ANALYSIS OF FARMERS' PERCEPTIONS AND ADOPTION BEHAVIOUR TOWARDS IMPROVED MAIZE TECHNOLOGY AMONG MAIZE FARMERS IN THE BAWKU WEST DISTRICT OF THE UPPER EAST REGION

BY

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THIS THESIS IS SUBMITTED TO THE UNIVERSITY FOR DEVELOPMENT STUDIES IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTERS OF PHILOSOPHY IN INNOVATION COMMUNICATION

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DECLARATION

I, John Abugri Akumbole, declare that with exceptions of various forms of assistance and references to literature which has been duly cited and well acknowledged, the work presented in this thesis entitled “analysis of farmers’ perceptions and adoption behaviour towards improved maize technology among maize farmers in the Bawku West District of the Upper East Region,” was done by me in the Department of Agricultural Extension, Rural Development and Gender Studies of the University for Development Studies, Nyankpala Campus, Tamale from 2014 to 2017. I further declare that this thesis, in whole or part, has never been presented in this University for the award of any degree or elsewhere in the world.

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This thesis has been submitted for examination with our approval as supervisors.

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ABSTRACT

As part of the National agricultural modernization agenda, through the promotion of technology driven agriculture, efforts of research and development had over several decades now been concentrated on developing and disseminating improved technologies and best agricultural practices to farmers with little success. Maize, being the major cereal crop in the country, several projects have been implemented to develop the maize sub-sector. However, these efforts have not achieved the commensurate results with low technology adoption and poor yields still being the main problem in the maize sub-sector. In finding answers to the problem, this research analysed farmers' perceptions and adoption behaviour towards improved maize technologies among maize farmers in the Bawku West District. Exploratory survey design was employed with multi-stage sampling techniques adopted in selecting four hundred (400) maize farmers using Cochran's sample size determination formula, interviewed for this study. Also concerned staff and operational managers of NGOs working to improve Agriculture in the District were interviewed. Interview, questionnaire, observations and focus group discussions were the main methods employed in data collection. Also Q – methodological process was employed in gathering narratives and farmers' concourse on improved maize technologies. Descriptive statistics, Probit regression, Analysis of Variance and factor analysis were applied to analyze the data hence the various research questions. Results of the study revealed that out of the fifteen production recommendations, majority of farmers adopt many of these production recommendations within the improved maize technology and six factor solutions as the underlying constructs characterizing farmers' perceptions towards improved maize technologies. Also the probit regression analysis identified nine (9) variables as significant determinants regarding farmers' level of adoption of improved maize technology. The study also found significant relationship between level of adoption and yield of maize. High cost of inputs was ranked the top most constraint to farmers' ability to adopt the improved maize technology. While incompatibility, complex nature of the technology and poor access to information were ranked 2nd, 3rd and 4th top most constraints to the adoption of the improved maize technology respectively. The study recommended that farmer education on improved maize technologies should be intensified and facilitated to get access to information, inputs to promote adoption of improved maize technologies.

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DEDICATION

This Thesis is dedicated to my Father Mr. Akumbole Ayariga of blessed memory and Mother Asumai Akumbole, my siblings; Yaw, Mathew, Robert, Thomas and above all God Almighty for His grace and aspiration.

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ACRONYMS

ADDRO	Anglican Diocesan Development Organization
ADVANCE	Agricultural and Value Chain Enhancement Programme
AEAs	Agricultural Extension Agents
ANOVA	Analysis of Variance
CIMMYT	International Maize and Wheat Improvement Centre
CODI	Community Development Initiative
CRI	Crop Research Institute
CSIR	Council for Scientific and Industrial Research
DT	Drought Tolerant
EFA	Exploratory Factor Analysis
FASDEP	Agriculture and Food Sector Development Policy
FBOs	Farmer Based Organizations
FCDP	Food Crops Development Project
GDP	Gross Domestic Product
GGDP	Ghana Grains Development Project
GIS	Geographical Information System
GoG	Government of Ghana
GPRS	Ghana Poverty Reduction Strategy
GSGDA	Ghana Shared Growth and Development Agenda

GSOP	Ghana Social Opportunities Project
GSS	Ghana Statistical Service
IFPRI	International Food Policy Research Institute
IITA	International Institute of Tropical Agriculture
ISSER	Institute for Social Statistical and Economic Research
JSDF	Japan Social Development Fund
KMO	Kaiser-Meyer-Oklin
M	Mean Score
METASIP	Medium Term Agriculture Sector Investment Plan
MOFA	Ministry of Food and Agriculture
NADMO	Natural Disaster Management
NGOs	Non-Governmental Organizations
NPK	Nitrogen Phosphorus Potassium
NRGP	Northern Rural Growth Programme
OPV	Opened Pollinated Varieties
QPM	Quality Protein Maize
R & D	Research and Development
RTIMP	Tuber Improvement and Marketing Programme
RUT	Random Utility Theory
SD	Standard Deviation

SPRING	Strengthening Partnership, Results and Innovation in Nutrition Globally
SPSS	Statistical Package for Social Sciences
TAM	Technology Acceptance Model
TPB	Theory of Planned Behaviour
TORA	Theory of Reasoned Action
USAID	United States Agency for International Development
UTAUT	Unified Theory of Acceptance and Use of Technology
WFP	World Food Programme
WVG	World Vision Ghana

CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

This section presents background to the study concepts, research questions and objectives set up to guide the study, problem statement and justification of the study.

History is awash with evidence to the fact that agriculture and economic development are intricately linked. It has been aptly argued and empirically demonstrated that no country has ever sustained rapid economic productivity without first solving the problem of food insecurity and nutritional challenge of her populates (Timmer, 2002; Juma, 2015). Juma, (2015) asserts that evidence from industrialized countries, as well as countries that are rapidly developing, amply demonstrates that agriculture stimulates growth in other sectors and supports overall economic development and general well-being of people.

At early stage of any country's development, agriculture was the main driver of progress, producing food and fibre for the people as well as providing source of employment for majority of her citizens.

Evidence as outlined in Hazell, Poulton, Wiggins, & Dorward, (2007) and Timmer (2014) as cited in Abate et al (2016) suggests that in most countries, sustained agricultural growth in the early stages of development was central to rapid economic growth and poverty reduction. This phenomenon has been the case for the development of even the European industrialized countries and North America, as well as the emerging Asian countries like Japan (Lains&Pinella, 2010 and Timmer, 2014 as cited in Abate et al, 2016). Also Abate et al, (2016) citing available literature (Fan, Xing,Fang, & Zhang, 2006; Mendola, 2007; Rashid, Cummings,& Gulati, 2007) pointed out to the most recent example of the Green Revolution in Asia, where the introduction of improved farm technologies led to an increase in agricultural production, which helped fuel overall economic growth, reduce poverty, and improve the livelihoods of rural households.

It is a common knowledge that agricultural development and farm productivity have largely been driven by advances in science and technology which had helped generate better understanding of crops and animals leading to breeding of high yielding, disease and pest resistance varieties of crops and better performing livestock (Abate *et al*, 2016). The green revolution in Europe and some part of Asia occasioned as a result of breeding and release of high yielding varieties of staple crops such as wheat and rice, coupled with institutional reforms to support agricultural development have aptly demonstrated the significant role advances in science and technology play in agricultural development (Abate et al, 2016; Fan, Xing, Fang, & Zhang, 2006; Mendola, 2007; Rashid, Cummings,& Gulati, 2007).

However, Abate et al, (2016) observed that this development is yet to manifest in many African countries, especially in countries south of the Sahara. Although modern technologies—such as improved seeds, fertilizer, and agro-chemicals—are readily available, their rates of adoption have been the lowest in Africa (De Janvry & Sadoulet, 2010; Jayne & Rashid, 2013 as cited in Abate et al, 2016). Currently, the continent has the largest yield gaps (i.e., the difference between possible and actual yields) in major cereals such as rice and maize.

Ghana has expressed Agricultural Food sector policy interventions for leveraging on agricultural growth for overall national development (FASDEP I & II, GPRS I & II and GSGDA).As a result, agricultural sector in Ghana is widely regarded as an important engine of growth and pathway out of poverty. In the national development agenda, agriculture is expected to lead the growth and structural transformation of the economy and maximize the benefits of accelerated growth (MOFA, 2010; 2015).As a results successful governments have implemented series of projects aimed at agricultural modernization and sustainable agricultural production. Promotion of technology based agricultural production propelled by research and development (R & D) and vigorous extension activities have long been implemented to facilitate adoption of improved farming technologies and practices.

However, the sector is underperforming in recent times. The sector had witnessed consistent decline in its contribution to national GDP within the last decade. The sector's contribution to national GDP dropped from 31% in 2008 to just 20.1% in 2016, with growth rate falling from 7.4 to 3.6 within the same period (GSS, 2012 and GOG, 2017), registering average annual growth rate of 4.1compare with 6% annual growth rate envisaged in the METASIP. These have been largely attributed to low technology adoption, high cost of agricultural inputs, particularly agrochemical and machineries (MOFA, 2010). This led to re-introduction of agricultural subsidy in 2008 with particular focus on chemicals to increase use of fertilizer in line of the Abuja declaration. As part of the national food security strategy, some efforts are being made to improve the production and productivity of major staples such as maize, rice and cassava which are widely cultivated and consumed in the country (MOFA 2010; MOFA 2012; MOFA, 2015).

Maize is the most important staple crop in Ghana and accounts for more than 50 percent of total cereal production in the country. It is the second most important crop in the country after cocoa. The bulk of maize produced goes into food consumption and it is certainly the most important crop for food security (Ofori, Opare, Lartey and Agyei-Ohemeng, 2015). The maize sub-sector in Ghana has witnessed the implementation of many projects and research activities aimed at improving maize production and productivity. Notable among them are the Ghana Grains Development Project (GGDP) and the Sasakawa Global 2000 maize improvement programme. The GGDP was the last large long-term programme focusing on the maize sector development (IFPRI, 2013 and Morris, Tripp and Dankyi, 1998).

1.2 Problem Statement

Agriculture in Ghana is largely a rural based economic activity and mainly undertaken by smallholder farmers deploying rudimentary technologies and tools in managing and operating largely subsistence cropping and rearing of domestic animal to produce about 80% of the country's agriculture products (MOFA, 2010, 2012; and GSS, 2015). Agricultural sector's contribution to Ghana Gross Domestic Product (GDP) have witnessed consistent decline in recent times, dropping from 31.8% in 2009 to just 19.9% in 2014 (GSS, 2015). Similar trends have been observed regarding agricultural sector's growth rate, showing a steady declined from 7.2 in 2009 to 5.2 as reported in Ghana Statistical Service's revised version of 2014 GDP. This phenomenon is worrying considering the fact that agriculture still remains the largest source of employment in Ghana (MOFA, 2010) and it is expected to play a critical role in poverty reduction and generation of worth.

Low technology adoption by smallholder farmers coupled with low level of investment into the agricultural sector as well as undeveloped agricultural market and commodity value chain system have been largely blamed for the general stagnation and low productivity for which Ghana's agricultural sector has being experiencing (MOFA, 2010 and ISSER, 2012).As observed by Kwadzo, Ansah, Kornu and Amegashie (2010), agricultural research has produced various technological packages for farmers to increase their productivity and profitability. Evidence available seems to suggest that adoption of these technologies among smallholders is limited.

As a result of low technology adoption and lack of modernization of agricultural production, there are wide yield gaps between actual yields and attainable yields of many major crops particularly maize production in Ghana. As observed by IFPRI (2013) and also cited in MOFA (2011), yields are generally less than half of economically attainable yields for staple crops such as maize and rice. For example, national average yields range between 1.7 metric tons/hectare and 2.5 tons/hectare for maize and rice respectively (MOFA 2009–2011); however, data from different on-station and on-farm trials suggest that yield averages of 4 to 6 tons/hectare for maize and 6 to 8 tons/hectare for paddy rice are achievable (IFPRI, 2013). This huge yield gap can be bridged through adoption of improved technologies.

Ministry of Food and Agriculture through its Extension Directorate have been promoting the adoption of improved maize technologies ranges from use of improved seeds, best agronomic practices, use of fertilizer and post-harvest management for many years now. This notwithstanding, many studies still identified the cause of low productivity of maize, which enjoys wide cultivation in the country, as low adoption of productivity-enhancing technologies, including improved varieties, management practices and low use of purchased inputs, especially fertilizer (IFPRI, 2014, MOFA, 2010 and MOFA, 2013).

Rogers (1983), asserted that one reason why there is so much interest in the diffusion of innovations is because getting a new idea adopted, even when it has obvious advantages, is often very difficult, in spite of the fact that there is a wide gap in many fields, between what is known and what is actually put into use. Some studies have examined technology adoption and its impacts on maize productivity (Bechdol, 2012, Dalton and Guei 2003, Horna and Nagarajan 2010). However, those studies have concentrated largely on impacts of technology adoption on farm productivity without examining the factors accounting for the low technology adoption by maize farmers.

Empirical studies on agricultural technology adoption suggest that factors such as socio-economic characteristics of farmers, access to credit or cash resources and information from extension and other media significantly influence adoption rate of new agricultural technologies among farmers (Ayinde et al., 2010; Zakaria, 2014and Idrisa et al., 2012).These studies have focused on agricultural technology adoption in general and not only maize technologies.

Also, those studies employed quantitative methodologies which often failed to capture farmers' narratives on why they are not adopting the improved maize technologies. In such studies farmers' perceptions and attitudes are often ignored and measurable and observed quantities such as farms size and cost of inputs are often projected.

However, in Davis (1986), Technology Acceptance Model (TAM), Fishbein and Ajzen (1975) Theory of Reasoned Action (TRA) Roger's (1995, 1991 and 1983) innovation diffusion model and Ajzen (1991) Theory of Planned Behaviour (TPB) all emphasised on the significant influence of perceptions and attitudes on technology adoption.

In spite of an intrinsic link between perception, attitudes and beliefs on technology adoption, many conventional studies on technology adoption seem to focus much on socioeconomic and farmers characteristics (Seline, 2015). Knowledge, attitudes and perceptions in relation to the benefits and challenges of the technology play a key role in the decision to adopt. It is therefore imperatives that holistic study on technology adoption should consider the conventionally variables such as farmer characteristics and economic variables in addition to the perceptions, attitudes and beliefs individual holds towards the technology to inform decision-making process and shape existing models focusing on extrinsic factors.

However, very few studies (Asiedu – Darko, 2014, Adam, Zakaria and Abujaja, 2014 and Zakaria, 2015) examined the effect of farmers' perception, attitude and beliefs towards a technology in addition to farmer and economic variables on the adoption of the said technology. It is therefore clear that there exist an apparent knowledge gap regarding how farmers' perceptions and attitudes affect technology adoption.

This study was therefore conducted to examine farmers' perception and attitudes towards adoption of improved maize technologies among maize farmers in the Bawku West District of the Upper East region of Ghana. This study sought to presents empirical evidence on farmers' perceptions and attitudes towards improved maize technologies and its effect on technology adoption with the view of contribution to the debate on technology adoption and diffusion.

1.3 Research Questions

The main research question is 'what are the effects of farmers perceptions and attitudes toward Improved Maize Technologies and their adoption among smallholder farmers of the Bawku West District'. The study is aimed at examining the following specific research questions:

1. What perceptions and attitude do maize farmers in the Bawku West District hold towards improved maize technologies?
2. What is the level of adoption of improved maize technologies among maize farmers in the Bawku West District?
3. What factors determine the adoption of improved maize technologies among maize farmers in the Bawku West District?
4. How do levels of adoption of improved maize technologies affect yield of maize among maize farmers in the Bawku West District?
5. What are the constraints to adoption of improved maize technologies among maize farmers in the Bawku West District?

1.4 Research Objective

The main objective guiding this study is to examine the effect of farmers' perceptions and attitude towards improved maize technologies on their adoption of such technologies.

Specific objectives are:

1. to analyse farmers' perception and attitude towards improved maize technologies among maize farmers in the Bawku West District
2. to examine the level of adoption of improved maize technologies among maize farmers in the Bawku West District
3. to analyse the determinants of adoption of improved maize technologies among maize farmers in the Bawku West District
4. to examine the effect of farmers' level of adoption of improved maize technologies on yield of maize among maize farmers in the Bawku West District
5. to examine constraints to adoption of improved maize technologies among maize farmers in the Bawku West District

1.5 Justification

The Ministry of food and agriculture (MOFA), through its extension directorate had over several decades been disseminating information on improved maize technologies and good farming practices to facilitate their adoption among farmers with little success. Low technology and the use of rudimentary production tools and techniques still characterised maize production in Ghana. As a result maize yields are still far lower than the potential,inspite of the fact that maize is widely cultivated in the country.

To achieve national agenda of modernizing agriculture, there is the need to step up technology adoption in agricultural production and making farming a technology driven enterprise. This can be achieved through promotion of technology adoption among farmers by facilitating their access to information and eliminating inherent barriers and constraints to technology adoption.

To facilitate technology adoption, policy makers and implementers should have clearer understanding of factors affecting technology adoption among farmers and the challenges and constraints facing farmers in accessing and adopting technologies. Such understanding should be borne out of empirical assessment of farmers' situation, their perceptions and attitudes towards technologies being disseminated to them. As such findings of this study which sought to examine farmers' perceptions and adoption of improved maize technologies is very important and handy as it presents information on how farmers think about the available maize technologies and how these views influence their adoption decision.

It will provide useful information to help guide policy formulation and implementation strategies aimed at improving adoption of improved technologies among maize farmers. It will also expand the debate on influence of perception and attitudes on technology adoption.

1.6 Theoretical and conceptual Framework

Understanding farmers' technology adoption behaviour is imperative in developing and designing suitable innovation dissemination methods aimed at facilitating farmers' technology adoption process to agricultural productivity. Agricultural technology adoption study has many policy implications in agricultural development.

It serves as a tool for evaluating the distributional impacts of new innovations, for documenting the impact of an innovation or extension effort, for identifying and recommending measures for reducing constraints to adoption, and as a research guide to focussing innovation priority (Doss, 2003; Langyintuo &Mungoma, 2008; as cited in Fadare , Akerele and Toritseju 2014).

This section presents an overview of theoretical and conceptual frameworks upon which the concepts, issues and variables used in this study draw their bases.

1.6.1 Theoretical framework

Theoretically, many models and theories have postulated some understanding of technology adoption or acceptance behaviour. One of the well-known models related to technology acceptance and use is the technology acceptance model (TAM), originally proposed by Davis in 1986. TAM has proven to be a theoretical model in helping to explain and predict user behaviour of information technology (Legris, Ingham, &Collerette, 2003). Rogers (2003) classified factors influencing technology diffusion as innovation attributes such as relative advantage, compatibility of the innovation, innovation complexity, observability and triability of the innovation; attributes of characteristics of end users and institutional framework promoting and disseminating the innovation.

TAM has proven to be a theoretical model in helping to explain and predict innovation adoption behaviour of prospective users (Legriset e'tal, 2003). TAM is considered an influential extension of Theory of Reasoned Action (TRA) proposed by Ajzen and Fishbein (1980) which postulates that individual technology adoption intention is significantly determined by their perception and attitude towards the technology and subjective to social norm. Venkatesh and Davis (2000) commenting on the applicability of TRA in explaining the influence of social pressure on behaviour indicated that the TRA holds that the practical impact of subjective norm on behavioural intention is that an individual may choose to perform a specific behaviour, even though it may not be favourable to him or her to do so but just to conform with social norms.

1.6.2 Conceptual framework

Davis (1989) and Davis, Bagozzi, and Warshaw (1989) proposed TAM to explain why a user accepts or rejects a technology by adapting TRA. TAM provides a basis with which one traces how external variables influence belief, attitude, and intention to use. Two latent variables which fall within the cognitive domain regarding beliefs are posited by TAM:

perceived usefulness and perceived ease of use. According to TAM, one's actual use of a technology system is influenced directly or indirectly by the user's behavioural intentions, attitude, perceived usefulness of the system, and perceived ease of the system. TAM also proposes that external factors affect intention and actual use through mediated effects on perceived usefulness and perceived ease of use leads to a technology acceptance or otherwise.

Guided by TAM and TRA, this study conceptualized farmers' technology adoption behaviour as their disposition towards accepting and using technology disseminated to improve maize production in the District. The factors which influence technology adoption are conceptualized in this study as external factors (factors outside the technology attributes) such as farmers' characteristics, access to information and credit among others, innovation attributes such as perceived usefulness of the innovation and perceived ease of usage of the innovation, all of which influence farmers' attitudes towards the innovation and therefore their behavioural intention concerning the innovation. Figure 1.1 presents schematic demonstration of these narratives.

As shown in the figure 1.1, it is conceptualised that external factors such as socioeconomic and farm characteristics will shape how farmers see the usefulness of the improved maize technologies as well perceived ease of use of the technology. Literate farmers are expected to better understand the production recommendations and such will be in the better position to appreciate their usefulness and their application. Similarly, more experienced farmers who have been practising agronomic practices of maize production will be more likely to appreciate the technology than less experienced ones.

Also the way farmers see how useful the technologies are (perceived usefulness) and how easy or difficult it is to apply them (perceived ease) is conceptualised to have direct influence on their attitude towards the technology and hence their adoption intention and actual adoption.

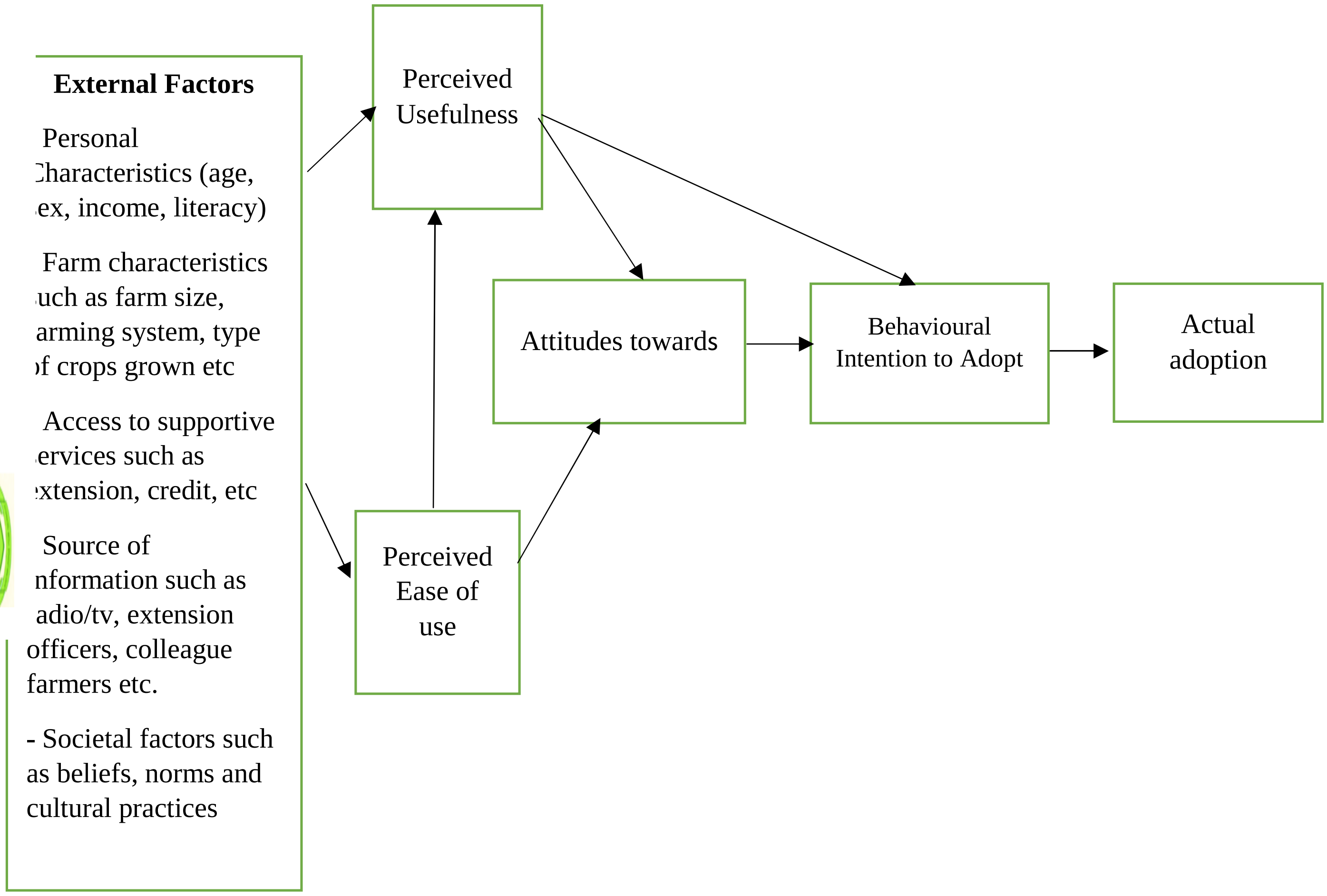

Figure 1.1: Conceptual Framework

Source: Adopt from TAM (Davis, 1989)

1.7 Scope and Limitation of the study

This study advanced the argument that technology adoption among farmers is largely determined by individual attributes such as perceptions and attitudes they hold about a technology and technology attributes such perceived usefulness and perceived ease of use. However, technologies studied in this research are limited to maize based technologies disseminated to farmers in the Bawku West District of the Upper East Region. Concepts such as farmers' views, perceptions and attitudes towards these technologies and their adoption behaviours are the main issues studied in this research.

