance source (relatives, friends, personal finance and traders) accounted for 81.25%. The inability of these subsistence farmers to increase their production and implement an improved postharvest handling method is as result of poor access to loan or credit, this meant that subsistence farmers who wished to switch to the improved method of stored (which gives good protection to stored maize and reduce harvest loss) had no choice than to adapt the traditional method choice due to financial constraint. Administration procedures from banks deter subsistence farmers from seeking credit since loans from banks are not granted at the time they are needed most. (Ref. collaterals) Farmers are also asked by banks to provide collateral security which most farmer do not really have, thereby been refused the loans out right. On the other hand, farmers who are granted the loan are always given lesser than the money they requested and do not manage to meet their budget for most farming seasons.

Due to this, subsistence farmers prefer to finance their farming and storage activities through their own source of income or to obtain credit from friends/relatives and traders as interest rate for such credits are lower than that of the bank. Credits from close friends and relatives are at times given to farmers at interest free. The lack of collateral demand, nearness of the farmer to the informal credit source, the flexibility of repayment, apparently no transaction cost may be the reasons for the high usage of the informal finance source. It was found that most subsistence farmers greatly relied on their personal savings to finance their farming post-harvest handling activities due to the bureaucracies in the banks. About 56.25% of the farmers financed their farming and storage activities personally. The lifeline for most farmers in financing their farming at the beginning of each growing season is by personal means. Most subsistence farmer interviewed had a backyard livestock or domestic poultry which normally is sold to help supplement their source of capital to keep their

households. The proceeds gained or obtained from the sales of the poultry or livestock are used in situations where farmers fail to acquire credit at the beginning of a farming season.

Credits taken by subsistence farmers from informal source are granted based on agreed contract that are verbal with witness or written. This depends on the level of intimacy between the lender and the farmer. The period of payment for such credits is short with about 12.25% acquiring credits from relatives and friends. Some subsistence farmers opted to acquire credit from traders as this accounted for 12.25%. It was noted that some traders did not always give cash instantly to subsistence farmers but rather supply them with farming inputs at the beginning of the farming season. The financial constraints encountered by farmers is as a result of inadequate capital of credit facility to support farming and storage activities lead to the construction of poor storage structures as well as non-treatment of maize due to high cost involved. This leads to increase in the quantity of maize loss incurred by farm household because if farmer happens to be financially sound, they will manage to afford to construct good and efficient storage structure which will give good protection to stored maize and reduce the quantity of maize loss in these farm households.

The unavailability of credit is a big setback in the quest for farmers to reduce postharvest loss of maize because they are not able to implement an improved PHHT method. This causes farmers loose higher magnitude of their maize during harvesting, drying and shelling stages. For example, a farmer with initial DA testified about losing almost a quarter of maize he stored leaving him almost nothing to feed on as early as April, therefore the only choice he had was to rely on what he borrowed from his brother in-law till he grew and harvested new maize. The losses incurred by farm households at harvest, drying and shelling and at storage level push them further down to the brink of being food insecure and this could be reduced if farmers secure better source of finance for their farming activities and implement an improved PHHT method each year.

Use of access to credit also had positively and significantly influenced on the likelihood of adoption of improved PHHT significance level. From this result it can be stated that those farmers who have access to formal credit from Dangbe Rural Bank at Prampram and other micro finance institutions in the district are more likely to adopt improved maize technology than those who have no access to formal credit. Farmers NP, MD and ZY all high adopters explained that the size of their activities is due to their access to credit from the banks. Earlier study also reveals that credit is one of factors that affect the probability of adoption of improved maize variety (Sisaye, 2016) also reported that use of credit correlate positively with the adoption of improved technologies by farmers.

5.7 Contact with Extension Agents as a source of Information

The number of contacts with extension agents per month had significant positive effects on the adoption of PHHT of maize at significance level. Therefore, respondents who highly contact with extension agents per month have more chance to adopt the improved maize variety in the area. The result obtained from key informant interview revealed that farmers who gets contact with extension officers are better informed on improved PHHT, their knowledge and skills on farming practices are improved and practice innovative and improved PHHT mostly the high adopters. This agreed with receiving training and advice from extension agents and the perceived usefulness of extension agents' advice are major factors that explain the likelihood of technology adoption. This result is consistent with other studies (Agidew and Amanuel, 2017) found a similar result.

Information on postharvest handling of maize plays vital role in the reduction of harvest loss but inadequate information on postharvest maize handling available to subsistence or smallholder farmers result in improper handling of the maize each farming season. The same mistakes are being repeated by farmers which lead to substantial quantity and quality of maize loss. Ideally the extension

service officers are responsible for the dissemination of information on postharvest handling to farmers, but it was noted that the extension officers are overstretched. From the subsistence farmers AA, CD EE and BT's point of view, *it is the cash crops (influential) farmers who receive most of the attention of the extension officers whiles they do not get the chance to meet them more often because we are poorly resourced.* The researcher noticed that subsistence farmers do not receive information easily from the extension officers and even the ones they receive is not readily adaptable, this information need to be explained for adoption, since it attracts extra cost of storage a farmer lamented. The study took into consideration the source of information or extension services on postharvest handling that were available to farmers. From the study 72% of the respondents (subsistence farmers interviewed) received information on postharvest handling of maize from relatives and other farmers. It was found out that, officers from the Ministry of Agriculture or extension service workers were not contributing enough in terms of the dissemination of information on postharvest handling of maize to farmers because only 28% of the respondent assessed information from this source. This indicates that information on improved postharvest handling of maize and new technologies were limited which encouraged farmers to be over reliant on the traditional methods of harvesting drying and shelling. But these traditional methods have some deficiencies associated with it that lead to high quantity of maize loss which in a long run affects the food security status of most households.

5.8 Participation on Demonstration (Demon)

Participation on demonstration had positively and significantly influenced the probability of adoption of improved PHHT at a level. Farmers who have an opportunity to participate on demonstration of improved maize variety are more likely to use improved PHHT maize than those farmers who have no similar opportunity. Farmers with initials CD and KK told me that '' *we are at an advantage since we gave part of our plots for demonstration, we are always invited to participate in demonstrations. We have learnt a lot from the practices''.* Other things held constant, participation in demonstration implies that, as farmers' exposure to agricultural information increases Similar results were identified by (Abdi. et al., 2015) found a similar result.

5.9 Reflections as a researcher

This study has granted me the opportunity to gain experience in conducting research and reflect on myself as a professional and a researcher. I was very enthusiastic about the topic for study; Adoption of Post-harvest technologies and its effects on smallholder farmers. The topic of the research had as its focus the engagement of farmers .Throughout my preparations to conduct this research from the formulation of the initial research questions to the drafting of the focus group discussion protocol, my positionality as a researcher studying issues of postharvest handling technologies remained at the forefront of my mind. I have come to understand that research is a process and continues as I reflect on the development of an idea; on data collection; on findings, and; on implications. My reflections on my research projects have led me to consider the interaction between myself and the participants who were kind enough to share their time and thoughts with me.

Methodology; For the purposes of the study, focus groups were used as the primary means of data collection. Individual interviews supplemented focus group data, and observational data was collected by the researcher to further supplement the focus group and interview data. Each of these data collection tools provided opportunities to gain insights about the experiences of the farmers Focus groups were chosen as the primary means of data collection because the data that comes from group interactions might not otherwise be collected (Stewart, Shamdasani, & Rook, 2007). Focus groups and individual interviews were digitally recorded and followed a semi structure protocol. Open-ended questions were asked to provide participants with the most opportunities to tell their stories and to

encourage their own voices to come through in the data. Through the course of each focus group and individual interview, follow-up questions were asked based upon statements made by participants.

The analysis is thematic in content, based on the findings, there are so many ideas arising which were raised by the respondents and selecting which data to choose and which to reject is so tricky. I used the strategy of taking ideas which have been repeatedly raised by most of the respondents but also another approach was to find if a new idea are coming up and take them. But all those ideas must answer the research questions.

During the focal group discussion, it was revealing, interesting and intriguing for me to know that maize husks are additional source of income for women, when I asked why the maize is not dehusk in the field before storage to reduce insect infestation. All the female respondents said ‘*’the husks are additional source of income. if we dehusk in the field we would not get the husks for our traditional meal (kenkey)''.* The husks are finely sorted, bagged and sold to women in the kenkey business their traditional food. I enjoy the meal very much, but I have never thought of how the meal is prepared. Now I know why maize is not dehusked before harvesting. It is an eye opener for me as aresearcher.

The research brought a new experience professional wise and academically due to its challenges throughout the research process. As a researcher, time management matters a lot. When I look back, I realized that all those challenges equipped me with confidence and widened my horizon of my thinking in research and academic writing skills in general. It was also a steppingstone towards doing a better and more research in the future.