Also only maize farmers in the District were targeted for the study as the survey did not extend beyond the District. Notwithstanding the above assertion, because farmers in the region share similar characteristics and trace their agricultural information from the same source and the fact that probability sampling techniques were applied in selecting the sample for the study, findings of this study can be inferred for other Districts in the Region.

1.7 Organization of the Study

This thesis is organized into five chapters with various sections and subsections.

Chapter one which is the introductory chapter, presents background to the study. Research problem, questions and objectives are also discussed in chapter one. The chapter also contains justification of the study as well as theoretical and conceptual frameworks applied in the study.

Chapter two presents a review of available literature on the concepts, issues and variables being studied in this research. Literature on maize production in Ghana as well as available maize based technologies. The chapter also contains literature reviews on technology adoption theories and models and their applicability. Literature on factors affecting technology adoption among smallholder farmers is also presented in this chapter.

Chapter three presents the methodological process used in conducting the research. Research design, sampling process as well as data collection methods and analysis are presented in the chapter three. Also description of the study area and the subjects are presented in this chapter.

Chapter four presents results and discussions on the findings of the research. The results of analysis of farmers' perceptions towards improved maize technologies as well as their adoption level are presented in this chapter. The chapter also presents results and discussion of factors affecting improved maize technologies among farmers surveyed and the constraints limiting their adoption.

Finally, chapter five presents a summary of the findings, conclusions and recommendations drawn from the findings.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

This chapter review relevant literature pertaining to the study. The chapter presents detail review of very concepts and issues being studied in this research. The review concentrated farmers' perception and adoption of improved technologies in maize production. As such key concepts such as maize production in Ghana, maize based technologies, technology adoption and constraints and challenges to technology adoption by smallholder farmers.

2.1 Agriculture and Development

Literature on development abounds on the significant contribution of agriculture to any nation development. Most developed countries started their development journey as agrarian economics (Juma, 2015 & Timmer, 2002). Juma (2015), asserts all industrial countries leveraged on their agriculture growth in propelling to industrial economies. Agricultural development through the green revolution in the eastern countries had been the propeller for growth in other sectors of the economies starting from industrialization to service and financial based economies

At early stage of any country's development, agriculture was the main driver of progress, producing, food and fibre for the people as well as providing source of employment for majority of her citizens. Classical understanding of the linkages between agriculture and economic development tends to portray it as a linear modelling which agriculture is seen as a source of input into other sectors of the economy (Byerlee, Janvy and Sadoulet, 2009). In fact this linear model that treat agriculture as a transient stage toward industry phases of the economy is being replaced by a more sophisticated outlook that recognizes the role of agriculture in fields such as "income growth, food security and poverty alleviation; gender empowerment; and the supply of environmental services" (Byerlee, Janvy and Sadoulet, 2009 and Pingali, 2010).

It is for these interconnectivity and stimulating role that agricultural development play in other sectors of the national economy that agricultural stagnation is viewed as a threat to national economic wellbeing and general prosperity. Over the last 30 years, agricultural yields and the poverty rate have remained stagnant in sub-Saharan Africa (Juma, 2015). Therefore prioritizing agricultural development in this region could lead to significant, interconnected benefits, particularly in achieving food security and reducing hunger, increasing incomes and reducing poverty, advancing the human development agenda in health and education, and reversing environmental damage (Abate et al, 2016).

2.1.1Ghana Agriculture and Maize Production

Agriculture continue to be an important sector in Ghana economy, in spite of the structural modifications of Ghanaian economy which have seen the service sector being the lead contributor to GDP in recent times (GSS, 2015).Agricultural sector still remains the main employer in the country, providing direct employment to about 36% of the active labour force and indirectly employed additional 35% of the labour force through agro-processing, marketing and supply of agricultural inputs and services (ibid).

However, the sector's contribution to Ghana's GDP has seen decreasing trend over the last decade. From a leading contributing sector for several years, the sector currently trails behind the Service sector with a contribution rate of 21% in 2016 (GOG, 2017). Notwithstanding, agriculture still remains the backbone of rural economy in Ghana serving as the main source of livelihood for majority of rural dwellers.

Agriculture in Ghana is predominantly practiced on smallholder, family-operated farms using rudimentary technology to produce about 80% of Ghana's total agricultural output, (MOFA, 2012). The poor performance of the agricultural sector has been blamed on low technology adoption and lack of modernization of agricultural practices. However, agricultural growth has been aptly demonstrated to have a positive link with overall national development (see Juma, 2015 and Timmer, 2002). To harness the potential of agricultural sector to propel national development, successful governments have implemented policies, programmes and reforms aimed at promoting technology adoption and overall modernization and mechanization of agricultural production (see GOG, 2017; MOFA, 2010 and MOFA, 2012).

2.2 Maize Production in Ghana

Maize (Zea mays), is a versatile crop; grown across a broad range of agro ecological zones in Ghana. Since its introduction in Ghana in the 16th century, maize had established itself as important food crop throughout the country. It is grown in the forest, transition, southern regions, upper west, upper east and northern regions of Ghana. In 2011, production was highest in Brong Ahafo, which accounted for 27 percent of national production, followed by Eastern (20 percent), Central (12 percent), Ashanti (12 percent), and Northern (11 percent) (IFPRI, 2013). Maize enjoyed this wide coverage in terms of cultivation partly because it is the largest staple crop in Ghana and contributes significantly to consumer diets. It is the number one crop in terms of area planted (about 1,000,000 hectares) and accounts for 50-60% of total cereal production (Facts and Figures by MOFA, 2013).

Maize is Ghana’s most important cereal crop and is grown by the vast majority of rural households. It is widely consumed throughout the country, and it is the second most important staple food in Ghana, next to cassava. Maize enjoyed this wide cultivation because it is one of the main cereal grains serving as staple food for many Ghanaians. Maize follow by rice and millet are the cereals most frequently consumed in Ghana and can be prepare into many local dishes widely consumed across the country.

Ghana is one of the major maize producers in Africa south of the Sahara, accounting for about 9 percent of the total acreage among surveyed countries in the DIVA project and 7 percent of the total acreage in West and Central Africa (Alene and Mwalughali, 2012). As shown in the figure 1.1, there have been steady upward trends of maize output within the last five decades. As shown in the figure 2.1, production of maize in Ghana had soared from just under 300Mt in the 1960s to about a million Mt in the 1990s and then a little under two million Mt in 2016. Apart from season fluctuations in which 1983 registered a sharp decline in production, falling from 326, and 000Mt in 1982 to just 172, 000Mt in 1983, there had been an increasing trend in maize production in country over the past decades.

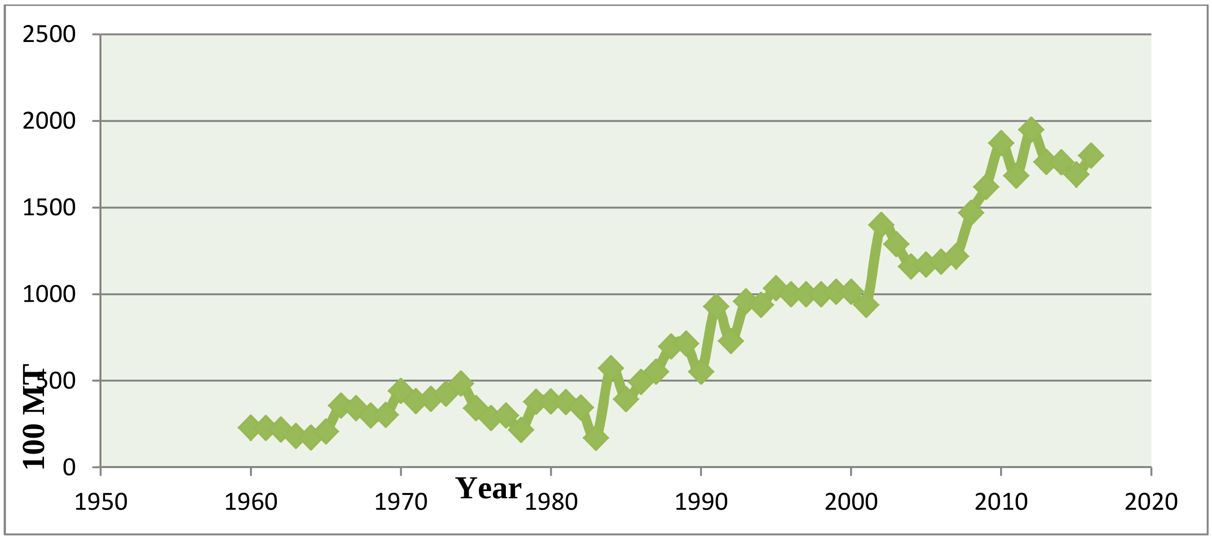

Figure 2.1: Trend of Maize Production from 1960 to 2016 in Ghana

Source: United States Department of Agriculture report on Ghana agriculture, 2017

2.3 Improved Maize Technologies

The maize sub-sector in Ghana has witnessed the implementation of many projects and research activities aimed at improving maize production and productivity. Notable among them is the Ghana Grains Development Project (GGDP), which ended in 1997. The GGDP was the last large long-term programme focusing on the maize sector development (see IFPRI, 2013 and Morris, Tripp and Dankyi, 1998). In addition to its research component, the

Ghana GGDP supported a number of activities designed to improve the transfer of improved technologies generated through the project to farmers. The strong emphasis on technology transfer issues were reflected in three types of activities:

(1) Building linkages between research and extension,

(2) Providing support to extension activities, and

(3) Strengthening seed production capacity

According to Morris, Tripp, and Dankyi's (1998) as cited in IFPRI, (2013) the GGDP had achieved a number of notable successes. Several varieties were developed and disseminated under the project; many agronomic practices were evaluated; production guides were produced; and a heavy investment was made in the extension and dissemination of improved technologies. Obatanpa, a quality protein maize developed through the project, has become widely popular in Ghana and in other countries in Africa south of the Sahara (IFPRI, 2013).

Other notable programmes implemented in the maize sub-sector in Ghana included the Sasakawa Global 2000 programme and Food Crops Development Project (FCDP), in addition to several small projects focussed on seed multiplications (see Manu, Fialor and Issahaku, 2012). Several farm demonstrations were conducted to test and promote modern varieties under the Sasakawa Global 2000 programme. One of the focus technology packages tested and promoted under Sasakawa Global 2000 was the zero-tillage package, involving no ploughing, the use of herbicide in land preparation, and planting in mulch (IFPRI, 2013). Through collaboration with Crop Research Institute (CRI) of the Council for Scientific and Industrial Research (CSIR), Sasakawa Global 2000 with sponsorship from Monsanto, several farm demonstrations on zero-tillage and other improved maize technologies were tested and its adoption promoted among farmers (IFPRI, 2013 and Manu et al, 2012).

In continuation of projects started under the GGDP, the Food Crops Development Project (FCDP) was implemented in eight districts in various regions that funded field trials, production manuals, extension, input provision, and processing. Many impact assessment studies demonstrate positive impact of the FCDP on maize productivity. A study by Manu, et al (2012), shows that FCDP has provided greater access to credit, provided information about improved technologies, increased maize output, and improved food security compared with pre-project levels.

As part of the national food security and emergency preparedness and in line of agricultural modernization agenda several maize improvement technologies ranging from varietal development through good agronomic practices to mechanization and post-harvest management have been disseminated to farmers. Most of the efforts by the national research institutes in relation to maize are in varietal improvement and testing. Several trials on agronomic practices have also been conducted, mainly under GGDP and FCDP, on improved land preparation, row planting, fertilizer use, herbicide use, pest and disease control, and water management, among others (IFPRI, 2013).

2.3.1Improved Maize Varieties

According to IFPRI, (2013) twenty-seven improved varieties have been released since the 1960s (Table 2.1). Varietal improvement and testing done by CRI and SARI focus on high yield, protein content (that is, quality protein maize [QPM]), tolerance to pests and disease (mainly blight, rust, streak, and stem borers), Striga resistance, kernel type, lodging resistance, and early maturity. Two main varietals lines namely open pollinated and hybrid varieties with different improved traits such pest/disease resistant, drought tolerant, striga resistant were the most developed and released maize varieties to farmers in the country.

Table 2.1—Improved maize varieties developed and promoted by CRI and SARI

Name of variety	Year of *formal* release	Origin (institute)	Maturity period (days)	Potential (tons/ hectare)	Selected characteristics
Mex 17 Early	1961	CIMMYT	90–105		Earliness, resistance to lodging
Comp 4	1972	CIMMYT	120		High yield, lodging resistant
Comp W	1972	CRI/CIMMYT	120		Yield, kernel type, tolerance to pests/diseases (blight, rust, streak, and stem borers), lodging resistance
Golden Crystal	1972	CRI/CIMMYT	105–110	4.6	Yield, suitable for poultry
Laposta	1972	CIMMYT	120		High yield, lodging resistant
Aburotia	1983	CRI/CIMMYT	105–110	3.5	High yield
Dobidi	1984	CIMMYT	120	5.5	High yield, lodging resistant
Kawanzie	1984	CIMMYT	90–95	4.6	Earliness
Safita – 2	1984	CIMMYT	90–95	3.5	Earliness
Okomasa	1988	IITA/CIMMYT	120	5.5	High yield, streak resistance
Abeleehi	1990	IITA/CIMMYT	105–110	4.6	Yield, streak resistance
Dorke SR	1992	IITA/CIMMYT	95	3.8	Yield, kernel type, tolerance to pests/diseases (blight, rust, streak, and stem borers), lodging resistance
Obatanpa	1992	IITA/CIMMYT	105	4.6	Yield, quality protein maize, kernel type, tolerance to pests and diseases (blight, rust, streak, stem borer), lodging resistant
Mamaba (hybrid)	1996	CIMMYT	105	6.0–7.0	High yield, drought tolerant (hybrid), lodges heavily in certain conditions
Cida-ba (hybrid)	1997	CIMMYT	110	6.0–7.0	High yield, protein content (hybrid)
Dada-ba (hybrid)	1997	CIMMYT	110	6.0–7.0	High yield, protein content (hybrid)
Dodzi	1997	IITA	80–85	3.5	Extra early, open pollinated
Aziga (yellow)	2007	CIMMYT	110	4.7	High yield, QPM, good for poultry and livestock industry, contains carotene which imparts yellow color to egg yolk, similar to Golden Jubilee except that it is more flint/dent type (better for storage and more resistant to weevil attack)
Akposoe	2007	CIMMYT/IITA	80–85	3.5	Extra early, QPM, DT, excellent taste when boiled or roasted
Etubi (hybrid)	2007	CIMMYT	105–110	6.5–7.0	QPM hybrid, DT, lodging tolerance (an advantage for Mamaba)
Golden Jubilee (yellow)	2007	CIMMYT	105–110	5.0	High yield, QPM, cross of white Obatanpa and a yellow QPM, good for poultry and livestock industry, contains carotene which imparts yellow color to egg yolk
Aburohemaa	2010	IITA	90	5.0	DT, *Striga* tolerant, QPM; all 2010 varieties are drought resistant and mature early, were suitable for the forest and coastal zones, as well as that of Northern and Sudan savannah zones.
Enibi (hybrid)	2010	CIMMYT/IITA	110	6.5	QPM hybrid, DT, lodging resistant
Abontem	2010	IITA	75–80	5.0	DT, *Striga* tolerant, QPM
Omankwa	2010	IITA	90	4.7	DT, *Striga* tolerant; QPM
Aseda	2012		110–115	6.7	Hybrid white, DT, very good for domestic purposes
Opeaburoo	2012		110–115	7.5	Hybrid white, DT
Tintim	2012		110–115	7.9	Hybrid white, DT
Nwanwa	2012		110–115	7.9	Hybrid yellow, suitable for human, poultry, livestock consumption
Odomfo	2012		110–115	6.5	Hybrid yellow, suitable for human, poultry, livestock consumption
Honampa	2012		110–115	5.2	Open-pollinated variety, yellow, source of pro-vitamin A

Source: IFPRI, (2013) citing DIVA project raw data; MOFA/CRI/SARI (2005); and personal communication with scientists in the Council of Scientific and Industrial Research.

CIMMYT = International Maize and Wheat Improvement Centre; CRI = Crops Research Institute; SARI = Savannah Agricultural Research Institute; IITA = International Institute of Tropical Agriculture; QPM = quality protein maize; DT = drought tolerant.

The most popular variety is Obatanpa. It was released as a medium-maturing open-pollinated QPM variety in 1992, but it is still by far the most popular variety (IFPRI, 2013). It has long been grown and as such adapted to the growing conditions in the lowland tropics and has been adopted extensively in Ghana and many other African countries (Sallah et al. 2003). Obatanpa accounted for about 96 percent of certified seed production from 2001 to 2011—about 2,500 tons in 2011 (3,466 tons average in 2009 through 2011).

According to IFPRI, (2013) four varieties were released in 1997: three of them were high-yield, QPM hybrids (Mamaba, Cida-ba, and Dada-ba), and the other was an extra-early-maturing OPV (Dodzi). Four varieties were again released in 2007: two were high-yield, QPM, open-pollinated yellow maize varieties (Aziga and Golden Jubilee); one was an extra-early maturing, QPM, drought-tolerant variety (Akposoe); and the other was a QPM, drought-tolerant hybrid variety (Etubi). In 2010, another set of four varieties was released: three drought-tolerant, Striga-tolerant, QPM OPVs and one drought-tolerant, QPM hybrid (Etubi).

2.3.2 Recommended Ploughing and Zero tillage

Ploughing is one of the fundamental operations undertaken in conventional tillage. Conventional tillage practices modify soil structure by changing its physical properties such as soil bulk density, soil penetration resistance, soil moisture content (Rashidi and Keshavarzpour, 2008 as cited in Gomez, 2010), soil porosity and soil air. Papworth (2010) indicated that tillage influences crop growth and yields by changing soil structure and moisture removal patterns over the growing season.

In the 1980s, research to adapt zero tillage, or no-till, with mulch as a sustainable alternative to slash-and-burn was initiated by CRI in conjunction with the International Maize and Wheat Improvement Centre, Monsanto, and Sasakawa Global 2000 (IFPRI, 2013). Zero tillage, or no-till, is a management practice that involves no ploughing (no disturbance of the soil), no burning, using herbicide during land preparation, and planting into mulch.

2.3.3 Fertilizer Use

Maize is particularly sensitive to soil nutrient deficiencies of both the major and minor nutrients. Amounts and types of fertiliser required will depend on soil type, cropping history and geographical location (Price, 1997 as cited in Gomez, 2010). Maize requires adequate supply of nutrients particularly nitrogen, phosphorus and potassium for good growth and high yield. Nitrogen and phosphorus are very essential for good vegetative growth and grain development in maize production (Gomez, 2010).

Fertilizer application is one major farming operation needed to correct deficiencies in the soil in order to ensure proper growth and functioning of crops with the aim of increasing yield.

Recommended rates of fertilizer application depend on the agro-ecological zone, soil type, and cropping history. According to Morris, Tripp, and Dankyi (1998), numerous trials were conducted under GGDP to derive these recommendations. Split application is recommended. Compound fertilizer (for example, NPK 15-15-15 or NPK 20-20-0) is recommended, and the starter fertilizer should be applied about 5 centimetres away from the hills at planting, and if not possible, just after germination (one to two weeks after planting). Sulphate of ammonia (N21 S24) or compound fertilizer (NPK 20-20-0 or NPK 20-20-20) is recommended as a side-dress applied four to five weeks after planting at the soil surface (except for sloping fields) (IFPRI, 2013). Urea (N45) can also be used but needs to be buried in the soil for maximum benefit. Urea loses its nutrients easily, and if stored or sealed improperly for a year, it would not retain any nutrients.

2.3.4 Crop Protection

The methods employed to manage weeds vary, depending on the situation, available research information, tools, economics, and experience (Monaco, 2002). Weed control is an important management practice for maize production that should be carried out to ensure optimum grain and forage yield (Gomez, 2010). Weed control in maize can be carried out by mechanical and/or chemical methods.

The general rule is to keep maize plots free from weeds especially during the first 30 days of planting. CSIR and MOFA recommend the use of herbicide before and after planting. Glyphosate (for example, Roundup or Roundup Turbo) is a systemic herbicide and is recommended for actively growing weeds two weeks before planting (IFPRI, 2013). Examples of formulations of herbicides that have been tested and are available in Ghana are Roundup (360 grams/litre of glyphosate) and Roundup Turbo (450 grams/litre glyphosate.

Recommended application is 2.5 to 4 litres of glyphosate (depending on the strength of its formulation) per 15-liter knapsack sprayer to spray a hectare. A second application is also recommended with lasso-atrazine to the soil immediately after planting. The recommended rate is about 4 litres of lasso-atrazine per 15-liter sprayer per hectare (MOFA/CRI/SARI 2005 as cited in IFPRI, 2013).

2.3.5 Plant Density, Spacing, and Row Planting

Plant configuration recommendations specifically on plant density, seeds per hill, spacing, timing, and planting in lines were developed in Ghana based on extensive on-station and on-farm trials mainly under GGDP and the Sasakawa global 2000 project. Trials concluded that lodging increases with higher plant density and greater interplant competition, or a planting density of about 56,000 to 76,000 plants per hectare (based on two-seeds-per-hill planting) or approximately 20 kilograms of seed per hectare (IFPRI, 2013 and MOFA/CRISARI, 2005).

Farmers had been used to planting as many as five seeds per hill, and researchers examined the effect of number of seeds per hill at different plant densities in several on-station trials.

2.3.6 Harvesting of Maize

Most maize is harvested by hand in Ghana, especially among smallholder farmers. This often involves large numbers of workers and associated social events. Some one-and two-row mechanical pickers are used. By hand or mechanical picker, the entire ear is harvested which then requires a separate operation of a maize Sheller to remove the kernels from the ear (Gomez, 2010). Information of timely harvesting by harvesting at the correct moisture level and proper harvest handling and storage have been disseminated to farmers under many of the maize improvement projects (IFPRI, 2013 and MOFA/CRI/SARI, 2005). However, traditional method of harvesting maize is still being used by farmers. The combine with a maize head cuts the stalk near the base and then separates the ear of maize from the stalk so that only the ear and husk enter the machinery. The combine separates the husk and the cob, keeping only the kernels (Gomez, 2010).