Chapter 6: Conclusion

Results of the study reveals that all the adopter categories express the feeling that they are very much aware of the post-harvest handling technologies. Awareness levels are high, but the implementation of the technologies needs much to be desired. Farmers gave various reasons such as the additional cost of the technology and perceived risks as some of the reasons for not adopting although they are aware of the technologies. This answers the first sub question of what the awareness level of PHHT is.

What is the adoption level of adoption of PHHT in the district? Out of the 25 respondents' farmers, (64%) were adopters and (36%) were non-adopters of improved PHHT as shown in the table above. The 36% comprise of (9) nine farmers not adopting any of the practices at all. The low adopters (7) seven famers 28% are practicing some aspects like timely harvesting, (6) six 24% partially adopts but sometimes goes their traditional way. Only (3) three thus 12% fully adopts and practices PHHT. The studies show that high-level adopters are very low in percentage. Researched showed that this might be that the high adopters have more resources to access other assets as compared to the other category of farmers. The high adopters were perceived to be influential and very entrepreneurial. It is also evident that contacts with extension agents per quarter is rather very low per the farmer and does not motivate the farmers to improve on their methods and therefore feel reluctant in implementing the improve technologies. The non-adopting farmers feel that the given technology without supervision. or extension service delivery is ineffective.

The third and fourth questions are inter-linked, what is the cost of PHHT and the perceived risks of the technology? All the respondents mentioned the cost and risks involved in the adoption of the technologies is high, hence their reluctance in adopting although they are aware of the innovations. Browning, Halcli and Webster (2001:1) states that people calculate the likely cost and benefits of any action before deciding what to do like the usage of a given post-harvest technology. All the farmers interacted with in various ways express vulnerability factors to deal with, their level of exposure to economic and social risks. It is also evident that the smallholder farmers would only adopt technologies that have a lower risk and a greater appeal to them who are naturally risk averse. Decision making of choosing a given post-harvest technology to use depends on the risk and uncertainties involved.

To answer the main question of *what the factors are influencing the adoption of PHHT among small holder farmers at Afienya*, from a discrete variable, education, sex, use of credit, extension agent contact, attending training, access to information, conducting demonstration and farmer's attitude, were found to have significant relation with adoption of improved PHHT of maize at Afienya.

Sex of the household head was found to be positively and significantly, influencing adoption decision of improved PHHT of maize. This implies male-headed households were more adopting improved PHHT of maize than female-headed households because female-headed households have less access to improved technologies, land and information revealed, than a male-headed household that helps for the adoption of improved PHHT of maize.

Education was found to be positively and significantly influencing farmer's adoption decision of improved PHHT of maize. The diffusion of the technology could, thus, be facilitated by educated farmers to be used as contact farmers, besides improving farmers' level of education.

Use of credit was also found to have a positive and significant effect on the adoption improved maize variety implying that farmers who don't have cash and access to credit may find it very difficult to

adopt new technologies while those who have access to credit can overcome their constraints and be able to buy inputs ,hired labour and expand their farm size.

Contact with extension agents has a positive and significant effect on the adoption improved PHHT of maize .The information obtained from key informants interview revealed that, farmers' who had regular contact with extension agents are advised and had trainings from agricultural extension agents by attending training initiated; improved their knowledge and skills on farming practices and improved farmers' utilization of improved PHHT of maize.

Recommendations to NGO

Based on the above conclusion the following recommendations is forwarded: -

- There is the need for the NGO to continue to collaborate with the extension service of the ministry of agriculture in the district to intensify their activities to educate farmers on the impact of PHHT in reducing maize loss.
- That the organization at least organizes training sections or forum twice every farming season to get farmers abreast with PHHT and get motivated. When farmers become abreast with the implementation of the various techniques involved with the improved postharvest handling or operations associated with maize production, then postharvest loss of maize will be ideally reduced.
- Agricultural extension services, NGOs, and private sectors should give special attention for women farmers in interventions of new technologies because women are at the forefront of all agricultural activities from sowing to the final consumer. Equipping them with the needed knowledge will motivate and enhance their output. .
- For farmers to overcome some of the constraints involved in the postharvest handling of maize, it is suggested that they form co-operatives which will obtain institutional loan as a group to purchase necessary inputs to be use by its members. Because it would facilitate the adoption of improve technologies in the study area.
- That the engineering department of the ministry of agriculture should reintroduce the production of simple tools for shelling maize.
- The NGO should continue their efforts in encouraging smallholder farmers to adopt PHHT, especially to farmers who are still glued to their traditional or local methods of harvesting, drying and shelling, this will help increase their farm income thereby enhancing their household welfare.
- Based on the results of this study further researches can be performed in the future in order to improve maize productivity in the study area.

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