2.4 Theory of Technology Adoption

The process of adopting new innovations has been studied for several decades with various theories and models developed to explain the process of innovation adoption. Notable among the theories and model are Roger innovation diffusion theory, technology acceptance model, theory of planned behaviour and the Theory of Reasonable Action. As observed by Lai, (2017) the various theories and model of technology adoption include but not restricted to the Theory of Reasonable Action (TRA) (Fishbein and Ajzen, 1975), Theory of Planned Behavior (TPB) (Ajzen, 1991), Decomposed Theory of Planned Behaviour, (Taylor and Todd, 1995), Roger innovation diffusion theory (Roger, 2003), the Technology Acceptance Model (TAM) (Davis, Bogozzi and Warshaw, 1989), Technology Acceptance Model 2 (TAM2) Venkatesh and Davis (2000) and Technology Acceptance Model 3 (TAM3)

Venkatesh and Bala (2008). However Roger's innovation diffusion theory is widely cited and used theory in modeling technology adoption.

2.4.1 Innovation Diffusion Theory

Rogers (1995) proposed that the theory of 'diffusion of innovation' was to establish the foundation for conducting research on innovation acceptance and adoption. After synthesizing over 508 diffusion studies Roger came out with the 'diffusion of innovation' theory for the adoption of innovations among individuals and organization. The theory explicates "the process by which an innovation is communicated through certain channels over time among the members of a social system" (Rogers, 1995, p. 5).

Essentially, diffusion is the process through which innovation is communicated to members of a social system over time. The Rogers' (1995) diffusion of innovation theory explained that the innovation and adoption happened after going through several stages including understanding, persuasion, decision, implementation, and confirmation that led to the development of Rogers (1995) S-shaped adoption curve of innovators, early adopters, early majority, late majority and laggards (Lai, 2017).

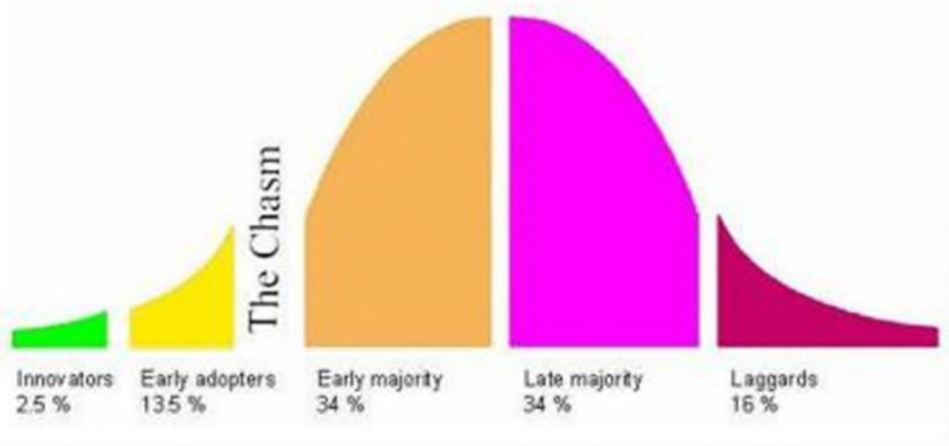

Figure 2.2. Innovation Adoption Curve

Source: Roger, 1995

Similarly, Parasuraman and Colby (2001) classified technology adoption process based on individual’s technology readiness. Technology readiness (TR) refers to people’s propensity to embrace and use of new technologies for accomplishing goals in home life and at work (Parasuraman and Colby, 2001 as cited Lai, 2017). Based on individual’s technology readiness score and the technology readiness, Parasuraman and Colby (2001) further classified technology consumers into five categories as explorers, pioneers, skeptics, paranoids, and laggards. Comparatibly it matches with Rogers (1995) S-shaped adoption curve of innovators, early adopters, early majority, late majority and laggards.

2.4.2 Theory of Reasoned Action

Fishbein and Ajzen, (1975) Theory of Reasoned Action (TRA) is one of the most popular widely used technology adoption theories in model individual behavioural intention regarding innovation adoption. TRA provides model for explaining and determining behavioural intention of the person’s attitudes toward that behaviour. The theory opined that individual behaviour is based on their intention and that intention depends on individual perception and attitude towards the said behaviour. In addition, expression of intention is subject to social and acceptable norms referred to as ‘subjective norm’. Fishbien and Ajzen (1975) defined “attitude” as the individual’s evaluation of an object and defined “belief” as a link between an object and some attribute, and defined “behaviour” as a result or intention. Attitudes are affective and based upon a set of beliefs about the object of behaviour (Lai, 2017). A second factor is the person’s subjective norms of what they perceive their immediate community’s attitude to certain behaviour. Figure 2.3 provides schematic view of TRA. The theory of Reasoned Action postulate that an individual’s behavioural decision in a specific context depends on their attitude toward performing the target behaviour and on subjective norm, which refers to how one reacts to influence and pressure coming from other people he or she is related to and considered important regarding the performance or otherwise of a behaviour.

Subjective norm visualized social context which demand conformity to socially accepted norms and behaviours.

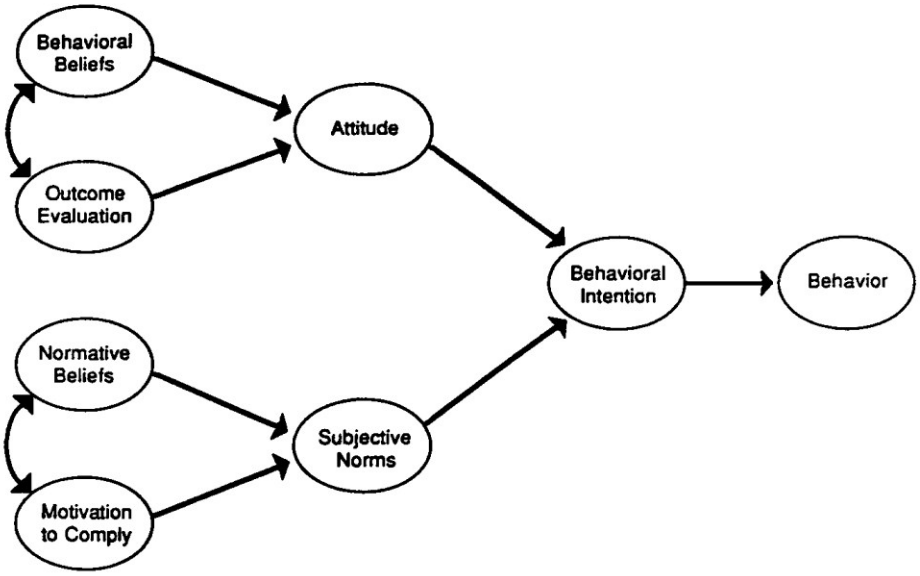

Figure 2.3. The Theory of Reasoned Action

Source: Fishbein and Ajzen, 1975

2.4.3 Theory of Planned Behaviour

Theory of Planned Behaviour (TPB) developed by Ajzen (1991) and later modified by Ajzen (2006) further advanced Fishbein and Ajzen, (1975) TRA that determines behavioural intention of the person's attitudes toward that behaviour as shown. The first two factors in the TPB are the same as Theory of Reasonable Action (Fishbein and Ajzen, 1975). The third factor that is known as the perceived control behaviour is the control which users perceive that may limit their behaviour. The overall aim of the TPB is to predict deliberative and planned behaviour. The theory includes the construct perceived behavioural control as an addition to the TRA to take into account the more common situation in which individuals do not have complete voluntary control over their behaviour, such as when they lack skills or resources to perform a particular task (Ajzen 1991and Ajzen 1985). In a nutshell, the TPB posits that behavioural decision is a function of an individual's beliefs in three areas:

- behavioural beliefs (Attitude toward Behaviour) reflecting or representing individual perceptions about the probable outcome of a behaviour
- normative perceptions (Subjective Norm) – meaning individual perceptions about the normative expectations of his/her immediate social environment such as family, friends/colleagues and society at large; and
- Control perceptions (Perceived Behavioural Control) – meaning the perceptions/beliefs regarding absence or presence of factors that might facilitate or impede the performance of the behaviour (Ajzen 1991).

As explained in Ajzen, (2005) behavioral beliefs link the behaviour of interest to expected outcomes. A behavioral belief is the subjective probability that the behaviour will produce a given outcome. Although a person may hold many behavioral beliefs with respect to any behaviour, only a relatively small number are readily accessible at a given moment. It is assumed that these accessible beliefs, in combination with the subjective values of the expected outcomes, determine the prevailing attitude toward the behaviour.

Attitude toward a behaviour is the degree to which performance of the behaviour is positively or negatively valued (Ajzen, 2005 and Ajzen, 1991). According to the expectancy-- value model, attitude toward a behaviour is determined by the total set of accessible behavioural beliefs linking the behaviour to various outcomes and other attributes as argued in Ajzen, (2005).

Subjective norm is the perceived social pressure to engage or not to engage in behaviour. Drawing an analogy to the expectancy-value model of attitude, Ajzen, (2005) observed that subjective norm is determined by the total set of accessible normative beliefs concerning the expectations of important referents.

Control beliefs have to do with the perceived presence of factors that may facilitate or impede performance of behaviour. It is assumed that these control beliefs in combination with the perceived power of each control factor determine the prevailing perceived behavioural control (Ajzen, 2005). Specifically, the perceived power of each control factor to impede or facilitate performance of the behaviour contributes to perceived behavioural control in direct proportion to the person's subjective probability that the control factor is present.

Intention is an indication of a person's readiness to perform a given behaviour, and it is considered to be the immediate antecedent of behaviour (Ajzen, 2005 and Ajzen, 1991). The intention is based on attitude toward the behaviour, subjective norm, and perceived behavioural control, with each predictor weighted for its importance in relation to the behaviour and population of interest.

Behaviour is the manifest, observable response in a given situation with respect to a given target. Single behavioural observations can be aggregated across contexts and times to produce a more broadly representative measure of behaviour (Ajzen, 2005). In the TPB, behaviour is a function of compatible intentions and perceptions of behavioural control. Conceptually, perceived behavioural control is expected to moderate the effect of intention on behaviour, such that a favourable intention produces the behaviour only when perceived behavioural control is strong. In practice, intentions and perceptions of behavioural control are often found to have main effects on behaviour, but no significant interaction.

Actual behavioural control refers to the extent to which a person has the skills, resources, and other prerequisites needed to perform a given behaviour (ibid). Successful performance of the behaviour depends not only on a favourable intention but also on a sufficient level of behavioural control. To the extent that perceived behavioural control is accurate, it can serve as a proxy of actual control and can bemused for the prediction of behaviour (Ajzen, 2005 and Ajzen, 1991). Figure 2.4 presents schematic view of the TPB. Similarly to TBP is the decomposed theory of planned behaviour

Introduced by Taylor and Todd (1995), the decomposed Theory of Planned Behaviour (Decomposed TPB) consists of three main factors influencing behaviour intention and actual behaviour adoption which are attitude, subjective norms and perceived behaviour control (Lai, 2017). It provides detail details examination of the three antecedents of the intention in the TPB.

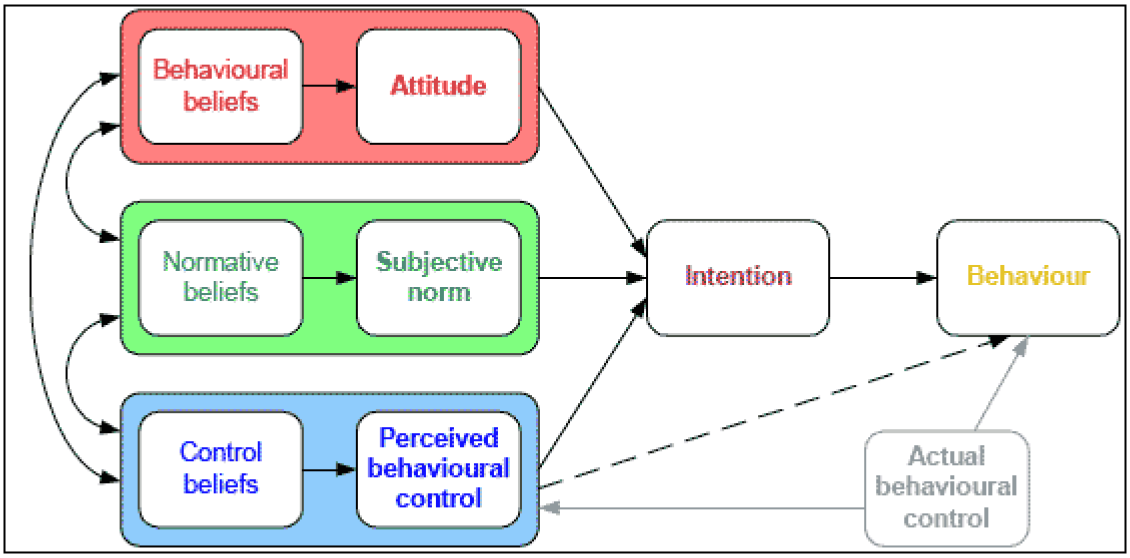

Figure 2.4 Diagram Depicting the Theory of Planned Behaviour (TPB)

Source: Ajzen, 2005

2.4.4 Technology Acceptance Model (TAM)

The technology acceptance model (TAM) is an information systems theory that models how users come to accept and use a technology (Davis, 1986).Two factors namely, perceived usefulness and perceived ease of use is critical in determining individual technology acceptance and as such are important variables in TAM (Davis, 1986, Lai, 2017 and Surendran, 2012). Davis, (1986) defines perceived usefulness as the prospective user's subjective probability that using a specific application system will enhance his or her job or life performance. Perceive ease of use (EOU) can be defined as the degree to which the prospective user expects the target system to be free of effort. Surendram (2012), observed that these two factors are influenced by external variables.

The main external factors that are usually manifested are social factors, cultural factors and political factors. Social factors include language, skills and facilitating conditions. Political factors are mainly the impact of using technology in politics and political crisis.

Lai, (2017) observed that there has been a great deal of research on the Theory of Reasoned Action (Ajzen & Fishbein, 1980; Sheppard, Hartwick, and Warshaw, 1988) Theory of Planned Behaviour (Ajzen, 1991) and Decomposed Theory of Planned Behaviour, (Taylor and Todd, 1995) but mostly used for products already in the marketplace and included the view of society (Subjective norm). However, Technology Acceptance Model (TAM) introduced by Fred Davis in 1986 is specifically tailored for modelling users' acceptance of information systems or technologies. Diagram depicting TAM is shown in the figure 2.5.

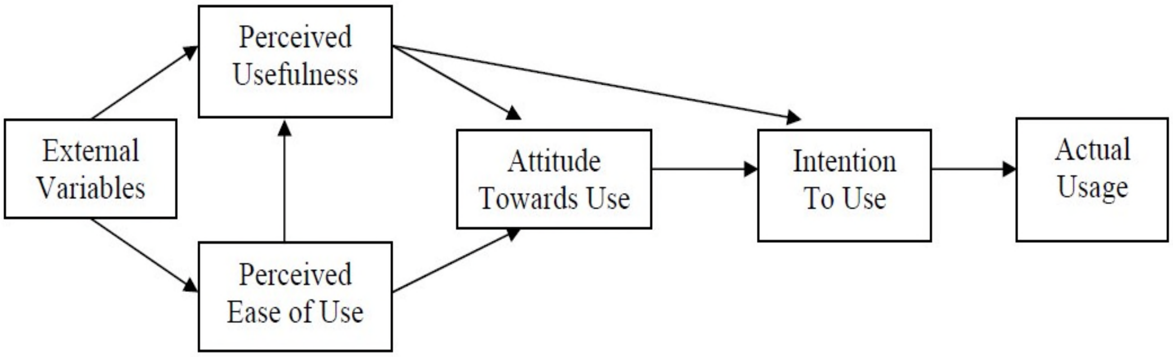

Figure 2.5. Technology Acceptance Model

Source; Davis, 1989

Technology Acceptance Model is one of the most popular theories that is used widely to explain Information System usage. So many studies have been conducted which has led to the changes in the originally proposed model (Surendran, 2012).

Venkatesh and Davis (2000) proposed the TAM 2 which provided more detail explanations for the reasons users found a given system useful at three (3) points in time: pre-implementation, one month post-implementation and three month post implementation. TAM2 theorizes that users' mental assessment of the match between important goals at work and the consequences of performing job tasks using the system serves as a basis for forming perceptions regarding the usefulness of the system (Venkatesh and Davis, 2000 as cited in Lai, 2017).

Also Venkatesh and Bala (2008) combined TAM2 of Venkatesh and Davis, (2000) and the model of the determinants of perceived ease of use of Venkatesh, (2000), and developed an integrated model of technology acceptance known as TAM3. Venkatesh and Bala (2008) added four different factors namely individual differences, system characteristics, social influence, and facilitating conditions in modeling technology acceptance.

These four factors determine individual perceived usefulness and perceived ease of use. In TAM3 research model, the perceived ease of use and perceived usefulness in explaining behavioral intention were moderated by experiences (Lai 2017, Surendram 2012and Venkatesh and Bala 2008). The TAM3 research model was tested in real-world settings of IT implementations (Lai, 2017). Figure 2.6 presents diagram of TAM3

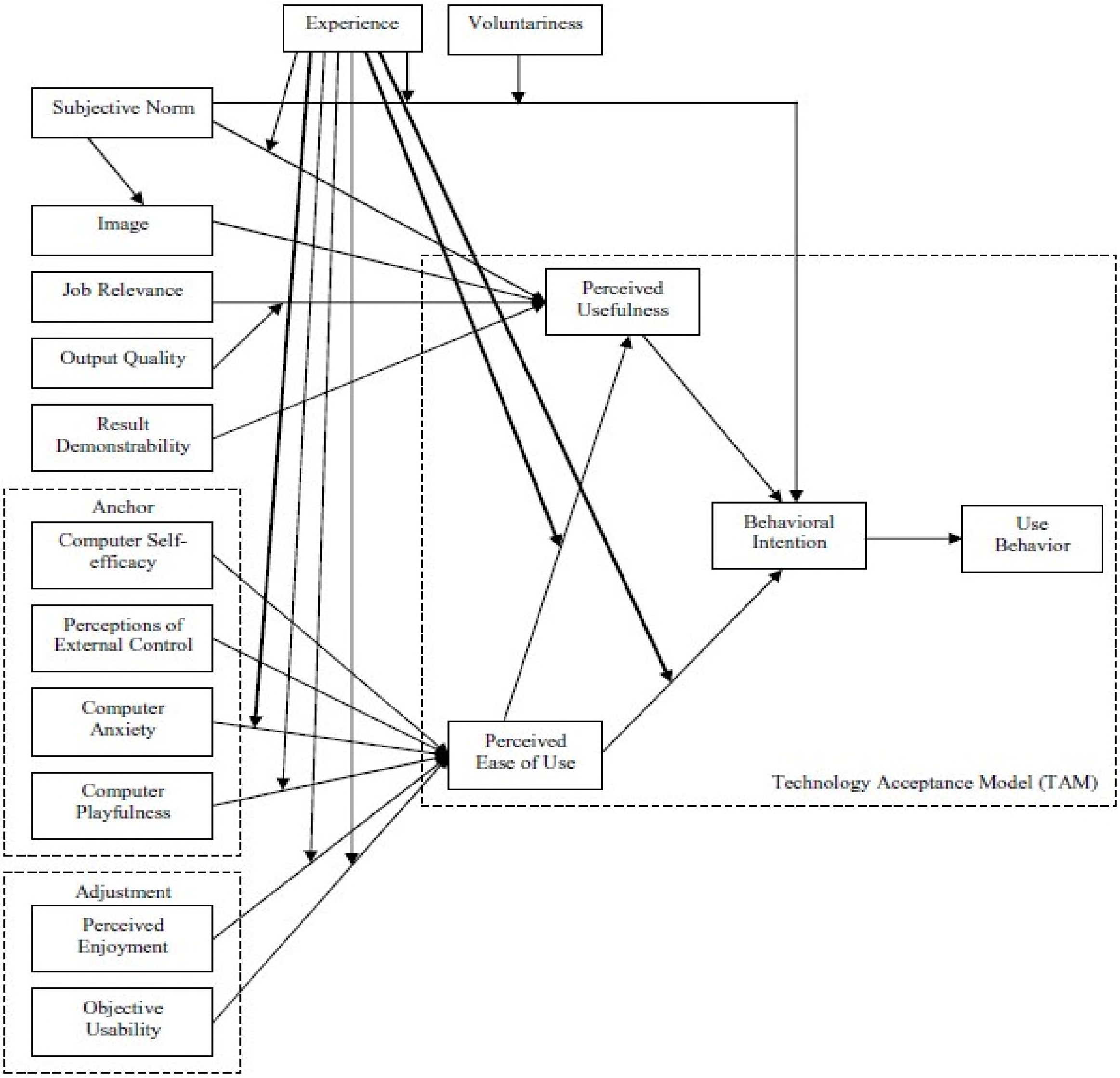

Figure 2.6 Technology Acceptance Model (TAM 3)

Source: Venkatesh and Bala, 2008.

Park, (2009) in analyzing university students' behaviour intention to use e–learning employed TAM3 to understand users' behavioural intention to use e-learning. The general structural model, which included e-learning self-efficacy, subjective norm, system accessibility, perceived usefulness, perceived ease of use, attitude, and behavioral intention to use e-learning, was developed based on the technology acceptance model (TAM). There result proved TAM to be a good theoretical tool to understand users' acceptance of e-learning. Similarly, Lee, Cheung and Chen (2005) employed integrated TAM with motivational theory to assess students' adoption of internet based learning medium.

Further studies and application of TAM, TAM2 and TAM3 led to the formulation of Unified Theory of Acceptance and Use of Technology (UTAUT). Venkatesh, Morris, Davis and Davis (2003) studied from the previous models/theories and formed Unified Theory of Acceptance and Use of Technology (UTAUT) to predict behavioural intention and performance expectancy. As shown in the Figure 2.7, the UTAUT has four predictors of users' behavioral intention and there are performance expectancy, effort expectancy, social influence and facilitating conditions (Lai, 2017 and Venkatech, 2003).

Lai, (2017) observed that five similar constructs including perceived usefulness, extrinsic motivation, job-fit, relative advantage and outcome expectations form the performance expectancy in the UTAUT model while effort expectancy captures the notions of perceived ease of use and complexity. As for the social context, Venkatesh et al. (2003) validation tests found that social influence was not significant in voluntary contexts.

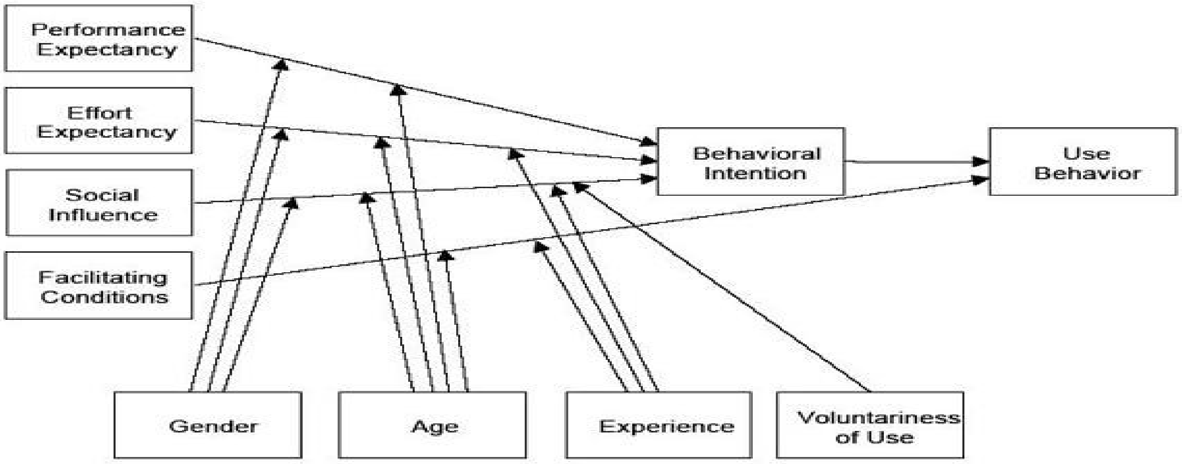

Figure 2.7.Unified Theory of Acceptance and Use of Technology (UTAUT)

Source: (Venkatesh, Morris, Davis and Davis, 2003).

In fact, TAM has become so popular that it has been cited in most of the research that deals with users' acceptance of technology (Lee, Kozar and Larsen, 2013). TAM attempts to help researchers and practitioners to distinguish why a particular technology or system may be acceptable or unacceptable and take up suitable measures by explanation besides providing prediction (Lai, 2017).

2.4.5 Comparing the Models

The TAM, TRA, TPB, TAM2, TAM3 and UTAUT have been used over the years by various researchers to explain technology adoption behaviour of individual, groups, firms and organization. They have varying strengths and limitation, as different variables are highlighted and added by the different models. This section briefly discusses the comparisons of these theories and justified by why TBP was preferred and used in this study.

Study by Davis, Bagozzi and Warshaw's (1989) compared the Technology Acceptance Model (TAM) with Theory of Reasoned Action (TRA) and resulted in the convergence of TAM and TRA. This led to a model based on the three theoretical determinants which are the perceived usefulness, perceived ease of use and behaviour intention (Lai, 2017). The findings of Davis et, al, (1989) as cited in Lai, (2017) indicated that social norms (SN) as an important determinant of behavior intention to be weak and that TAM does not include social norms (SN) as a determinant of behavior intention (BI), which is an important determinant, theorized by Theory of Reasoned Action TRA and Theory of Planned Behavior (TPB).

Arguing for usage of combination of TRA, TBP and TAM to overcome their individual limitation and maximize their collective strengths, Mathieson (1991) and Yi, Jackson, Park, and Probst (2006) argued that human and social factors could play a role in the adoption of technology using TPB model. Therefore, the TAM could be extended with constructs from the TPB to incorporate the social factors that could explain technology adoption. Some studies have applied more than one adoption theories in explaining adoption behaviour.

For instead, Shih and Fang (2004) as cited in Lai, (2017) examined the adoption of internet banking by means of the TPB as well as Decomposed TPB and found that it was in line with the findings of Venkatesh and Davis (2000) that subjective norm was likely to have a significant influence on behavioural intention to use in a mandatory environment, whilst the effect could be insignificant in a voluntary environment.

Davis, Bagozzi and Warshaw (1989), as cited in Lai, (2017) explained that social norms scales had a very poor psychometric standpoint, and might not exert any influence on individual’s behavior intention, especially when the technology being disseminated is fairly personal while individual usage is voluntary. TAM was also specifically designed to address the factors of users’ system technology acceptance (Chau and Hu 2002 as cited in Lai, 2017). Thus, the comparisons of the study confirmed that Technology Acceptance Model was easy to apply across different research settings. Han (2003) as well as Lai and Zainal (2014; 2015) noted that using TAM capability was favorable compared with TRA and TPB.

In this study farmers' perceptions and attitude towards improved maize technologies are of interest and as results TPB was considered appropriate in modeling farmers' adoption behaviour. Farmers' adoption behaviour was conceived to be antecedents of their perceptions and attitude towards the improved maize technology and social pressure and views of other farmers were construed to have effects on farmers' adoption. As TPB was considered appropriate, because it include variables such as attitude, perceived behavioural control and social norms which allowed the research to capture farmers' socioeconomics characteristics, perceptions and attitudes as well as farm characteristics' in assessing their adoption decision.

2.5 Factors Affecting Maize Technology Adoption

Many studies have documented factors affecting technology adoption. Flowing from the theories of technology adoption it can be argued that factors ranging from technology characteristics (Roger, 2005; 1991), such perceived usefulness and ease of use (Taylor and Todd, 1995), social norms and perceived behavioural control (see Ajzen & Fishbein, 1980; Sheppard, Hartwick, and Warshaw, 1988) have direct effect on people's technology adoption behaviour.

Salifu and Salifu, (2015) in assessing the Determinants of Farmers Adoption of Improved Maize Varieties in the Wa Municipality, found that age, marital status, education of household head, and farmers' experience in maize production and varietal characteristics as significant in influencing adoption of improved maize varieties. Similarly Fadare, Akerele and Toritseju, (2014) found that farm size, education level of farmers and access to extension services would significantly influence adoption of improved maize technologies. Similarly, Singha and Baruah, (2011) found that extension contact, annual income, innovation proneness and positive attitude towards farm diversification of farmers had positively significant relationships with the extent of adoption of improved cereal cultivation practices.

A study by Ghimire, Wen-chi and Shrestha , (2015) showed that technology specific variables (e.g. yield potential and acceptability) are significant for explaining adoption behaviour, implying that it is important to take farmers' preferences to varietal characteristics into consideration in the design of a research and development programme

2.6 Perceptions, attitude and technology Adoption

The process by which people translate sensory impressions into a coherent and unified view of the world around them which shape attitude of individual. Though necessarily based on information, perception is equated with reality for most practical purposes and guides human behaviour in general. Perception can be defined as our recognition and interpretation of sensory information. Perception also includes how we respond to the information. We can think of perception as a process where we take in sensory information from our environment and use that information in order to interact with our environment.

Fishbien and Ajzen (1975) defined "attitude" as the individual's evaluation of an object and defined "belief" as a link between an object and some attribute, and defined "behaviour" as a result or intention. Attitudes are affective and based upon a set of beliefs about the object of behaviour (Lai, 2017).Attitude is a predisposition or a tendency to respond positively or negatively towards a certain idea, object, person, or situation

Theory of Reasonable Action (TRA), Roger Theory of Innovation Diffusion, Theory of Planned Behaviour (TPB) and Technology Acceptance Model (TAM) all underscored the effect of individual perception on technology adoption. While TRA argued that individual perception towards a technology determine their intention and final adoption of the technology. Also TRA is of the view that intention is subject to social and acceptable norms referred to as 'subjective norm'.

In spite of intrinsic link between perception, attitudes and beliefs on technology adoption, many conventional studies on technology adoption seem to focus much on socioeconomic and farmers characteristics. A review study by Seline et al, (2015; p50) concluded that 'while we suggest that knowledge, attitudes and perceptions in relation to the benefits and challenges of the technology play a key role in the decision to adopt, we do not claim that conventionally studied variables such as farmer characteristics and economic variables are not important in the decision-making process or that existing models focusing on extrinsic factors are flawed'.

Maize farmers hold varying perception about production recommendation disseminated to them. And such perceptions influence their adoption such technologies. A study by Asiedu – Darko (2014), to analyze Farmers' perception on agricultural technologies a case of some improved crop varieties in Ghana, revealed that farmers perceived the improved crop varieties with particular reference to Maize (Zea maize), Cassava (Manihot esculentus) and Oil Palm (Elaies guineensis) as lacking some good characteristics of the landraces and also expensive to adopt.

2.7 Effect of Technology Adoption on Productivity

The very essence of innovation is to achieve efficiency and productivity. As such effort of agricultural research and development is to generate innovation to propel agricultural productivity, farmers' welfare and rural development in general. Literature abounds on impact of agricultural technology on productivity, farmers' welcome and economic growth. The role of agricultural technology adoption in improving farmers' wellbeing, ending poverty and food insecurity has been well discussed by Besley and Case (1993); Doss and Morris (2001); Mendola (2007); and Becerril and Abdulai (2009).

However, there are mixed stories in developing countries. According to Ajayi et al.(2003), Gemeda et al. (2001) and Morris et al. (1999)in developing countries, improving the livelihoods of rural farm households via agricultural productivity would remain a mere wish if agricultural technology adoption rate is low. Hence, there is a need to adopt the proven agricultural technologies so as to heighten production as well as productivity and thereby the living condition of the rural poor. Furthermore, for developing countries, the best way to catch developed countries is through agricultural technology diffusion and adoption (Foster and Rosenzweig, 2010).

Most impact studies, either review or empirical studies have been conducted globally and in many countries on the agricultural technology adoption. Several approaches ranging from conventional econometric modeling to qualitative narratives have been used to assess the impact of agricultural technology on productivity, farmers' welfare and other important social and development variables (Hailu, Abrha and Weldegiorgis, 2014)

In studying adoption and impact of agricultural technologies on farm income Hailu, Abrha and Weldegiorgis (2014) adopted econometric modeling in which Probit and Ordinary Least Square (OLS) regression models were employed. The regression result also revealed that agricultural technology adoption has a positive and significant effect on farm income by which adopters are better-offs than non-adopters.

2.8 Constraints to Smallholders' Technology Adoption

Technology adoption among smallholder farmers have been observed to very low, spite of several effort made facilitate their access to agricultural information and improved technologies (Ajayi et al., 2003 and MOFA, 2010). Technology adoption is decision making process which subject certain constraints. These constraints are usually issued from external factors as captured in TAM2 and TAM3.

A key determinant of sustained adoption is farmers' capacity to meet the resources and technical demand of the technology. Applied new technology come at cost and demand for farmers to acquire the requisite skills and expertise. Most smallholder farmers in Ghana are illiterate and resource poor) MOFA, 2010). The changing prices for agricultural products are shown to be a major factor in agricultural technology adoption (Kijima et al, 2011). Initially attracted by higher product prices, farmers can abandon the technologies if the expected benefits from adoption are lower than the prevailing costs.

Another reason highlighted in the literature, which drives agricultural technology adoption, is peer effects or learning from other farmers. According to Oster and Thorton (2009) any technology adoption process, peer effects work in three major ways: (1) individuals profit from acting like friends or neighbours; (2) individuals gain knowledge of the benefits of the technology from their friends; and (3) individuals learn about how to use a new approach from peers.

Smallholder farmers are constraints regarding their access to agricultural information and extension services. Because of they are resource constrained they often lack the resources to access information. According to Kasirye, (2013) literature on agricultural technology adoption highlights two major drivers of successful agricultural technology adoption in developing countries: (i) the availability and affordability of technologies; and (ii) farmer expectations that adoption will remain profitable—both which determine the extent to which farmers are risk averse (Foster and Rosenzweig, 2010; Carletto et al, 2007). A number of factors drive the above expectations, ranging from availability and size of land, family labour, prices and profitability of agricultural enterprises, and peer effects. The conceptual framework presented here highlights the various pathways through which different factors influence household decisions to adopt agricultural technologies.

One of the most highlighted constraints to agricultural technology adoption is the availability of cultivable land (de Janvry et al, 2011 and Carletto, Kirk and Winters, 2007). It is argued that availability of land helps reduce the liquidity constraints faced by households and also reduces risk aversion. On the other hand, ownership of large tracts of land can facilitate experimentation with new agricultural technologies, and also determine the pace of adoption as large land owners are more likely to be the early adopters (de Janvry et al, 2011).

CHAPTER THREE

METHODOLOGY

3.0 Introduction

This chapter presents methodology used in carrying out the research. It presents overview of the description of the study area, research design employed in carrying out the study as well as sampling techniques used in selecting farmers for the study. Also, data collection procedure and methods of data analysis are presented in this chapter.

3.1 Study Area

The study was conducted in the Bawku West District of the Upper Region. The District was selected because it is among the major maize growing Districts in the Region.

3.1.1 Location

The Bawku West District can be located within the north-eastern area of the Upper East Region and lies roughly between latitudes 10^0 30’N and 11^0 10’N and between longitudes 0^0 20’E and 0^0 35’E as shown in the figure 3.1 (GIS, 2014). The District shares boundary to the North with the Province of Zabre in neighbouring Burkina Faso, to the East with the Binduri and Garu-Tempane Districts, to the West with the Talensi and Nabdam Districts and to the South by the East Mamprusi District. The District capital is Zebilla with the following as major towns; Teshie-Soogo, Binaba-Kusanaba, Sapelliga, Tilli-Widnaba, Saaka, Kobore, Tanga-Timonde, Gbantongo, and Zongoire.

Figure 3.1: Map of Bawku West District

Source: GIS, 2014 cited from GSS, 2014

3.1.2 Agricultural operational Areas

The District Department of Agriculture in facilitating extension delivery has zoned the District into four (4) Zones with twenty- four (24) Operational areas. The operational areas in the four (4)zonesare Galaka, Sapeliga, Komaka, Googo, Saaka-Yikurugu, and Kubore-Yarogu, constitutes zone one. Zone two contains five operational areas namely Zebilla Central, Teshie-Soogu, Kansoogo-Lamboya, Widnaba and Tilli. Zone three contains six (6) operational areas which are Tanga, Timonde, Kamega-Yelwoko, Gbantogo, Boya Central and Boya-Zuyanga, whiles Zone four (4) constitute six (7) operational areas as Binaba Central, Kusanaba, Zongoire, Apotdabogo, Kopella-Agargo, Gabulga, and Gumbare-Aragbira (Documentary review of Bawku West District Department of Agriculture).

3.1.3 Natural Resources

Significantly, two important tributaries of the Volta River, namely the White and Red Volta run contiguous to the District's eastern and western boundaries respectively. The District covers an area of 1,070 km^{-2}, about 12% of the total land area of the Upper East Region and fifth in terms of land (GIS, 2014). The soils and water supply conditions of the District are directly related to the underlying rocks. The major rocks fall within the Birimian and Granite geological formation (Adu, 1969).

The District has less accumulation of organic material in the surface horizons. Annual burning of the vegetation cover at the onset of the farming season and after harvesting reduces the amount of the soil's organic content (District Department of Agriculture, 2017).

The Birimian rocks, often associated with granites, consists of steeply dipping metamorphosed sediments. The predominant soil types mapped in the District belong to *Luvisols, Leptosols, Gleysols* and *fluvosols.* Other less extensive soils include *Plinthosols, Regosols, Vertisols and Cambisols* (Adu, 1969)

Most of the soils, having developed over thoroughly weathered parent materials, are old and have been leached over a long period of time. As a result their organic matter content averaging less than 1% is generally low (Adu, 1969). Their buffering capacity as well as cation exchange capacity is also low since their predominant clay mineral is kaolinitic. Most of the soils are consequently of low inherent fertility. The two most important frequently deficient nutrients are nitrogen and phosphorus. The build-up of any amount of organic matter is constrained by regular burning of crop residue and/ or competitive use of these residues for fuel, animal feed or building purposes (Department of Agriculture, 2016).

3.1.4. Population of the District

The population of Bawku West District, according to the 2010 Population and Housing Census, is 94,034 representing 9.0 percent of the Upper East Region's total population. Males constitute 48 percent and females represent 52 percent of the district's population. It has a population growth rate of 3.5% and a population density of 77.6 persons per square kilometre. The average household size is estimated at 6 persons per household (GSS, 2014).

3.1.5 Agriculture and Farming Activities

Agriculture constitutes the dominant economic activity in the district. More than 80% of the active population derives their income and livelihood from agriculture (farming – crops, livestock and fishing) and agriculture related activities (agro-processing – pito brewing, shea butter extraction, groundnut oil extraction, malt production, rice processing, dawadawa processing).The total hectareage in the district suitable and unsuitable for crop production is 58,406 and 336,687 respectively (District Department of Agriculture, 2017).

The main farming system is rain-fed, mixed cropping and permanent farms. Farming households have an average of 1ha around their dwelling places and with 2ha of bush farms. The Department of Agriculture is solely responsible for effective and efficient extension service delivery through the dissemination of proven and tested agricultural technologies and sound innovations to farmers for sustainable agricultural production. The Department does this in collaboration with other relevant stakeholders. Some of which include, the District Assembly; Japan Social Development Funds (JSDF) under Ghana Social Opportunities Project (GSOP), World Vision Ghana (WVG), World Food Programme (WFP) Action Aid (Ghana) International, Northern Rural Growth Programme, (NRGP), Root and Tuber Improvement and/Marketing Programme (RTIMP), USAID ADVANCE and SPRING, Techno-serve Ghana, Anglican Diocesan Development Relief Organisation, and formerly Rural Aid, CODI, NADMO, AgSSIP, SPFS and Diocesan Development Organization (DDO), Tamale (District Department of Agriculture, 2017).

Though there is only rain-fed farming season, most of the farmers engage themselves in dry season farming. Crops mostly grown in the main season are millet, sorghum, groundnuts, rice maize, soya beans and cowpea. The other main crops cultivated in the dry season include onions, watermelon, tomatoes, pepper, okra, and other vegetables. These crops form major cash crops for these farmers. Most rural dwellers depend mainly on agriculture and agriculture related activities for their livelihood. Incomes from these crops are spent on school fees, hospital bills and family upkeep (District Department of Agriculture, 2000).

3.2 Population and Sample Size Determination

All maize farmers in the district constituted the population of this study. These farmers have been contacted by extension officers with information on improved maize technologies. A list of maize farmers in all the 24 operational areas were sourced from the District Department of Agriculture. From the list it was realised that about 5,750 farmers were introduced to the improved maize technologies. Therefore 5750 farmers constituted the sampling frame from which the sample size was drawn.

3.2.1 Sample Size

Cochran's (1977) sample size determination formula was employed in calculating the sample size to be used in this study. Applying Cochran (1977), sample size (n) computation formula as:

$$n = \frac{N}{1+Ne^2}$$

Where n = sample size

N = population of maize farmers who have been introduced with the technology

e = marginal error (5%)

Information gathered from MOFA in the district gave the total number of maize farmers who have been introduced to the improved maize technology as 5,750 farmers.

Thus N = 5,750

$$n = \frac{5{,}750}{1+5{,}750(0.05)^2} = 373.4$$

Thus n = 374 maize farmers. Adding 10% of this to cater for contingencies gave the total sample size targeted as 411 maize farmers. However, 11 farmers sampled could not be reached for interview. Therefore the sample size used in this study is 400 maize farmers.

3.3 Sampling Procedure

The multi-stage sample procedure was employed in selecting respondents for this study. The District (Bawku West) was purposively selected because it is one of the leading maize producing districts in the Upper East Region. Also many NGOs such as Techno – serve, ADVANCE USAID and ADDRO are actively working in the District to promote adoption of improved maize technology. This was followed by stratified random sampling techniques in which the district was stratified along the 24 MOFA operational areas. The 24 operational areas were found not to differ much by the number of maize farmers per the records of AEAs operating in the areas. As such almost equal numbers of samples were selected from each operational area. With the total sample size of 400 farmers, 17 farmers were selected from 16 operational areas and 16 farmers from the remaining 8 operational areas.

From the list of maize farmers introduced to the improved maize technology, a lottery method of simple random sampling techniques was applied in sampling respondents from each operational area.

3.4 Data collection methods

Both primary and secondary data were collected from the sampled farmers, the district department of agriculture and the NGOs working in the district to help improve agricultural production and rural development. Personal interviews, focus group discussions, key informant interviews and in-depth interviews were employed in collecting primary data. While document reviews, web search and discussion with agriculture officers in the district were employed in gathering secondary data for the study.

Semi-structured questionnaire (Appendix ‘A’) was developed and validated by experts and pre-tested in two communities in the Nabdam district, also of the upper east region. The questionnaire is divided into five sections. The first section contains questions on demographic characteristics of the respondents, while section two was used to collect data on agriculture and maize cultivation activities of the respondents. Section three contains questions which sought data on agriculture information on maize technologies, while section four collected data on farmers adoption behaviour. The last section of the questionnaire contains series of statements designed to sourced information on farmers' perceptions towards improved maize technologies.

The questionnaires were administered to the sampled farmers in their own dialect (Kusaal). Since the researcher could speak the language and research assistants also being natives, language barriers was not a problem. Farmers were interviewed in their homes and farms which allowed enumerators to also observed farmers practices relevant to the study.

With the aid of a check list, nine (9) focus group discussions were held in which farmers discussed issues ranging from maize production, technology adoption, access to agricultural information, challenges to constraints limiting their technology adoption. The nine focus group discussions were facilitated by the researcher and two assistant researchers or enumerators who assisted in taking down notes.

Key informant interviews were held with the Director of the District Department of Agriculture, District Extension Officer, Production Managers of ADVANCE-USAID in charge of the Bawku Zone, Food Security Coordinator of ADDRO and officer in charge of business development of Techno-serve – Ghana. These key informants were taking through in-depth interviews sessions in which maize technologies disseminated to farmers in the District were discussed, the technological dissemination strategies use, level of adoption so far and the challenges and constraints to their respective organizations' efforts in improving maize production in the district.

3.4.1 Q – methodological process

In order to collect data on farmers' views, perceptions and general narratives regarding improved maize technologies, Q – mythological process was employed. Q methodology invented by British physicist/psychologist William Stephenson in 1935, is probably the most central and mixed-methodological approach for studying people's subjective points of view about an issue or particular topic of interest (Stephenson, 1935).

Q methodological approach, aside its systematic approach of gathering communicability or discourse surrounding a topic under investigation, everything else about Q methodology falls between qualitative and quantitative approach which makes it robust for perception studies. Upon the development of mixed research methodological approach in the late 1980s by the works of Creswell (Creswell, 2010), both Q Methodology and Q factor analysis is common in behavioural and social science research even though neither are new techniques (Newman and Ramlo, 2010).

Q study has a laid down systematic procedure guiding the gathering of discourse or narratives surrounding an issue of interest. It contains systematic procedure of selecting representative statements from a central fact (concource) gathered and presenting the selected statements to participants sampled for sorting. Watts and Stenner, (2012) observed that Q is a clearly structured, systematic, and increasingly used methodology in studying narratives, perspectives and viewpoints of an issue of interest. It therefore provides a systematic methodology for researchers to explore distinct perspectives, discourses, or viewpoints within a group in order to address practical matters such as the acceptance of new policies and technology or issue of public concern.

Du Plessis, (2005) phased the process of Q methodology into five. The five systematic phases or procedures in Q study, begin with the researcher first collecting a narratives from people involving an issue and then selects a sample of statements representative of the range of communicated ideas in the discourse (Charles, 2011 and Annette and Ulrike, 1997).

After the narratives statements surrounding the issue under investigation is gathered, the task of the researcher then becomes one of selecting or drawing a subset of the collected statements which is representative of the gathered statements (concourse). This selected representative statements is referred to as the ‘Q sample’ which is usually 20 to 60 items, which are eventually presented to participants in the form of a Q sort (Saheed, 2014 and Lefin, 2009).Once the Q sample has been finalised, the statements extracted from either primary and/or secondary need to be prepared for the Q sorting process to commence. Donner (2001) observed that no list of statements is perfect or has to be perfect, the real interest is that the statements selected should be fairly representative of narratives people hold about the issue under study.

Equally an important step in undertaking Q study is selecting participants from people involved in the discourse and asking them to arrange the sample of ideas in their preferred order of importance. In Q methodology, participants are selected from people involved in the discourse. This group of participants is referred to as the person-sample (Du Plessis, 2005).

In this study, farmers’ views and perception relating to improved maize technologies were of interest, as such farmers general narratives or concourse were sought. Primary source of concourse (Primary Q sort) in which farmers, prior to the main field survey were asked open – ended questions on what they think about the various maize technologies, their concerns regarding and the challenges they faced in accessing and adopting the technologies. Twenty four farmers, one from each of the operational areas was contacted to respond to these open ended questions. They were allowed to expressed themselves and their narratives were recorded and or written. The information obtained represents farmers’ narratives or concourse on improved maize technologies. These narratives were constructed into statements representing farmers’ general views on improved maize technologies. To achieve fair representation of the concourse, structured Q –sort process was adopted in which the statements were grouped into issues relating access to information, adoption challenges, perceived usefulness and perceived ease of used. Statements were selected from each sub groups to form the Q sample of 44 statements.

During the personal interview sessions, sampled respondents were asked to rank their agreement regarding the statements and this was recorded as a measured of their perception towards improved maize technologies.

3.5Data Analysis

With the aid of SPSS and STATA, both descriptive and inferential statistics were employed in analysing the data gathered from the administration of the questionnaire. The analytical techniques employed to address each objective is discussed below.

3.5.1. Factor Analysis of farmers' perceptions

In assessing farmer's perception and attitude towards maize based technology, Q – methodological process of gathering narratives was employed. In identifying patterns and connectivity among the various narratives of farmers' perceptions towards the improved maize technology, exploratory factor analysis was applied to the set of narratives gathered.

Factor analysis is a method for investigating whether a number of variables of interest Y_1, Y_2, Y_i, are linearly related to a smaller number of unobservable factors F_1, F_2, ……., F_k. The fact that the factors are not observable disqualifies regression and other multivariate variant analytical techniques (Bengt and Kaplan, 2011).

The factor analysis model can be written algebraically as expatiated in Manly, (2005) and Rencher, (2002). If we have p variables $X_1, X_2, . . . ,X_p$ measured on a sample of ɲ subjects, then variable i can be written as a linear combination of m factors $F_1, F_2, . . . , F_m$ where, as explained above $m < p$. Thus,

$$X_i = \alpha_{i1}F_1 + \alpha_{i2}F_2 + . . . + \alpha_{im}F_m + e_i\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.\ (1.1)$$

Where the α is are the factor loadings (or scores) for variable i and e_i is the part of variable X_i that cannot be 'explained' by the factors.

In obtaining the empirical model, there are three main steps to be followed in undertaking the factor analysis. These are (1) calculating initial factor loadings, (2) factor rotation and (4) calculation of factor score.

Calculate initial factor loadings: This can be done in a number of different ways. The two most common methods are principal component method and principal axis factoring (Bengt and Kaplan, 2011; Manly, 2005 and Rencher, 2002). In this study, the principal axis factoring was employed. With the principal component method as the name suggests, carries out a principal components analysis. However, the factors obtained will not actually be the principal components (although the loadings for the kth factor will be proportional to the coefficients of the kth principal component). Principal axis factoring tries to find the lowest number of factors which can account for the variability in the original variables that is associated with these factors while the principal components method looks for a set of factors which can account for the total variability in the original variables.

However, these two methods will tend to give similar results if the variables are quite highly correlated and/or the number of original variables is quite high. Whichever method is used, the resulting factors at this stage will be uncorrelated (Jolliffe, 2014).

3.5.1. 1 Suitability and Factor Extraction

Exploratory Factor Analysis was applied. The 43 statements were presented to 400 sampled farmers for ranking during the field survey and the rank scores were subjected to factor analysis suitability test to ensure the data set is suitable for factor analysis. Although sample size is important in factor analysis, there are varying opinions, and several guiding rules of thumb as observed by Williams et al, (2012). Also Tabachnick and Fidell, (2007) lamented the lack of agreement on suitable sample size for factor analysis and suggested that at least 300 cases are needed for factor analysis. The Minimum of 300 cases or sample size being suitable for factor analysis is widely referred to as ‘Tabachnick’s rule of thumb’. As such with a sample size of 400 being used in this study, it can then be said that it meets the minimum of 300 case for factor analysis to be conducted.

Before factors analysis was undertaken for factor extraction, Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy (Kaiser, 1970 and Kaiser, Little, Jiffy and Mark, 1974) and Bartlett's Test of Sphericity (Bartlett. 1950) was conducted to determine the accuracy and suitability of the data set for factor analysis. Williams et al, (2012) observed that KMO index, is particularly recommended at least for every one variable or items, there should be at least five participants (1:5). In this study, 400 participants were involved in ranking 44 items, representing cases to variable ratio of 1: 10. The KMO index ranges from 0 to 1, with 0.50 considered suitable for factor analysis (Hair et al, 1995 and Tabachnick et al, 2007). The Bartlett's Test of Sphericity should be significant ($p<0.05$) for factor analysis to be suitable (Williams et al, 2012).

3.5.1.2Criteria in Determining Factor Extraction

The very essence of extraction is to reduce the dimension within the data, in other words to reduce a large number of items into factors. In order to produce simplify factor solutions, several criteria are available to researchers (Williams *et al*, 2012). In order to arrive at reasonable and representative factor solution no single criteria should be used in guiding factor extraction (Costello and Osborne, 2005). Many extraction rules and approaches exist including cumulative percentage of variance criterion, Kaiser’s criteria (eigen value > 1 rule), the Scree test, the cumulative percent of variance extracted, and parallel analysis.

Cumulative percentage of variance (criterion) presents a percentage of variability explain by any given factor solution. Threshold considered reasonable to terminate factor extraction varies across disciplines. Williams *et al*, (2012) observed no fixed threshold exists, although certain percentages have been suggested. According to Hair *et al* (1995) in the natural sciences, factors should be stopped when at least 95% of the variance is explained. In the humanities, the explained variance is commonly as low as 50-60%, as observed in Williams et al, (2012).

The ‘Scree Test’ was given its name by Cattell, (1978) due to the Scree Test graphical presentation, which has visual similarities to the rock debris (Scree) at the foot of a mountain (Williams et al, 2012).Inspecting and interpreting of a Scree plot involves two steps:

1. Draw a straight line through the smaller eigen values where a departure from this line occurs. This point highlights where the debris or break occurs. (If the Scree is messy and difficult to interpret, additional manipulation of data and extraction should be undertaken).

2. The point above this debris or break (not including the break itself) indicates the number of factors to be retained.

However, as noted by Gorsuch (1983), Tabachnick and Fidell, (2001) and Thompson, (2004) interpreting Scree plots is subjective, requiring researcher judgement. Thus, disagreement over which factors should be retained is often open for debate. Although this disagreement and subjectivity is reduced when sample sizes are large, N:p ratios are (>3:1) and communalities values are high (Pett et al, 2003).

The study employed all these approaches in determining the number of factor solutions to extract. Thus multiple decision rule was applied in guiding the number of factor solutions to extract. The decision to apply multiple criteria for determining the number of factors to extract was informed by literature.

Thompson and Daniel (1996; p.200) stated that the "simultaneous use of multiple decision rules is appropriate and often desirable". Also Hair *et al*, (1995) point out that the majority of factor analysts typically use multiple criteria. Williams *et al*, (2012) observed that many peer-reviewed educational and psychological measurement journals now request that multiple extraction techniques are used for a manuscript to be accepted for publication.

3.5.1.3 Selection of Rotational Method

Rotation is applied to rank matrix or plot into simplify the factor structure of a group of items, or in other words, high item loadings on one factor and smaller item loadings on the remaining factor solutions (Costello and Osborne, 2005 as cited in Williams et al, 2012). As such rotation allowed clearer distribution of factor loading among various factors and as such make it easy to see which item is loaded strongly to which factor.

Rotation maximises high item loadings and minimises low item loadings, therefore producing a more interpretable and simplified solution (Williams et al, 2012). Two rotation methods are commonly used. These are orthogonal rotation and oblique rotation. Researchers have several methods to choose from both rotation options, for example, orthogonal varimax/quartimax or oblique olbimin/promax. In this study, varimax rotation method was applied. Orthogonal Varimax rotation is the most common rotational technique used in factor analysis (Thompson 2004). However, regardless of which rotation method is used, the main objectives are to provide easier interpretation of results, and produce a solution that is more parsimonious (Hair and Anderson, 1995 and Kieffer, 1999).

3.5.1.4 Factor Interpretation

After factor extraction, researchers by examining the items loads interpret the factors and labelled them. Interpretation involves the researcher examining which variables are attributable to a factor, and giving that factor a name or theme (Williams et al, 2012). For example, a factor may have included five variables which all relate to pain perception; therefore the researcher would create a label of "pain perception" for that factor. Henson and Roberts (2006) observed that, traditionally, at least two or three variables must load on a factor so it can be given a meaningful interpretation.

The factors extracted in this study were labelled based on the meaning of statements loaded onto them. Finally, calculation of factor score and the determination of factor constructs after rotation have been undertaken were accomplished by standardization of the factor score. This final phase of a Q study involves analysing and interpreting the results of the factor analysis. This is accomplished through the assessment of factor scores and the interpretation of the factor array as well as identifying consensus statements as shared view of the participants.

3.5.2 Analysing Level of Adoption

For objective two, which sought to 'examine the level of adoption of improved maize technology among maize farmers in the Bawku West District' descriptive statistics was used to analyze the number of production recommendations adopted by a farmers. From MOFA and the three NGOs dissemination the technology, it was gathered that the improved maize technology being disseminated comprises of 15 production recommendation as shown in the Table 3.1. Respondents were asked to indicate how frequent they follow these production recommendations in their maize production process. Three Likert points scale as 1if always follow a production recommendation, 2 if sometime follow and 3 if a farmer do not follow a production recommendation at all, were used in scoring farmers' adoption of production recommendations.

Respondents who were always following more than seven (7) production recommendations were classified as high adopters, otherwise low adopters. Frequency distributions were undertaken in SPPSS version 20 to identify the number of production recommendations always follow by farmers.

Table 3.1 Maize Production Recommendations Disseminated to Farmers

Production Recommendations	**Descriptions**
1. Using improved certified seed	Open Pollinated Varieties (pro-seed, abontem, wandata, aburotia, abontem) and hybrid seeds (mamaba, etubi, pannar, pioneer) and hybrid seeds
2. Ploughing	Lose soil to allow root development and movement about 25cm depth for all varieties
3. zero tillage	Practice after ripping land for at least 2 years
4. ridging	Sustain proper moisture and flow of water on the field about 25cm depth.
5. Harrowing	To attain high precision of leveling and fine soil texture about 25cm depth
6. planting in row with recommended planting distance	Aim at increasing plant population in the field, Open pollinated varieties(OPVs) and hybrid seeds, planting distance of 80cm between rows and 40cm between plants and 75cm between rows and 25cm between plants respectively
7. first fertilizer application at the recommended rate and time	To provide the necessary nutrients step for plants, Apply day of planting and or after 4 weeks
8. Second Fertilizer application at the recommended rate and time	To provide the necessary nutrients step for plants, apply after 6 weeks
9. first weeding recommended time	To reduce competition with plants, Use herbicides or weed after 2 weeks
10. Second weeding recommended time	Use selected herbicides or weed after 4 weeks
11. Harvesting at the right	Harvest timely to avoid infections and post-harvest loses, that is 110 days for both OPVs and hybrids but 90 for pioneer and Abontem
12. Drying cobs to the right moisture level	1 week sun drying under moist free environment. using of plastic / ‘tapoli’ platform
13. Drying grain to the right moisture level	1 week to a moisture content of 20 degree celcious
14. Market sourcing	Agri-Care, feeding schools and or open market

15. Signed up to Crop insurance policy	Ghana Agricultural Insurance Pool, Premium is 5% of the cost of production; Drought Index Insurance for 50 acres or less and Double Peril Insurance for 50 acres or more. 1st phase (planting)-20% 13 days drought, 2nd phase (weeding and fertilizer application)-50% 26 days drought. If water content is ranging 150mm-75mm or less during flowering-100% of production cost payment is triggered.

Source: District Department of Agriculture, 2017

3.5.3Analysis of Determinants of Adoption

To identify the factors that influence the adoption of improved maize technology among farmers, probit regression model was adopted. The theoretical basis of modeling determinants of farmers' level of adoption is informed by the Random Utility Theory (RUT).

The random utility theory follows the utility-maximization condition which assumes that rational farmers will select a product only if the products provide him the highest utility given a constraint. Based on this theory, farmers' decision to adopt a technology is a problem of choice. McFadden (1974) developed the random utility models which are appropriate for modeling individuals' behaviour based on choices. The utility a farmer derives from a product can be represented as having two components; a utility function of observed characteristics known as the deterministic component of utility and the unobserved component known as the random component. The deterministic component is exogenous and includes farmers' characteristics and technology characteristics and a set of linearly related parameters and the random component may result from missing data/variables (omitted variable), measurement errors and misspecification of the utility function.

This function is specified below:

$$U j = X\beta + \varepsilon \qquad (2.1)$$

Where,

$$X\beta = v$$

where U_{ij} is the maximum utility attainable when alternative j is chosen by consumer i; $X\beta$ is the deterministic component of the utility function, X is a vector of observable socio-demographic and economic characteristics, product-specific factors that influence utility, β is the unknown parameter vector to be estimated and ε is the stochastic term.

3.5.3.1The probit regression model

The probit model was used to estimate determinants of adoption of improved maize technology. Probit model is appropriate for modeling dichotomous dependent variable (adoption) which takes value 1 for high adopters, (if a farmers adopts more than seven out of the 15 production recommendations constituting the improved maize technology) and 0 for low adopters (if a adopts less than seven of the production recommendations of the improved maize technology).

Another important discrete model is the logit regression model which produces similar results as the probit model. The difference between logit and probit models lies in this assumption about the distribution of the errors. The logit model has standard logistic distribution of errors where the probit model has standard normal distribution of errors. Again, the estimated parameters in the probit results are between 50% and 60% smaller in absolute value than the corresponding parameter estimates in the logit results.

But then the choice of employing the probit model for the analysis was based on its realistic standard normal distribution of errors. The Probit model assumes that there is a latent continuous variable that determines the value of the observed dependent variable credit specified as;

$$y^* = \beta_0 + \sum_{i=1}^{n} x\beta + u_i \qquad (2.2)$$

Where y* is the latent continuous variable, X_i is a set of explanatory variables assumed to influence adoption, β_i is a vector of unknown parameter to be estimated and u_i is the statistical noise assume to be normally and independently distributed with a zero mean and a constant variance. The method of estimation of the probit model was by maximum likelihood and interpretation of probit results will be based on marginal effects treated as probabilities, which explains the slope of the probability curve relating one explanatory variable to prob(y=1|x), holding all other variables constant.

The observable dependent variable is defined by:

$$y = \begin{Bmatrix} 1 \text{ access if } \ y^* > 0 \\ 0 \text{ no access if } \ y^* \leq 0 \end{Bmatrix} \qquad (2.3)$$

The probit model Y follows the Bernoulli distribution with probability

$$\pi_i = prob(y=1) = \Phi(X\beta) \qquad (2.4)$$

where π_i is the probability that an individual adopted the improved maize technology, X_i' is the explanatory variables, β is the regression parameters to be estimated.

In the probit model functional distribution of the error is very important to constrain the values of the latent variable into desirable property of probability values of 0 and 1. The probit model assume a cumulative distribution function of standard normal distribution represented by Φ .

$$\begin{aligned} & prob(y=1) = prob(y_i^* > 0) = prob(\beta X + e > 0) \\ & = prob(e > -\beta X) \\ & = prob(e < \beta X) \\ & = \Phi(\beta X) \end{aligned} \qquad (2.5)$$

In the case of normal distribution function, the model to estimate the probability of observing a farmer adopting the improved maize technology can be stated as:

$$Pr\ ob\left(y_i = 1/X\right) = \Phi\left(\beta X\right) = \int_{-\infty}^{\beta X} \frac{1}{\sqrt{2\Pi}} exp\left[\frac{-z^2}{2}\right] \partial z \qquad (2.6)$$

Where

prob is the probability of the farmer adopting the improved maize technology, X is a vector of the explanatory Variables, z is the Standard Normal Variable (z ~N $(0, \delta^2)$) and β is a k by 1 vector of the Coefficients estimated.

Therefore, the Empirical Probit model is specified in the following form:

$LV_i = +\beta_0 + \beta_1X_1 + \beta_2X_{2i} + \beta_3X_{3i} + \beta_4X_{4i} + \beta_5X_5 + \beta_6X_{6i} + \beta_7X_7 + \beta_8X_8 + \beta_9X_9 + \beta_{10}X_{10} + \beta_{11}X_{11i} + \beta_{12}X_{12i} + \beta_{13}X_{13} + Ui$

Definition of variables used in the model is shown in the Table 3.2

Table 3.2: Variables used in the model

Variable		**Description**	**Hypothesized sign**
	Dependent Variable		
LV_i	Level of adoption	Dummied as 1 if adopt more than of recommendation and 0 otherwise	
	Explanatory Variables		
X_1	Age	In years	+/-
X_{2i}	Sex	Dummied as 1 if male and 0 if female	+/-
X_{3i}	Marital Status	Dummied as 1 if married and 0 otherwise	+
X_{4i}	Literacy	Dummied as 1 if have can read and/or write and 0 otherwise	+
X_5	HH Size	Number of persons in a household	+
X_{6i}	Member of FBO	Dummied as 1 if belongs to FBO and 0 otherwise	+
X_7	Experience	In years of farming maize	+
X_8	Farm Size of Maize	In acres	+/-
X_9	Farm Size Others	In acres	-
X_{10}	HH Annual Income	In GH C	+
X_{11i}	Access to labour	Dummied as 1 if have full access to labour and 0 otherwise	+
X_{12i}	Access to credit	Dummied as 1 if ever taken loan for farming and 0 otherwise	+
X_{13}	Extension contact	Number of extension visits received in a seasons	+

Source: Author, 2017

3.5.4 Analysis of effect of level of adoption and Maize yield

For objective four which sought to ‘examine the effect of farmers’ level of adoption of improved maize technology on yield of maize among maize farmers in the Bawku West District’ Analysis of Variance (ANOVA) was used and the following hypothesis was tested.

H_0: There is no difference in the maize yield of high adopters and low adopters

H_a: There is significant in the maize yield of high adopters and low adopters

3.5.5 Analysis of Constraints to Adoption

For objective five which sought to ‘examine constraints to adoption of improved maize technology among maize farmers in the Bawku West District’ the constraints were ranked inorder of severity and Kendall’s coefficient of concordance applied in assessing the level of agreement among the ranks.

The Kendall’s concordance analysis was used to test for the agreement among the rankings by the respondents. According to Legendre (2005Kendall’s coefficient of concordance (W) is a measure of the agreement among several judges (P) who are assessing a given set of (n) objects.

W is an index that measures the ratio of the observed variance of the sum of ranks to the maximum possible variance of the ranks. This idea is to find the sum of the ranks for each constraint being ranked. If the ranking are in perfect agreement, the variability among these sums will be maximum (Mattson, 1986). The Kendall’s concordance coefficient (W) is therefore given by the equation:

$$W = 12S/p^2 (n^3 - n) – pT \text{……………………………………………………………} (3.1)$$

Where W denotes the Kendall's Concordance Coefficient, p denotes number of constraints, n denotes the number of respondents (sample size), T denotes correlation factor for tied ranks and s denotes sum of square statistics. The sum of square statistic (S) is given as:

$S = \sum (R_i - R)^2$ ………………………………………………………………………… (3.2)

Where: R_i= rows sums of ranks

R = the mean of R_i

The correlation factor for tied ranks (T) is also given as:

$T = \sum (t_k^3 - t^k)$…………………………………………………………………………. (3.3)

Where: t_k = the number of ranks in each (k) of m groups of ties.

The hypothesis to be tested is stated as follows, where H_o and H_1 denotes null and alternative hypothesis respectively.

H_o: There is no agreement among the rankings of the constraints

H_1: There is an agreement of the Kendall's concordance was done using the chi-square (X^2) statistic which is computed using the formula;

$X^2 = p (n - 1) W$………………………………………………………………………….. (3.4)

p = number of constraints

w = Kendall's coefficients of concordance

The decision rule is that if the calculated chi-square is greater than the critical, then the null hypothesis is rejected in favour of the alternate hypothesis that there is agreement among rankings of the constraints.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.0 Introduction

This section presents results of analysis and discussion of data collected on 400 maize farmers in the Bawku West District of the Upper East Region. The data were gathered from a cross sectional survey conducted to assess farmers' perceptions towards improved maize technology and their level of adoption. This chapter is divided into six (6) sections with the first section dedicated to presenting demographic and farm characteristics of the 400 farmers surveyed. The second section presents findings of farmers' perceptions and attitudes towards the improved maize technology which have been disseminated to farmers in the District by MOFA and other NGOs for some years. The third section presents results and discussion on farmers level of adoption of the improved maize technology, while section four discusses factors found to be significant in influencing farmers adoption level. The fifth section presents findings and discussion of the effect of adoption of the improved maize technology on maize yield, while the last section (section six) presents findings of factors militating against farmers' adoption of the improved maize technology.

4.1 Personal and Farm Characteristics

This section presents description of demographic and farm characteristics of the farmers' surveyed in this study. The section presents sex, age, education, marital status and source of household income as selected socio demographic characteristics of the 400 farmers surveyed. It also presents information on farm characteristics such as farm size, major crops grown, access to labour and extension among others of the respondents surveyed.

4.1.1 Socio demographic Characteristics

The 400 farmers interviewed mainly engage in on-farm livelihood activities such as growing cereals crops, mainly maize, rice and millet, leguminous crops mainly soybean and groundnut and some vegetable such as pepper, okra and leafy vegetables. As shown in Table 4.1, almost all the 400 farmers (95.8%) indicated that their household depends on on-farm livelihood activities for their living and income sources. This finding is similar to the findings of Ghana living standard round six, which indicated that most Ghanaians in the three northern regions depend on farm or agricultural related activities for their livelihoods (see GSS, 2014a).

With female farmers playing critical role in agriculture in Ghana (MOFA, 2012) it was surprising that only a quarter (24.5%) of the maize farmers surveyed were female. The selection criteria used in this study could account for low level of female farmers captured in the study. In the study only farmers who have been introduced to the improved maize technology package either by MOFA or NGOs working in the district were targeted for sampling. Because female farmers always have little contact with extension field officers, their involvement in any agricultural projects are always low (MOFA, 2012).

The respondents surveyed in the study are within their youthful age range with majority (51%) being younger than 36 years, whiles about 45.3% were between the ages of 36 to 60 years, with only 2.5% being older than 60 years (table 4.1). This is in sharp contrast to the findings of Ghana agricultural sector review report, which indicated average Ghanaian farmer age and that the youth are not going into farming (MOFA, 2010).

Regarding marital status, the analysis reveals that overwhelming majority (87.5%) of the respondents are married, with only 8% being single and 4.6% being either divorced or windowed. This findings do not compare fairly well with the district's results of the 2010 Population and Housing census. The census results indicated that about half (52.2%) of the population aged 12 years and older are married, 36% have never married, 0.2 percent are in consensual unions, 9.2 percent are widowed, 1.5 percent are divorced and 1.0 percent are separated (GSS, 2014b).

Also most (67.3%) of the 400 maize farmers surveyed have no formal educational background, while 23.3% are educated to the basic level and 6.5% and 3% respectively have secondary and tertiary levels of education. Education has been noted as very critical in farmers' technology adoption and their ability to manage and profit efficient and profitable farming activities.

Table 4.1: Frequency Distribution of Farmers' on Socio demographic Characteristics

Sociodemographic Characteristics		**Frequency**	**Percent (%)**
Sex	Male	301	75.3
	Female	99	24.8
	Total	**400**	**100.0**
Age category	Younger than 25years	23	5.6
	25 - 35 years	181	45.3
	36 - 60 years	186	46.5
	60+ years	10	2.5
	Total	**400**	**100.0**
level of education	No formal education	269	67.3
	Basic level	93	23.3
	Secondary	26	6.5
	Tertiary	12	3.0
	Total	**400**	**100.0**
marital status	Married	350	87.5
	Single	32	8.0
	Divorced	9	2.3
	Windowed	9	2.3
	Total	**400**	**100.0**
Main Source of Household Income	Non-farm	383	95.8
	Off-farm	18	4.2
	Total	400	100.0

Source: Field survey data, 2016

4.1.2 Farm Characteristics

Most of the farmers interviewed indicated that they relied on labour pool from their household members to undertake their farming activities. The average household size was found to be about 9 persons per household with minimum household size of 3 persons and a maximum of 25 persons (table 4.2). This is more than double the average household size in Ghana which is 6 persons (GSS, 2012). Also the average persons per household who within the active labour group 15 – 60 years was found to be about 4 persons, while household members younger than 15 years was also found to be an average of 4 person per household (table 4.2).

Belonging to Farmer Based Organizations (FBOs) have been found to have significant positive impact on farmers' access to agricultural information and for that matter adoption of innovation. In this study, only 27% of the 400 farmers interviewed belong to farmer based organizations while the remaining 73% are not members of FBOs. However, the average extension contact (extension agent visits per season) was found to be 4.11 (SD = 2.63), indicating the farmers have reasonable contact with extension agents. Farmer groupings and establishing of FBOs have long be promoted by the Ministry of Agriculture in order to create a platform for farmer collective action and making agricultural information dissemination much easier and effective (MOFA, 2010 and 2012).

Farmers interviewed are very much experienced in maize farming with an average of 20 years' experience in cultivating maize. The least experienced maize farmer among the 400 farmers interviewed have been cultivating maize for just two (2) years, while the more experienced ones have been cultivating maize for 53 years. Experience in maize production has been demonstrated to have positive effect on improved maize technologies adoption and best practices in maize farming. Salifu and Salifu (2015), in assessing the determinants of

Farmers Adoption of Improved Maize Varieties in the Wa Municipality, found experience in maize farming to have a positive effect on adoption of improved maize varieties.

The farmers surveyed can be described as medium scale farmers, cultivating an average of 12 acres (5ha) of maize and about 5 acres (2ha) of other crops. Thus in total the average farm size for all crops being cultivated by the farmers surveyed is about 7ha compared with average farm holding in Ghana been 2ha (MOFA, 2010). As such they can be described as being medium scale farmers holding more than three times the average farm holding in Ghana.

Table 4.2: Descriptive Statistics of Farm Characteristics

Farm Characteristics	**Mean**	**Std. Dev.**	**Min**	**Max**
Household Size	8.90	4.01	3.00	25.00
Household Members less than 15yrs	4.25	3.35	0.00	19.00
Household member 15 - 60 years	4.33	2.30	0.00	11.00
Member of FBOs	0.27	0.44	0.00	1.00
Experience in years	20.16	9.95	2.00	53.00
Farm Size of Maize in acres	11.71	4.88	2.00	43.00
Farm Size Others in acres	4.67	1.57	2.00	9.00
Extension contact inmonths	4.11	2.63	2.00	20.00

Source: Field Survey Data, 2016

4.2Farmers' perception towards improved maize technology

This section presents findings on the perception of farmers towards maize technology and as such sought to address objective one of this study which sought to 'analyze farmers' perception and attitude towards improved maize technology among maize farmers in the Bawku West District'.

4.2.1 Exploratory Factor Analysis

Through Q methodological process, farmers' narratives on improved maize technology were gathered. Prior to personal interviews of the 400 maize farmers, in-depth interviews (focus group discussions) were conducted with ten (10) selected farmers on broad issues regarding the improved maize technology. This was done to gather their views on the improved maize technology, ranging from source of information on the technology, application of the technology, constraints and challenges to adopting the technology and the benefit of the technology.

Their entire views on the technology provided primary sources for the concourse of farmers' views on improved maize technology. Also information gathered from key informants' interviews of crop subject matter specialists in the District Department of Agriculture, staff of NGOs working to improve maize production, extension officers, seed and input suppliers were also relied on in compiling the concourse of narratives on improved maize technology.

Statements were extracted from the concourse and during the personal interviews of the 400 maize farmers, interviewees ranked their agreement level on the statements on five (5) Likert scale as 1; if strongly disagreed to 5; if strongly agreed. The agreement ranks scores were subjected to Exploratory Factor Analysis (EFA) to identify the underlying dimensions characterizing farmers' perceptions towards improved maize technology.

EFA is exploratory in nature and as such the investigator has no expectations of the number or nature of the variables. EFA allows the researcher to explore the main dimensions to generate a theory, or model from a relatively large set of latent constructs often represented by a set of items or statements (Pett, Lackey and Sullivan, 2003; Thompson, 2004; and Herson and Roberts, 2006).

In this study, forty four (44) statements were extracted from the concourse of farmers' narratives on improved maize technology and the ranking of the 44 statements were subjected to dimension reduction by the application of the EFA.

4.2.1.1Test for Suitability of Factor Analysis

Prior to the application of EFA, the suitability of the data set were subjected to various tests of suitability for factor analysis. These tests include Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy (Kaiser, 1970; Kaiser, Little, Jiffy and Mark, 1974) and Bartlett's Test of Sphericity (Bartlett, 1950). Williams et al, (2012) observed that KMO index, is particularly recommended at least for every one variable or items there should be at least five participants (1:5). In this study, 400 participants were involved in ranking 44 items, representing participants to variable ratio 9: 1. The KMO index ranges from 0 to 1, with 0.50 considered suitable for factor analysis (Hair et al, 1995 and Tabachnick et al, 2007). The Bartlett's Test of Sphericity should be significant ($p<0.05$) for factor analysis to be suitable (Williams et al, 2012).

As such the data set were subjected to KMO test conducted in SPSS together with Bartlett’s test. Table 4.3 shows the value of KMO and the results of Bartlet test. As shown in the Table, the KMO measure of sampling adequacy was 0.875, indicating a very high level of sampling adequacy suitable for factoring, while Bartlett’s test of sphericity was found to be significant at 1% level of significance. The meaningfulness of Bartlet test being significant at 1% and the appropriate value of KMO index showed that the correlation matrix in the sample is not zero. Therefore, the data set is suitable for factor analysis and as such the act of finding factors with this data is statistically justifiable.

Table 4.3: KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.875
Bartlett's Test of Sphericity	Approx. Chi-Square	24949.046
	Df	946
	Sig.	.000

Source: Field Survey Data, 2016

4.2.1.2 Determination of number of factors to extract

The determination of the number of factor solution was guided by available literature to ensure adequate number of factors which account for the underlying constructs of farmers' perceptions on improved maize technology. Many authors have commented on the importance of deciding on how many factors or components to retain when applying EFA (Ledesma and Valero-Mora, 2007; Hayton, Allen, and Scarpello, 2004 and Fabrigar, Wegener, MacCallum, &Strahan, 1999).

The guidelines widely used to determine the number of factors to retain in EFA are Kaiser's eigen value greater than one rule (K1), parallel analysis method of Monte Carlo, percentage of variance explain by a given number of factor and Scree test (Ledesma *et al*, 2007 and Hayton et al, 2004). As such in this study the number of factors extracted was guided by these principles to ensure optimum number of factors adequately addressing the underlying constructs characterizing farmers' perceptions on improved maize technology are retain.

The K1 method proposed by Kaiser (1960) is perhaps the best known and most utilized in practice (Fabrigar*et. al*, 1999). According to this rule, only the factors that have eigen values greater than one are retained for interpretation. As observed by Ledesma *et al*, (2007), despite the simplicity of K1 method, many authors agree that it is problematic and inefficient when it comes to determining the number of factors. To overcome this weakness, the eigen value >1 rule was applied together with the scree plot and the Total Percent Variance Explained by any given factor as recommended by Ledesma, *et al*, (2007) and Hayton *et al*, (2004).

The distribution of total variance explained by a given factor solution is shown in table 4.4. As shown in the table (table 4.11), a single factor dimension explained about 40% of the total variance, while two factor solution cumulatively explained more than half (51.4%) of the total variance. Also, three and four factor solutions cumulatively explained about 59.3% and 65.3% of the total variance in the data set respectively. Finally five and six factor solutions cumulatively explained about 70% and 73% of the total variance in the data set.

Cumulative percentage of variance (criterion) used as a threshold in determining the number of factors to be extracted from a data in factor analysis, varied across disciplines and focus of research interest. Henson and Roberts, (2006) asserted that, no fixed threshold exists as a criterion for determining the number of factors to be extracted as a true representative of the underlying dimensions within a data set.

However, according to Hair et al. (1995), in the natural sciences, factors extraction should be stopped when at least 95 percent of the variance is explained. In the humanities, the explained variance threshold used is usually peaked at 50-60 percent (Pett, Lackey and Sullivan, 2003). As shown in the Table 4.4, six (6) factor solutions cumulatively explained about 73% of the total variance and as such the factor extractions were terminated there.

Therefore six factors were extracted as the underlying dimension characterizing farmers' perceptions towards improved maize technology. The cumulative percentage of variance explained by the six factors extracted explained about 73% of the total possible dimensions within the data set. This met the threshold cumulative variance explained percent mostly used in humanities and social science as asserted by Pett*et al*, (2003).

Table 4.4 Distribution of Total Variance Explained by given number of factors

Factor	Initial Eigen values			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	17.636	40.082	40.082	17.462	39.686	39.686
2	5.370	12.205	52.287	5.144	11.692	51.378
3	3.764	8.555	60.843	3.497	7.947	59.325
4	2.997	6.812	67.654	2.620	5.954	65.279
5	2.197	4.994	72.649	1.922	4.368	69.647
6	1.555	3.534	76.183	1.261	2.866	72.513

Source: Field Survey Data, 2016

The six factors extracted in addition to the percentage of variance explained was also guided by scree plot as shown in the Figure 4.1. A scree plot displays the eigen values associated with a factor in descending order versus the number of factors. A scree plot shows the eigen values on the y-axis and the number of factors on the x-axis. It always displays a downward curve. The visual representation of the scree plot can be used in factor analysis to demonstrate and determine which factors explain most of the variability in the data. The point where the slope of the curve is clearly leveling off (the “elbow) indicates the number of factors that should be generated by the analysis (Tabachnick and Fidell, 2007). As shown in the figure 4.1, the point where the scree plot curve is clearly leveling off occurs at factor six which indicates that six factor solution is very appropriate in explaining the underlying dimensions characterizing farmers’ perceptions towards improved maize technology.

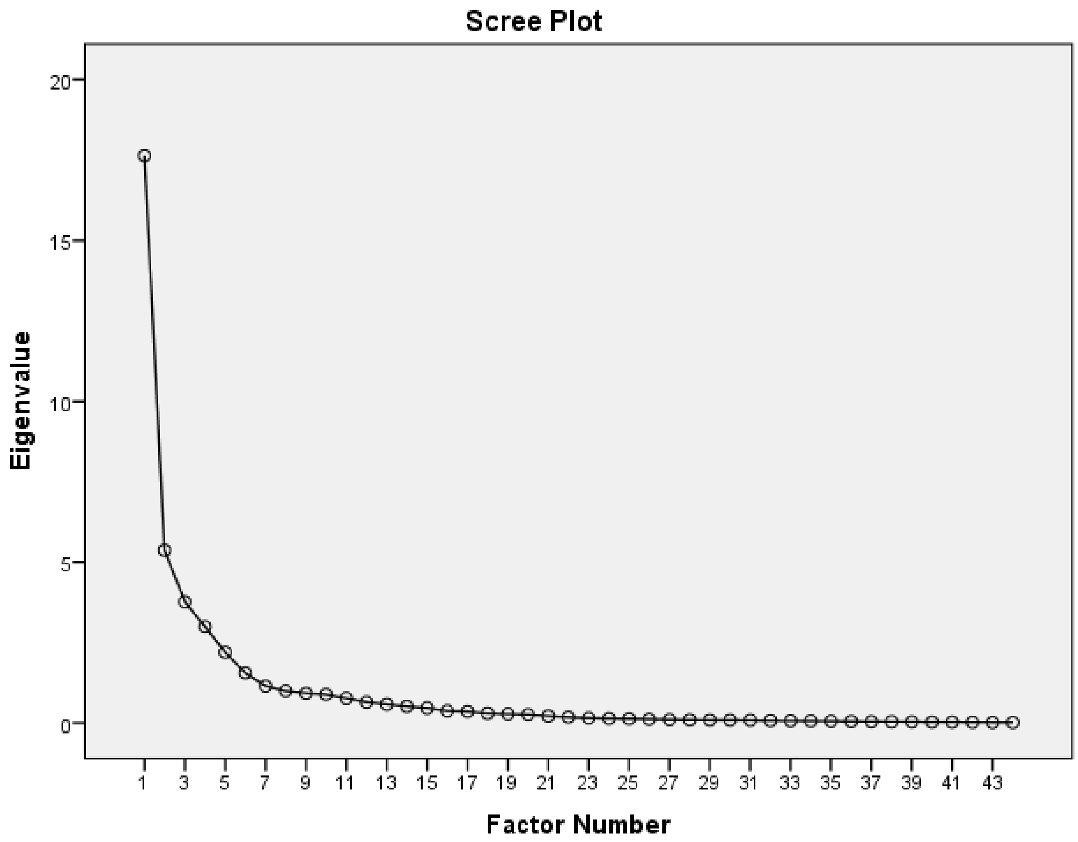

Figure 4.1: Scree plot of factor number and Eigen value

Source: Field Survey Data, 2016

4.2.1.3 Interpretation of factors Extracted

Respondents' agreement rank scores of the 44 statements extracted from farmers' narratives on improved maize technology, was analysed using Exploratory Factor Analysis (EFA) as a dimension reduction technique in order to reduce the 44 dimensions in the data sets to a manageable size which explain the underlying constructs of farmers' views on Improved maize technology. The six factors extracted explained about 73% of the total variance characterizing the various dimensions in the data set gathered on the narratives of maize farmers on issues relating improved maize technology and its adoption.

Factor loading which measure the relationship of each variable to the underlying factor and produced in SPSS factor analysis output was used in determining the number of statements or item associated with each of the four factors extracted. Distribution of factor loadings across the four factors is presented in the Table 4.5. Factor loadings below 0.4 were suppressed in order to have a clear factor interpretation and to clearly determine which variable strongly load to which factor.

As shown in the Table 4.5, the EFA with varimax rotation conducted revealed the following distributions of items loading onto the six factor solutions identified; ten (10) statements were loaded onto factors one (1), eight (8) statements were loaded onto factors two (2), seven (7) statements were loaded onto factors three (3) and another seven (7) statements were loaded onto factors four (4). Also another seven (7) statements were loaded to factor five (5) and five (5) statements on factor six (6).

The factor labeling was based on the generality of the statements loaded onto them. As shown in Table 4.5, the entirety of statements loaded on factor one suggest accessibility of information and inputs in order to implement the production recommendations in the package of the improved maize technology. As shown in the Table (table 4.5) statements such as ‘I don’t have access to weather information’, ‘certified maize seeds are not easily accessible in this area’ and ‘I don’t have access to extension staffs to enable me discuss problems with my maize for solution’ among others were all loaded to onto factor one. As such factor one is labeled as ‘**inaccessibility issues**’.

Table 4.5: Distribution of Factor loading across factors

	Factor					
	1	2	3	4	5	6
Inaccessibility issues						
1. I don’t have access to weather information	.888					
2. certified maize seeds are not easily accessible in this area	.880					
3. I don’t have access to enough land and that is why i don’t farm commercially	.877					
4. I don’t have access to extension staffs to enable me discuss problems with my maize for solution	.868					
5. I don’t have access to a combine harvester to harvest my maize	.735					
6. tractor service providers are not easily accessible so I don’t rely on them	.730					
7. I don’t have access to information concerning seasonal rainfall pattern or raining days	.658					
8. maize shelling and thrashing machines are difficult to access here that is why I thrush my maize late	.575					
9. I lack access to reliable market information and that affect pricing of my maize	.495					
10. I don’t have access to credit to expand my farm	.493					
Inappropriate technology						
1. I keep records because the banks ask for it any time i need a loan		.932				
2. I don’t use chemicals to control weeds because i have been hearing they can destroy the soil		.866				
3. what I have been hearing about this certified seed is not good		.856				
4. I often relied on bullocks or bulls to plough my farm land		.772				
5. the rain at times wet and destroys my maize when drying because I don’t use a tarpaulin or have enough tarpaulin		.699				
6. I am not sure the insurance companies will keep to their terms		-.623				
7. I hardly encounter disasters so insuring is waste of money		.567				
8. I have trust on maize seeds I select from my previous harvest		.454				
Complexity issues						
1. I don’t use weedicides to control weeds because it is difficult to follow recommended measurement and spray rate			.942			
2. loans payment terms are highly unbearably			.901			
3. I don’t have the necessary farm tools or implement to comply with the recommendations			.817			
4. recommended planting distance for certified seed is difficult to practice			.686			
5. the consequences of defaulting a loan is too strict			.654			

6. recommended planting distance for certified seed is time consuming to practice			.653			
7. I need a lot of labour to harvest on time, so that is why I always harvest some maize late			.592			
Incompatibility Issues						
1. records are not important to me that is why i don't keep records				.868		
2. loans processes is very cumbersome				-.716		
3. I don't normally keep farm records of my farm activities				.700		
4. mixed farming practices is the best to cope with on certainties in crop production				-.707		
5. I always use manure for my livestock to fertilize my maize farm				-.547		
6. keeping of livestock do not allow me to have enough time for my maize farm				.542		
7. the group mode of credit disbursement is not save and suitable for me				.487		
Cost and affordability issues						
1. I control weeds manually because I can't afford to buy weedicides to control them					.848	
2. tractor service are expensive and beyond what I can afford					.827	
3. the premium for crop insurance policy is too high					.802	
4. I don't use the tractor to thrush because i cannot afford to pay					.740	
5. maize farming is capital intensive but minimal profit margin, that is why I don't farm maize commercially					.695	
6. certified maize is very expensive and beyond what I can afford					.632	
7. record keeping attract cost and I cannot afford to pay for the service					.529	
Poor capacity issues						
1. I control weeds manually on my maize farm because I don't know how to use chemicals to control them						.920
2. I don't fully understand the concept of crop insurance						.566
3. certified seed growers always deceive us to buy their seeds						.761
4. I easily forget their difference in use and function						.767
5. there is poor marketing opportunities for maize						.488

Extraction Method: Principal Axis Factoring.
Rotation Method: Varimax with Kaiser Normalization.

Source: Field Survey Data, 2016

Also, as shown in the Table 4.5, statements such as ‘I keep records because the banks ask for it any time I need a loan’, ‘what I have been hearing about this certified seed is not good’, ‘I am not sure the insurance companies will keep to their terms’, ‘I hardly encounter disasters so insuring is waste of money’ and ‘I have trust on maize seeds I select from my previous harvest’ among others were loaded onto factor two (2). Critical examination of the general import of all the statements indicates that respondents are wondering about the appropriateness of some of the production recommendations in the improved maize technology package. As such factor two (2) is labeled as ‘**Inappropriate technology’** as perceived by farmers.

With regard to factor three (3) the generality of all the statements loaded onto it expressed farmers’ views of how difficult and complex it is for them to apply the production recommendations constituting the improved maize technology. As shown in table 4.5, statements including ‘I don’t use weedicides to control weeds because it is difficult to follow recommended measurement and spray rate’, ‘recommended planting distance for certified seed is difficult to practice’ and ‘I need a lot of labour to harvest on time, so that is why I always harvest some maize late’ were loaded onto factor three. As such factor three (3) was labeled as ‘**Complexity issues**’.

For factor four (4), the import of the statements loaded onto it paint a picture of incompatibility of some of the production recommendations with farmers’ current practice. Statements such as ‘records are not important to me that is why i don’t keep records’, ‘mixed farming practices is the best to cope with on certainties in crop production’ and ‘the group mode of credit disbursement is not save and suitable for me’ were loaded onto factor four. As such factor four is given the label ‘**incompatibility Issues** ’.

Regarding, factor five, the statements loaded on it were generally about issues of cost involve in implementing the production recommendations in the improved maize technology. As shown in the Table 4.5, statements such as ‘I control weeds manually because I can’t afford to buy weedicides to control them’, ‘tractor service are expensive and beyond what I can afford’, ‘certified maize is very expensive and beyond what I can afford’ and ‘I don’t use the tractor to thrush because i cannot afford to pay’ among others. As such, factor five is labeled as ‘**cost and affordability issues**’.

The last factor (factor six) have statements such as ‘I control weeds manually on my maize farm because I don’t know how to use chemicals to control them’, ‘I don’t fully understand the concept of crop insurance’ and ‘I easily forget their difference in use and function’ among others, loaded onto it. All these statements portrayed issues of individual farmer’s capacity to understand and adopt production recommendations in the package of improved maize technology being disseminated among maize farmers in the District. As such factor six is labeled as ‘**Poor capacity issues**’.

Thus, six factors are identified as underlying dimension characterizing farmers’ perceptions towards improved maize technology. These dimensions are **inaccessibility issues**, **inappropriateness** of some production recommendations, **issues of complexity**, **incompatibility issues**, **cost and affordability issues** and **issues of poor capacity** of farmers to adopt some of the production recommendations.

In general maize farmers surveyed are concerned with what they perceived as inaccessibility of some certified seeds and other inputs and information needed to adopt the improved maize technology. They are also concerned about the difficulties and complexities of implementing some of the production recommendations such planning in line at the recommended distance, applying fertilizer at the recommended rate and time among others. Farmers viewed some of the production recommendations as inappropriate in their case. There is also concerns about the cost of some of the inputs require to implement the production recommendations. They perceived the cost of certified and improved seeds, fertilizer and tractor services as high.

4.2.2 Attitude towards Improved maize technology

This section presents farmers' agreement ranking scores of all the statements falling in each factor, in order to assess farmers' inclination or disposition regarding those perceptions. This is to gauge their attitude towards those perceptions and views. Perceptions and attitude have been widely captured in the adoption theories. For instance Fishbein and Ajzen, (1975) Theory of Reasonable Action (TRA) provides a model for explaining and determining behavioural intention of the person's attitudes toward that behaviour. The theory opined that individual behaviour is based on their intention and that intention depends on individual perception and attitude towards the said behaviour. Fishbien and Ajzen (1975) defined "attitude" as the individual's evaluation of an object and defined "belief" as a link between an object and some attribute, and defined "behaviour" as a result or intention. Attitudes are affective and based upon a set of beliefs about the object of behaviour (Lai, 2017).

Likert type agreement score have been widely used to measure individual attitude towards issues of interest to researchers. To measure a representative of views of farmers regarding each of the statements, descriptive statistics was employed with one sample t-test applied to measure the representative of agreement mean score.

4.2.2.1 Farmers attitude towards Inaccessibility issues of improved maize technology

Distribution of mean agreement score of respondents on statements characterizing their inaccessibility views on improved maize technology is shown in the Table 4.6. The Table presents mean score (M), standard deviation (SD) and t –test values with their accompanying p-values.

As shown in the Table 4.6, farmers' generally were in agreement with the statements that 'tractor service providers are not easily accessible, so I don't rely on them' (M = 4.4; SD = 1.4; t = 35), 'I don't have access to credit to expand my farm' (M = 4.1; SD = 0.7; t = 119.1), ‘maize shelling and thrashing machines are difficult to access here that is why I thrush my maize late’(SD = 3.7; SD = 1.5; t = 50.3), ‘I don’t have access to weather information’ (M = 4.3; SD = 1.3; t = 33.9) and ‘I lack access to reliable market information and that affect pricing of my maize’ (M = 4.2; SD = 1.1; t = 78).

Thus farmers agreed generally, that tractor services in the area are not accessible, that they lack access to credit to invest in their farms and that there is very little market opportunities for them to market their farm produce and also purchase farm inputs. They were also concerned about the lack of access to weather information.

However, respondents generally disagreed with the statements ‘I don’t have access to extension staffs to enable me discuss problems with my maize for solution’ (M= 2.3; SD =1.4; t = 32.9), ‘I don’t have access to a combine harvester to harvest my maize’ (M = 2.3; SD = 1.6; t = 42.1) and ‘I don’t have access to enough land and that is why I don’t farm commercially’(M = 2.2; SD = 1.7; t = 30.9). This indicate that respondents do not think they lack access to extension and arable land to expand their farms.

However, they could form an opinion regarding their agreement on the statements ‘certified maize seeds are not easily accessible in this area’ (M = 2.8; SD = 1.6; t = 34.9), ‘I don’t have access to information concerning seasonal rainfall pattern or raining days’ (M = 2.8; SD = 1.7; t = 43.4). Thus respondents are undecided regarding the availability of certified seed in the district.

Issues of accessibility of agricultural information have been cited in literature as one of the constraining factors in technology adoption (Baruah, 2011; Fadare et al, 2014 and Salifu et al, 2015). Farmers in Ghana have long lamented about availability and accessibility to certified seeds of improved maize varieties because of limited certified seed growers in the country. The high extension officer to farmer ratio and less innovativeness in agricultural extension service delivery leads to inaccessibility of agricultural information (MOFA, 2010; 2012).

Table 4.6 Agreement rank scores on Farmers' inaccessibility Issues

Statement	Mean	SD	t	Df	Sig.
certified maize seeds are not easily accessible in this area	2.8	1.6	34.9	399.0	0.0
tractor service providers are not easily accessible so I don't rely on them	4.4	1.4	35.0	399.0	0.0
I don't have access to credit to expand my farm	4.1	0.7	119.1	399.0	0.0
maize shelling and thrashing machines are difficult to access here that is why I thrush my maize late	3.7	1.5	50.3	399.0	0.0
I don't have access to a combine harvester to harvest my maize	2.3	1.6	42.1	399.0	0.0
I don't have access to extension staffs to enable me discuss problems with my maize for solution	2.3	1.4	32.9	399.0	0.0
I don't have access to weather information	4.3	1.3	33.9	399.0	0.0
I don't have access to information concerning seasonal rainfall pattern or raining days	2.8	1.3	43.4	399.0	0.0
I don't have access to enough land and that is why I don't farm commercially	2.2	1.7	30.9	399.0	0.0
I lack access to reliable market information and that affect pricing of my maize	4.2	1.1	78.0	396.0	0.0

4.2.2.2 Farmers attitude towards Complexity views on improved maize technology

The mean agreement scores of all statements on the complexity statements of improved maize technology is shown in the table 4.7. The Table presents the mean agreement scores (M), standard deviation (SD) and one sample t test results with their accompanying significant values.

As shown in the Table, respondents generally agreed with the statements 'recommended planting distance for certified seed is difficult to practice' (M = 3.9; SD = 1.1; t = 70.1), 'recommended planting distance for certified seed is time consuming to practice' (M = 4.1; SD = 1.2; t = 69.9) and 'I need a lot of labour to harvest on time, so that is why I always harvest some maize late' (M = 3.8; SD = 1.3; t = 58.6). Thus respondents general agreed that it is difficult and complex to comply with the recommended planting spacing and that the improved maize technology is labour demanding, making it difficult to practice.

But, they generally disagreed with the statement that 'I don't have the necessary farm tools or implement to comply with the recommendations' (M = 2.2; SD = 1.7; t = 31.2), indicating that farmers are of the view that they have the needed farm tools to effectively implement the production recommendations in the package of the improved maize technology.

However, they generally were undecided regarding the statements 'loans payment terms are highly unbearably' (M = 2.8; SD = 1.5; t = 33.2), 'the consequences of defaulting a loan is too strict' (M = 2.7; SD = 1.3; t = 43.5) and 'I don't use weedicides to control weeds because it is difficult to follow recommended measurement and spray rate' (M = 2.7; SD = 1.7; t = 31.3).

The perceived ease of use which depends on how complex or otherwise a technology has been demonstrated to have significant effect on its acceptability and adoption. Two factors namely, perceived usefulness and perceived ease of use is critical in determining individual technology acceptance and as such are important variables in TAM (Davis, 1986, Lai, 2017 and Surendran, 2012). Davis, (1986) defines perceived ease of use as the degree to which the prospective user expects the target system to be free of effort. Therefore if farmers perceived any of the production recommendations within the package of improved maize technologies to be difficult they will be less likely to accept the practice.

Planting in line and proper spacing, appropriate method of fertilizer application and weedicide calibration were noted as difficult tasks in following the maize production recommendation. A participant at one of the focus group discussion observed that '*some of* *the things the agriculture people are telling us to do is very difficult and we cannot follow it fully…*' (comments of a participants)

Table 4.7 Agreement rank score on complexity statements

Statement	Mean	SD	t	Df	Sig.
recommended planting distance for certified seed is difficult to practice	3.9	1.1	70.1	399.0	0.0
recommended planting distance for certified seed is time consuming to practice	4.1	1.2	69.9	399.0	0.0
I don't have the necessary farm tools or implement to comply with the recommendations	2.2	1.7	31.2	399.0	0.0
loans payment terms are highly unbearably	2.8	1.5	33.2	399.0	0.0
the consequences of defaulting a loan is too strict	2.7	1.3	43.5	399.0	0.0
I don't use weedicides to control weeds because it is difficult to follow recommended measurement and spray rate	2.7	1.7	31.3	399.0	0.0
I need a lot of labour to harvest on time, so that is why I always harvest some maize late	3.8	1.3	58.6	399.0	0.0

Source: Analysis of field data, 2016

4.2.2.3 Farmers attitude towards Incompatibility Issues

Table 4.8 presents mean agreement scores of all statement loaded on the factor dealing with incompatibility issues regarding improved maize technology. The Table presents mean score (M), standard deviation (SD) and t –test values with their accompanying p-values.

As shown in the Table 4.8, respondents in general agreed with the statements 'the group mode of credit disbursement is not save and suitable for me' (M = 4.1; SD = 1.2; t = 68.6) and 'loans processes is very cumbersome' (M = 3.7; SD = 1.6; t = 40.9). This indicates that farmers in general are not satisfy with the loan disbursement process. They however, disagreed with the statements that 'keeping of livestock do not allow me to have enough time for my maize farm' (M = 1.9; SD = 1.2; t = 31.3) and 'records are not important to me that is why I don't keep records' (M = 2.2; SD = 1.5; t = 34.7). They could not form any opinion on the statements that 'mixed farming practices is the best to cope with on certainties in crop production' (M = 2.7; SD = 1.5; t = 36.6), 'I always use manure for my livestock to fertilize my maize farm' (M = 3.4; SD = 1.5; t = 45.8) and 'I don't normally keep farm records of my farm activities' (M = 2.7; SD = 1.8; t = 34.7). That farmers are undecided regarding the view that mixed farming practices is the best way of dealing uncertainty in farming and that farmers always used animal manure to fertilizer their farms.

Technology compatibility which is one of the innovation characteristics affecting technology adoption as noted in Roger innovation adoption model (Roger, 19191). Technologies or recommended practices which deviate much from farmers' own practice have negative effect on their adoption by farmers.

Table 4.8 Agreement Rank Scores on incompatibility statements

Statement	Mean	SD	t	Df	Sig.
the group mode of credit disbursement is not save and suitable for me	4.1	1.2	68.6	399.0	0.0
loans processes is very cumbersome	3.7	1.6	40.9	399.0	0.0
mixed farming practices is the best to cope with on certainties in crop production	2.7	1.5	36.6	399.0	0.0
I always use manure for my livestock to fertilize my maize farm	3.4	1.5	45.8	399.0	0.0
keeping of livestock do not allow me to have enough time for my maize farm	1.9	1.2	31.3	399.0	0.0
I don't normally keep farm records of my farm activities	2.7	1.8	30.6	399.0	0.0
records are not important to me that is why I don't keep records	2.2	1.5	34.7	399.0	0.0

Source: Field survey data, 2016

4.2.2.4 Farmers attitude towards Inappropriate Technology

Table 4.9 presents mean agreement scores of all statement loaded on the factor dealing with inappropriate technology issues regarding improved maize technology. The Table presents mean score (M), standard deviation (SD) and t –test values with their accompanying p-values. As shown in the Table 4.9, respondents generally agreed with the statements 'I have trust on maize seeds i select from my previous harvest' (M = 4.2; SD = 1.0; t = 81.4), 'I hardly encounter disasters so insurance is waste of money' (M = 4.0; SD = 0.9; t = 92.4) and 'I often relied on bullocks or bulls to plough my farm land' (M = 3.6; SD = 1.4; t = 52.6). The fact farmers have trust in their own seed selection is worrying as it will have negative impact on their acceptance and use of improved certified seeds which is part of the production recommendations of the improved maize technology. Their general agreement on the statement ‘I hardly encounter disasters so insurance is waste of money’ mean that they will have negative attitude towards crop insurance programme which is being introduced as part of the improved maize technology.

But, respondents in general disagreed with the statements ‘I don’t use chemicals to control weeds because I have been hearing they can destroy the soil’ (M = 2.2; SD = 1.5; t = 32.7) and ‘the rain at times wet and destroys my maize when drying because I don’t use a tarpaulin or have enough tarpaulin’ (M = 2.3; SD = 1.4; t = 35.3). They however, could not form opinion, on the statements that ‘what I have been hearing about this certified seed is not good’ (M = 2.8; SD = 1.7; t = 33.1), ‘I am not sure the insurance companies will keep to their terms’ (M = 2.6 SD = 1.1; t = 47.7), ‘I often relied on bullocks or bulls to plough my farm land’ (M= 3.6; SD = 1.4; t = 52.6) and ‘I keep records because the banks ask for it any time I need a loan’ (M = 2.7; SD = 1.6; t = 32.7). As shown by the mean agreement ranks on those statements above, respondents were undecided about them.

Table 4.9 Agreement Rank Scores on inappropriate technology

Statement	**Mean**	**SD**	**t**	**Df**	**Sig.**
I have trust on maize seeds i select from my previous harvest	4.2	1.0	81.4	399.0	0.0
what I have been hearing about this certified seed is not good	2.8	1.7	33.1	399.0	0.0
I hardly encounter disasters so insurance is waste of money	4.0	0.9	92.4	399.0	0.0
I am not sure the insurance companies will keep to their terms	2.6	1.1	47.7	399.0	0.0
I often relied on bullocks or bulls to plough my farm land	3.6	1.4	52.6	399.0	0.0
I don’t use chemicals to control weeds because I have been hearing they can destroy the soil	2.2	1.5	32.7	399.0	0.0
the rain at times wet and destroys my maize when drying because I don’t use a tarpaulin or have enough tarpaulin	2.3	1.4	35.3	399.0	0.0
I keep records because the banks ask for it any time I need a loan	2.7	1.6	32.7	399.0	0.0

Source: Field survey data, 2016

4.2.2.5 Farmers attitude towards Poor capacity Issues

Table 4.9 presents mean agreement scores of all statement loaded on the factor dealing with poor capacity issues regarding improved maize technology. The Table presents mean score (M), standard deviation (SD) and t –test values with their accompanying p-values.

As shown in the Table 4.10, respondents agreed with the statement ‘there is poor marketing opportunities for maize’ (M = 3.8; SD = 1.0; t = 73.4). This indicates that respondents have hopeless towards market opportunities for their maize produce. They however, disagreed with the statement ‘I easily forget their difference in use and function’ (M = 2.4; SD = 1.5; t = 32.6) and ‘I control weeds manually on my maize farm because I don’t know how to use chemicals to control them’ (M = 2.3; SD = 1.5; t = 33). Indicating respondents’ general rejection of the view that might lack the capacity to recollect the practices involve in the implementation of the production recommendations. They also reject the view that they might not be able to administer chemical control of weeds on their farms.

However, they could not decide on the statements that ‘certified seed growers always deceive us to buy their seeds’, (M = 3.2; SD = 2.8; t = 22.5) and ‘I don’t fully understand the concept of crop insurance’ (M = 2.5; SD = 1.3; t = 33)

Table 4.10 Agreement Rank Scores on statements portraying poor capacity issues

Statement	Mean	SD	t	Df	Sig.
certified seed growers always deceive us to buy their seeds	3.2	2.8	22.5	399.0	0.0
I easily forget their difference in use and function	2.4	1.5	32.6	399.0	0.0
I don’t fully understand the concept of crop insurance	2.5	1.3	37.9	399.0	0.0
I control weeds manually on my maize farm because I don’t know how to use chemicals to control them	2.3	1.5	33.0	399.0	0.0
there is poor marketing opportunities for maize	3.8	1.0	73.4	399.0	0.0

4.2.2.6 Farmers attitude towards Cost and affordability

Table 4.9 presents mean agreement scores of all statement loaded on the factor dealing with incompatibility issues regarding improved maize technology. The Table presents mean score (M), standard deviation (SD) and t –test values with their accompanying p-values.

As shown in the Table, respondents general agreed with the statements that 'certified maize is very expensive and beyond what I can afford' (M = 4.1; SD = 1.7; t = 47.6), 'I control weeds manually because I can't afford to buy weedicides to control them' (M = 3.8; SD = 1.0; t = 66.9) and 'I don't use the tractor to thrush because I cannot afford to pay' (M = 3.7; SD = 1.3; t = 57.2).

They however, could not form opinion regarding the statements that 'tractor service are expensive and beyond what i can afford' (M = 2.6; SD = 1.5; t = 36.3), 'the premium for crop insurance policy is too high' (M = 2.6; SD = 1; t = 36.3), 'the premium for crop insurance policy is too high' (M = 3.3; SD = 1.0; t = 66.9).

Cost of farm inputs such as improved and certified maize varieties, fertilizer, weedicide and machineries have been the challenge to farmers in adopting improved maize technologies. As results government reintroduced the fertilizer subsidy programme in 2008 to reduce fertilizer prices for farmers and encourage fertilizer application in line with the Abuja decalcification of fertilizer use in Africa.

A participants at one of the focus group discussion lamented '*how do you expected us to use more fertilizer and certified seeds when their prices keep on increasing every year but prices of our farm produce are always low..'*. (comments of a participant at a focus group discussion). Interactions with extension officers on the ground also revealed farmers though have information on the recommended production practices, but they often complain of lack of resources to purchase certified improved seeds, fertilizer and other inputs needed under the package of the improved maize technologies.

Table 4.11 Agreement Rank Scores on statements of Cost and affordability issues

Statement	**Mean**	**SD**	**t**	**Df**	**Sig.**
certified maize is very expensive and beyond what I can afford	4.1	1.7	47.6	399.0	0.0
tractor service are expensive and beyond what i can afford	2.6	1.5	36.3	399.0	0.0
the premium for crop insurance policy is too high	3.3	1.0	66.9	399.0	0.0
I control weeds manually because I can't afford to buy weedicides to control them	3.8	1.3	58.0	399.0	0.0
I don't use the tractor to thrush because I cannot afford to pay	3.7	1.3	55.6	399.0	0.0
record keeping attract cost and I cannot afford to pay for the service	3.7	1.3	57.2	399.0	0.0
maize farming is capital intensive but minimal profit margin, that is why I don't farm maize commercially	3.9	1.3	59.9	399.0	0.0

Source: Analysis of field survey data, 2016

4.3 Adoption of improved maize technology

This section presents findings of the study on level of adoption of improved maize technology which sought to address the objective two of the study, which is stated as 'to examine the level of adoption of improved maize technology among maize farmers in the Bawku West District'.

4.3.1 Improve Maize Technologies

The maize sub-sector in Ghana has witnessed the implementation of many projects and research activities aimed at improving maize production and productivity. Notable among them is the Ghana Grains Development Project (GGDP), Sasakawa Global 2000 Project and Food Crop Improvement Project. According to Morris, Tripp, and Dankyi's (1998) as cited in IFPRI, (2013) the GGDP had achieved a number of notable successes. Several varieties were developed and disseminated under the project; many agronomic practices were evaluated; production guides were produced; and a heavy investment was made in the extension and dissemination of improved technologies.

4.3.1.1 Improved Maize Technology Dissemination in the District

Interactions with management of the District Department of Agriculture and NGOs working in the area of agricultural development in the district through in-depth interviews revealed much information of the district efforts in improving maize production and challenges encountered in promotion technology based production.

According to District Extension officer and supported by reviewed of document at the district library production of maize gained prominence in the District in the early 1990s. '*A lot of technologies have being adopted by farmers and of course still in the process to gain the full confidence of other farmers*'. '*The District has a lot of success stories in this regard hence currently stands as the leading maize producer in the region*'.(Verbatim comment of the District extension officer).

Improved maize technologies being disseminated in the district constitute of package of production recommendations. These recommendations includes Improved seeds, Improved land preparation, Spacing and Row planting, Timely weed/easy weed control, Timely fertilizer application and appropriate rates, Maize accurate stand per hole, Timely harvesting and improved storage facilities as well as crop insurance. However, crop insurance had been recently introduced under Ghana Agricultural Insurance Pool.

The extension principles and strategies being used to facilitate adoption of these production recommendations includes:

- The District extension officer indicated that the district operates their extension delivery strategies guided by the principle that maize farmers' capacity need to be build or improve through education and technical support.

- Financial, inputs and knowledge assistance have to be designed with respect to individual differences economically, socially, culturally and educationally to holistically effect positive change in the development and value chains. This was more lauded more by NGOs delivering extension to farmers.
- Also capacity building of Agricultural Extension Agents (AEAs) is being implemented on on-going process through workshops and seminars. They are regularly trained on technology and farmer dynamics as well as weather and climate change to understand the issues.
- Again, regular supervision to all operational areas to ensure compliance is regularly done to make AEAs on the ground are working. This is essential to boast farm and home visit.
- Agents are being given the needed logistics and other resources, through NGOs support, to see to that farmers are following production recommendations.
- Field demonstration (both method and result) are carried out with farmers to enable them have first-hand information as to why to adopt as the advantages outweigh or surpasses status quo. Demonstrations also enable AEAs and the MOFA Directorate to evaluate their activities. There were at least three demonstration fields in each of the twenty four (24) operations areas in the District.
- Study tours were also regularly organised for farmers to visit places to study, interact and appreciate the success stories and efforts of other farmers. It boast their moral and give them positive motives to realize their dreams as well as learn from their colleagues. However it was only ADVANCE-USAID and Techno-serve-Ghana driven who were active in organising these field trips.
- Field days are rarely organize for farmers in the district to interact and be introduce to available technologies. It showcases the differentiating characteristics that clearly

attest why adopt hence farmers and other parties can make necessary comparism and for high yield, nutrients, agronomic practices, improved seed among others.

- Strengthening of farmer groups especially farmer based organization to widen their chance of solving their issues and grabbing opportunities. As farmers come together they share ideas towards their business growth, welfare and increase their chances of accessing financial or inputs support.
- Radio/TV programs are organize to educate the general public on maize technology, some concerns are also taken as they open the chance for phone calls to clear issues or take suggestions.

Analysis of responses of extension administrators and field officers in the district on the success they have made with the regard to adoption of improved maize technologies in particular and maize production in general reveals the following:

- They were of the view that there have improvements in adoption levels of improved maize technologies resulting in high productivity and efficient use of land. ADVANC-USAID Production manager in charged the zone observed that '*as farmers pick up better ways of production, it makes some activities faster and easier, increase yield makes the farming business attractive especially to the youth. As a result there will be food security in all spheres of life*'.
- They also of a sound conviction that income level of farmers had increases and their general livelihood as they get/earn a lot from the farming business are getting better.
- They observed that the farmers are taking advantage to expand their businesses, get resources to cater for their dependents in schools, absorb their health needs as well as security.
- In general they were optimistic that the rate at which commercial maize production in the Distract is growing there is opportunity for farmers to produce for the export

market. And that it can triggers industrialization as high production can push for establishment of factories for maize processing and other maize based products

4.3.2 Farmers' Application of Production Recommendations

Several research and development activities carried out various maize improvement projected have been executed in the country. Noble among the projects implemented in the maize sub-sector in Ghana included the Ghana Grain Development Project, Sasakawa Global 2000 programme and Food Crops Development Project (FCDP), in addition to several small projects focused on seed multiplications (see Manu, Fialor and Issahaku, 2012). Several farm demonstrations had been conducted to test and promote modern varieties and recommended agronomic practices in maize production (IFPRI, 2013). Some of them includes, land preparation (zero tillage and recommended plowing), planting in line with the recommend spacing among others.

The improved maize technology being disseminated to farmers in the District, is made up of a package of fifteen (15) production recommendations which maize farmers are expected to apply. How often the 400 maize farmers interviewed follow these production recommendations was measured on a three point Likert type scale as '1' if respondent always follow the recommendation, '2' if respondent sometimes fellow the recommendation and '3' if respondent never follow the recommendation. The Bar graph shown in the Figure 4.2 presents distribution of respondents' frequent of usage of the various production recommendations.

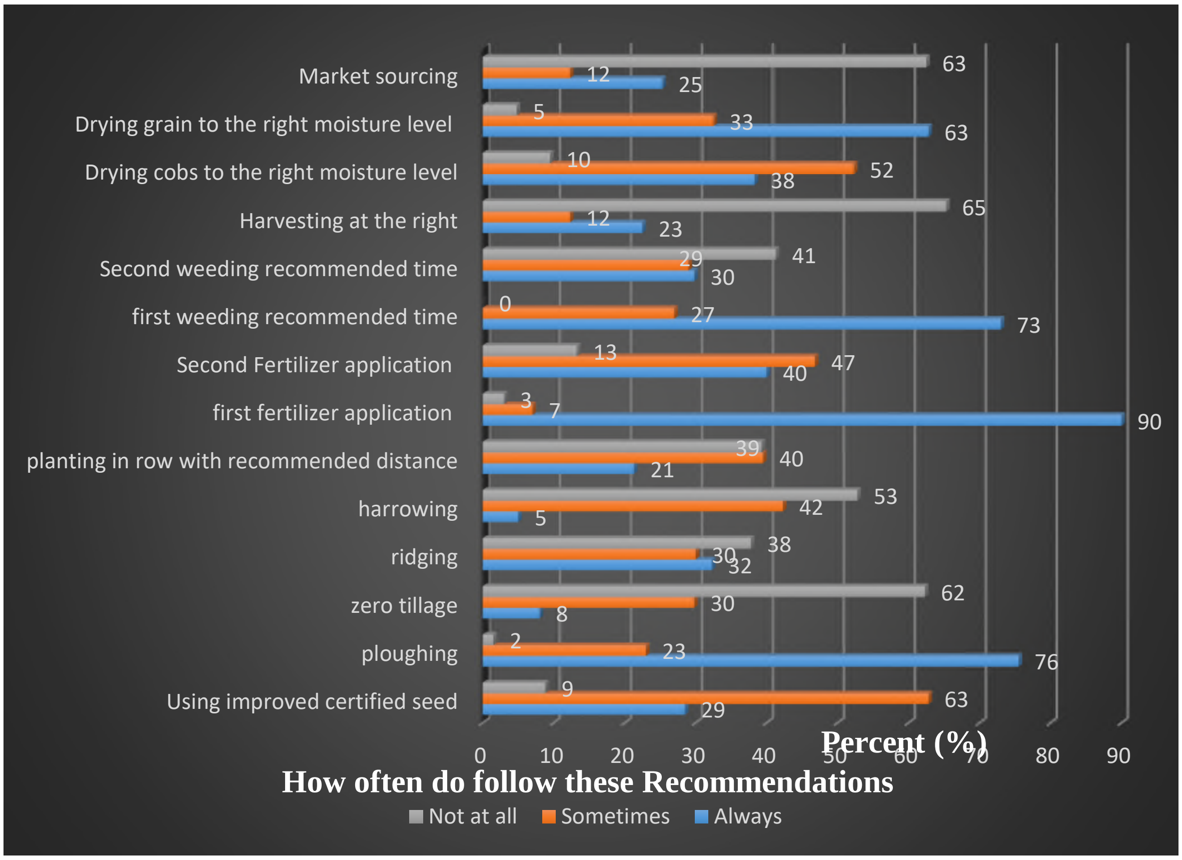

Figure 4.2: Frequency of Usage of Production Recommendations

Source; Field Survey Data, 2016

The 15 production recommendations are made up of:

Use of improved certified seed: Farmers are education to use improved seeds from certified source (that is pro-seed and hybrid seeds). According to IFPRI, (2013) twenty-seven improved varieties have been released since the 1960s (Table 2.1). Varietal improvement and testing done by CRI and SARI focus on high yield, protein content (that is, quality protein maize [QPM]), tolerance to pests and disease (mainly blight, rust, streak, and stem borers), Striga resistance, kernel type, lodging resistance, and early maturity.

Among these improved varieties Obatampa, wandata, mamaba, abontim, pannar and pioneer have been promoted in the district and widely cultivated. However obtaining the seed from certified seed grower have always been the concern of both extension officers and farmers.

As a result the study analysed farmers' response to the type of seed they most used and the sources from which they obtain these seeds.

As shown in the Figure 4.2, just only 29% of the 400 farmers interviewed indicated that they always used improved and certified seed in cultivating their maize farms, while about two – third (63%) said they sometimes used improved certified seed and only 9% indicated that they never used the improved certified seed. Farmers in the area traditionally select and stored seed from their previous harvest for use as seeds. This finding compare fairly well with IFPRI (2013) which found low level of used of certified seeds among farmers.

Farmers were of the view that their own seeds are known to them and they find them appropriate and tastier in preparing their local dishes and that they have gained experience cultivating their local varieties and will not want to take risks. Similar reasons were assigned to low adoption of improved varieties of maize in Asiedu – Darko, (2014). The study reveals that farmers find it extremely difficult to do away with traditional varieties because they maintained that they find them tastier and easier to preserve as compared to the improved varieties. These traits of the traditional varieties have motivated them to continuously cultivate them regardless of the fact that yields were low.

Cost and difficulties in finding certified seeds of improved varieties also featured prominently in farmers' reasons for not adopting the cultivation of improved and certified maize varieties.

Farmers who always or sometimes used certified seeds of the improved crop varieties stated that high yield, drought tolerant, resistance to pest and disease were their key motivation for adopting the technologies. One participant at the focus group discussion observed that '*even though it is expensive but it is good against drought, disease and yield more, ..so that why I always prefer it to my own stored seeds*' (Verbatim comment of a participant at a focus group discussion)

Ploughing: the way and manner by which land is prepared for crop cultivation have effect on crop growth and performance. As a result, the production recommendation also cover land preparation through land ploughing for seed planting. (That is 25cm depth for all varieties)

As shown in the figure (Figure 4.2) majority (76%) of the respondents followed the recommended ploughing method in preparing their land for maize growing while only 23% and 2% indicated that they sometimes and had never followed the recommended ploughing method respectively. Lack of tractor services, timeliness of getting tractor services and cost of hiring tractor were the main reason some of the respondent cited for not accessing ploughing their lands or do it at the right time. They were also of the view that, most of them do not own the tractors and as such cannot dictate to them to adjust the disc to ensure recommended ploughing depth. One participant at a focus group discussion indicated that '*the agriculture people should tell the tractor operators and owners to adjust their disc in line with what is being recommended … I do not owned tractor and I had to literately beg to hire their service, how can I then now turn around to ask them to adjust their disc* ..'(Verbatim comments of participant)

Zero tillage: Ploughing is one of the fundamental operations undertaken in conventional tillage. Conventional tillage practices modify soil structure by changing its physical properties such as soil bulk density, soil penetration resistance, soil moisture content (Rashidi and Keshavarzpour, 2008 as cited in Gomez, 2010), soil porosity and soil air. Papworth (2010) indicated that tillage influences crop growth and yields by changing soil structure and moisture removal patterns over the growing season. Even though zero tillage which promoted strongly under GGDP with many demonstrations and adaptive trials conducted in all the ecological zones in Ghana, it was much recommended for the forest and middle belt. However, based on the soil type and land condition, some areas in the savannah ecological zone also applied zero tillage.

Analysis of farmers response to the question on whether they always used zero tillage in preparing their land for sowing revealed that only 8% of the respondents always followed the zero tillage land preparation method, with 30% and 62% indicating that they sometimes followed it and had never followed it respectively (see figure 4.2). That very few farmers actually used zero tillage in preparing their maize lands. They cited reasons ranging from the nature of their soils, high cost of roundup weedicide used to spray the weeds before sowing and lack of information and knowledge of zero tillage for their low adoption of zero tillage.

Their reason of the nature of their soils and lack of information on zero tillage are valid because, as observed in IFPRI (2013) zero tillage had been much promoted in the forest zone and in the middle belt but not much encourage in the savannah areas because of the hard nature of the land and soils.

Ridging – part of zero tillage, tractor ploughing, making ridges by raising and loosing soil before planting had been also recommended for farmers in the district. Making ridging or raising beds for planting before planting their seeds or making ridging to protect maize plant stands from falling have not been widely followed. Results of analysis indicate that about a third (32%) said they always make ridge, while 30% and 38% indicated that they sometimes make ridges for maize plant and that they had never make ridges in their maize farms respectively.

Harrowing – harrowing at the recommended depth 25cm had been disseminated to farmers in the district. Farmers are being encouraged to harrow their lands after ploughing to further loosen the soil and reduce bulk density and improve soil aeration. . However, analysis of the data indicated that just about 5% of the 400 respondents indicated that they always harrowed their lands after ploughing before planting while 42% and 53% respectively indicated that they sometimes harrowed their lands and that they had never harrowed at all. They cited cost as the reason why they are not harrowing their lands. Poor access to tractor services was also mentioned as one of the reasons why they do not undertake harrowing of their land before sowing.

However, some respondents considered it to be a waste of time and resources. At the focus discussions, participants were of the view that this recommendation of ploughing is meant for rich farmers who have tractors or money to waste. They argued that they are yet to see the significant contribution of harrowing to yield. Their understanding of the purpose of harrowing is only to level the land for ease sowing. This clearly demonstrated that farmers needs more information on the relevance of some of the production recommendations, as they are struggling to see the link between them and yield.

Planting in Row – recommendation for planting spacing (planting distance) varies between open pollinated varieties (OPV) and the hybrid varieties. For OPV the recommended planting distance recommended for farmers in the district is 80cm between rows and 40cm between plants and hybrid 75cm between rows and 25cm between plants.

Planting in row with the recommended planting distance are not that much followed by farmers in the study area. As shown in the Figure 4.2, about 21% always followed the recommendation of planting in row, while 40% and 39% respectively indicated that they sometimes followed the planting in row recommendation and that they have never followed this recommendation at all. Thus majority of farmers do not always sow in line following the recommended spacing, planting distance and plant population density.

High labour demand for row planting coupled with lack of understanding of the technical process were the reasons for farmers low adoption of row planting. Time constraint and competing demand for their labour were highlighted in the focus group discussions as a reason for their inability to adoption the technology of row planting and following the recommended plant spacing. A participant at one of the focus group discussion queried '*where do they expected to get the time, manpower, rope, tapes and pegs to use in sowing when we have other things doing*'(Verbatim comment of a participant).

First fertilizer application at the recommended rate and time. Per the maize production recommendation captured in the maize production guide, the recommended rate of compound fertilizer (NPK) for OPV is three 50kg bags per acre and four 50kg bag per acre in the case of hybrid variety. Application should be planting day or one week later. This application should be repeated in 4 weeks' time if soil nutrients level is not good. Deep placement and cover is encourage in order to ensure effective utilization of fertilizer by plants and reduce losses due evaporation and leaching.

Maize is particularly sensitive to soil nutrient deficiencies of both the major and minor nutrients. Amounts and types of fertilizer required will depend on soil type, cropping history and geographical location (Price, 1997 as cited in Gomez, 2010). Maize requires adequate supply of nutrients particularly nitrogen, phosphorus and potassium for good growth and high yield. Nitrogen and phosphorus are very essential for good vegetative growth and grain development in maize production (Gomez, 2010).

Overwhelming majority (90%) of the 400 respondents always followed the recommendation of first fertilizer application, while 7% and 3% indicated that they sometimes followed the first fertilizer application recommendations and they had never followed it respectively.

Second fertilizer application at recommended rate and time: For second application of fertilizer or what is referred to as 'top dressing' one and half 50kg bags of Sulphate of Ammonia (SA) or urea per acre is recommend for OPV and two 50kg bags in the case of hybrid varieties. The application should done six week after sowing. When using compound fertilizer such ACTYVA or EXTRA-K for top addressing or second fertilization application, farmers are require to repeat the application.

Farmers' compliance of these recommendations regarding second fertilizer application were assessed and the results presented in the Figure 4.2. As shown in the figure 4.2, about 40% of the respondents said they always followed the second fertilizer application, with 46% indicating that they sometimes followed while 13% said they had never followed it at all.

From the results, it clear that most farmers applied second fertilizer application with only 13% indicating they do not. Due to poor soil fertility of most arable lands in the District, as observed by the district extension officer, farmers who failed to apply fertilizer usually get very low. As such the direct effect of the fertilizer application and yield is so obvious for farmers to see and this is driving the adoption of fertilizer application.

Also the government fertilizer subsidy programme which was reintroduced in 2008 have help in stabilizing fertilizer prices making it easy for farmers to plan and purchase fertilizer for their farms. However, in spite of the subsidy programme, some farmers still complain of high cost of fertilizer and poor access due to poor road network and lack of effective fertilizer delivery system within the District.

Weed control: The methods employed to manage weeds vary, depending on the situation, available research information, tools, economics, and experience (Monaco, 2002). Weed control in the District is most done manually and use of herbicide for spraying weeds. Weed control is an important management practice for maize production that should be carried out to ensure optimum grain and forage yield (Gomez, 2010).

The production recommendation, require farmers to undertake weed control twice at stages within the maize lifecycle. The general rule is to keep maize plots free from weeds especially during the first 30 days of planting. CSIR and MOFA recommend the use of herbicide before and after planting. Glyphosate (for example, Roundup or Roundup Turbo) is a systemic herbicide and is recommended for actively growing weeds two weeks before planting (IFPRI, 2013).

For chemical weed control, the recommended application is 2.5 to 4 litres of glyphosate (depending on the strength of its formulation) per 15-liter knapsack sprayer to spray a hectare. A second application is also recommended with lasso-atrazine to the soil immediately after planting. The recommended rate is about 4 litres of lasso-atrazine per 15-liter sprayer per hectare (MOFA/CRI/SARI 2005 as cited in IFPRI, 2013).

First weeding at the recommended time: For the first weeding it is recommended to use pre-emergence weedicides and weed after 2 weeks of sowing. Farmers who sprayed their farms with pre-emergence weedicides do not need to weed two weeks after because the farms will still be free of weeds. Analysis of the study data indicates that majority (73%) always practiced the first weeding recommendation, while 27% indicated that they sometimes practiced first weeding. While some of them applied pre-emergence weedicides, other weeds manually two weeks after sowing.

Second Weeding at the recommended time: The second weeding is expected to be done four weeks after sowing. As shown in the Figure 4.2, only 30% said they always followed the second weeding recommendation, while many (42%) had never followed it and 29% indicated that they sometimes followed the second weeding recommendation. Thus many respondents do not follow the second control recommendations. They cited competing demand for their labour, because they are multi-crop farmers, and high cost of weedicides as reason why they are unable to do the second weeding.

Harvesting at the right time: Manual harvesting of maize is the norm in the district, as it is the case for many smallholder farmers in Ghana. As such it is a labour intensive activity and because many farmers harvest their maize around the same time, the traditional norms of farmers assisting each other in undertaking farming activities is extremely challenged. By hand or mechanical picker, the entire ear is harvested which then requires a separate operation of a maize Sheller to remove the kernels from the ear (Gomez, 2010). Information of timely harvesting by harvesting at the correct moisture level and proper harvest handling and storage have been disseminated to farmers by the extension officers in the district. However, traditional method of harvesting maize is still being used by farmers.

Harvesting at the right time and with the right moisture level is critical in reducing post-harvest losses. As shown in the figure 4.2, just only 23% indicated that they always harvest their maize crops following recommended harvesting time, while majority (65%) said they had never followed the recommendation of harvesting at the right time, with only 13% indicating that they sometimes harvest their maize crops at the right time. They explain that during harvesting time they have competing demand on their labour because they grow many crops such that they are sometime not able to harvest their maize at the right time.

Drying cobs to the right moisture level; the recommendations given to farmers is to dry cobs a week long after harvesting before shelling. Farmers are require to dry their cobs in concrete or plastic floor free of moisture. Drying harvested maize cobs to the right moisture level before dehusking or shelling is quite practiced with 38% and 52% respectively indicating that they always and sometimes followed the recommendation of drying their harvested maize cobs before shelling.

Drying grain to the right moisture level: (dry maize to a moisture content of 20 degree Celsius after shelling or dehusking).As shown in the figure 4.2, majority (63%) of the respondents indicated that they always followed the recommendation of drying their maize grain to the right moisture level before storage, while about a third (33%) said they sometimes followed the recommendation.

Market Sourcing: (farmers linked to Agri-Care premium food and feeding schools)

Sourcing market opportunities and accessing market information is critical in ensure profitable maize production. Results of the analysis indicate that only 25% of the respondents indicated that they always practiced the recommendation of sourcing market information and opportunity of getting good price of their farm produce. While majority (63) said they had never followed the recommendation of sourcing market information for their produce with 12% indicating that they sometimes sourced market for opportunity for their produce.

4.3.3 Adoption of Production recommendations

Farmers who always practiced the production recommendation were classified as adopted, since adoption is continue use or application of innovation (see roger, 1991). However, those who sometime practiced a given recommendations or had never practiced it have been classified as non-adopted of the said the production recommendation.

Table 4.12 presents distribution of adoption of the various production recommendations of the improved maize technology package. As shown in the table, about 29% and 78% and 35% have adopted the improved certified seed, ploughing at the right depth and making ridging recommendations respectively. However, only 7%, 9% and 22% have adopted the harrowing, zero tillage and planting in row production recommendations respectively.

However, overwhelming majority adopted the first fertilizer application recommendation (90%), first weeding recommendation (74%) and drying of grain before storage recommendation (64%). Also some of the respondents adopted second fertilizer recommendation (40%), second weeding recommendation (31%), harvesting at the right time recommendation (24%) and market sourcing recommendation (25%).

Table 4.12: Distribution of adoption of various production recommendations

Recommendations	**Number of Adopters**	**Percent (%)**
Used of Improved certified seed	114	29
Ploughing	310	78
Ridging	139	35
Harrowing	28	7
Zero tillage	36	9
Planting in row with recommended planting distance	88	22
First fertilizer application at the recommended rate and time	361	90
Second Fertilizer	161	40
First weeding recommended time	294	74
Second weeding	122	31
Harvesting at the right	95	24
Drying cobs to the right moisture level	160	40
Drying grain to the right moisture level before bagging/storage	256	64
Market sourcing	101	25

4.3.4 Number of Recommendations Adopted by respondents

Results of the analysis of the number of production recommendations adopted per respondent are shown in the Figure 4.3. As shown in the figure, each one of the 400 farmers interviewed adopted at least three (3) production recommendations. As shown in the Figure about 17% of the 400 respondents adopted only three production recommendation, whiles 18% and 20% adopted four and five production recommendations respectively. Also 15% and 12% respectively adopted six and seven production recommendations. However, only one respondent adopted all the fifteen disseminated production recommendations.

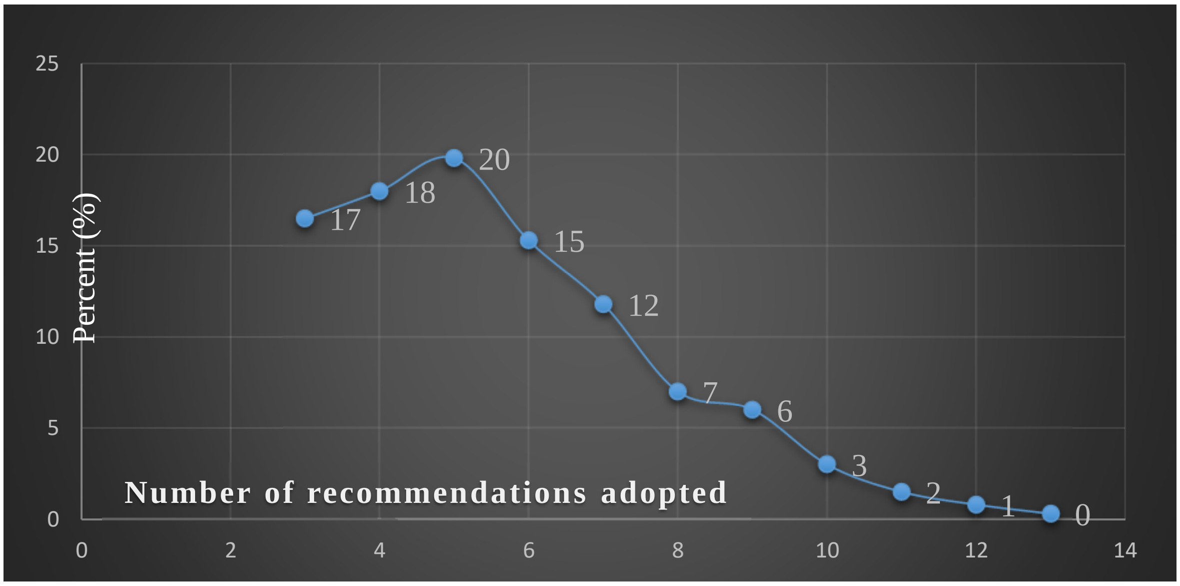

Figure 4.3: Diagram of number of recommendations adopted

4.4 Level of Adoption

All the 400 farmers interviewed adopted at least three production recommendations. Implying none of the respondents could be described as non-adopters since they are following some of the production recommendations. However, there were wide variations of adoption level regarding the various production recommendations. Farmers who adopted more than half (at least eight (8) production recommendations) of the disseminated production recommendations were regarded as high adopters while those adopting less than half are regarded as low adopters.

Based on this criterion, about 44% of farmers were found to have adopted more than half of the production recommendations and as such were regarded as high adopters, while 56% adopted less than half of the production recommendation and as said labeled as low adopters. Thus majority of farmers in the district still are not applying majority of maize production recommendations disseminated to them. Salifu et al, (2015) found similar results regarding the adoption of improved maize varieties among farmers in the Wa Municipality of the Upper West region. Also found Singha and Baruah (2011), that farmers were poor in adoption of recommendations of those relatively complex practices in nature such as seed treatment, application of manure and fertilizers and plant protection measures under different farming systems.

Analysis of the qualitative data gathered showed that farmers have concerns about some production recommendation, seeing some of them to complex and labour intensive. One participant at a focus group discussion expressed his feeling as '*the agriculture people think it is only maize that we grow, that why they want us to use all our labour and time to do planting in line, dip and buried of fertilizer application method among others*' (verbatim comments of participants at a focus group discussion). Another participant observed that '*if you don't go to school, you can't understand some of the things they are telling us to do*'.

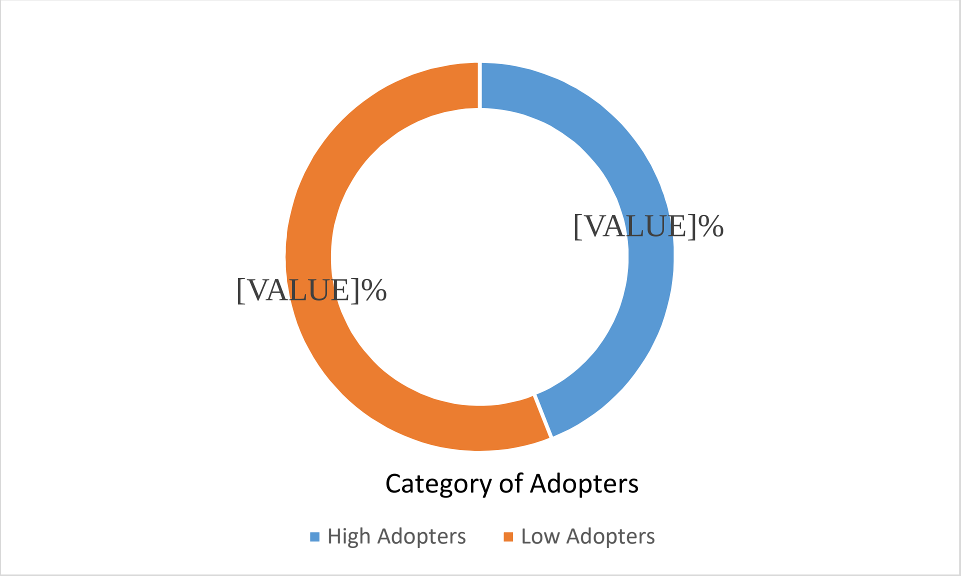

Figure 4.4 Pie Chart of level of adoption

Source: Analysis of field survey data, 2016

4.5 Determinants of Level of Adoption

This section presents results and discussion of factors affection farmers' level of adoption of improved maize technology. Probit regression analysis was adopted in assessing determinants of level of adoption of the improved maize technology among the 400 maize farmers interviewed in the Bawku West District.

4.5.1 Descriptive Statistics of the variables used in the regression equation

Based on Random Utility Theory and adoption literature, thirteen (13) explanatory variables ranging from socioeconomic characteristic of farmers, to farm attributed were used in the regression analysis. The dependent variable is level of adoption which were measured as dummied as ‘1’ if high adopters and ‘0’ otherwise.

Descriptive statistics of the variables used in the probit regression is shown in the Table 4.13.

As shown in the table, the average of farmers is 42.6 years (SD = 10.36), while only 25% of the respondents being female. Average household was found to be 9 persons per household with only 31% of the farmers being able to read and/or write.

Average farm size of maize was 11.7 acre (SD = 4.9) compare with that of other crops being 4.7 (SD = 1.6). Also average years of experience for cultivating maize was found to be 20years (SD = 9.95), with that of annual household income being GHS 9,329.33. Average of extension contact (extension agent visits) was found to be 4 times per season (table 4.13)

Table 4.13 Descriptive Statistics of variable used in the model

Variable	Mean	Std. Dev.	Min	Max
	Dependent Variable			
Level of adoption	0.44	0.50	0	1
	Explanatory Variables			
Age	42.60	10.36	24	75
Sex	0.75	0.43	0	1
Marital Status	0.88	0.02	0	1
Literacy	0.31	0.46	0	1
HH Size	8.90	4.01	3	25
Member of FBO	0.27	0.44	0	1
Experience	20.16	9.95	2	53
Farm Size of Maize	11.71	4.88	2	43
Farm Size Others	4.67	1.57	2	9
HH Annual Income	9329.33	15773.86	300	32,0000
Access to labour	0.49	0.50	0	1
Access to credit	0.42	0.47	0	1
Extension contact	4.11	2.63	2	20

Source: Field survey data, 2016

4.5.2 Coefficient of determinants of level of adoption

Table 4.14 presents coefficients of regression of probit regression, while that of Table 4.15 show marginal effects of the probit regression. The regression model was found to be significant (1%) with Log likelihood -174.59856; LR chi^2 (13) = 190.71(Prob> chi2 = 0.0000). Also with Pseudo R^2 = 0.532, implying that about 53% of the variation in farmers' level of adoption is jointly explained by the explanatory variables used in the model.

Out of the thirteen (13) variables entered into the model, nine (9) variables are found to be significant determinants of farmers' level adoption. The significant variables are age, sex, household size, experience in farming maize and maize farm size. The others are household annual income, access to labour, access to credit and extension contact.

These findings are similar to Salifu et al, (2015). In their study of assessing the Determinants of Farmers Adoption of Improved Maize Varieties in the Wa Municipality, found that age, marital status, education of household head, and farmers' experience in maize production and varietal characteristics as significant in influencing adoption of improved maize varieties.

Similarly Fadare, Akerele and Toritseju, (2014) found that farm size, education level of farmers and access to extension services would significantly influence adoption of improved maize technologies. Similarly, Singha and Baruah, (2011) found that extension contact, annual income, innovation proneness and positive attitude towards farm diversification of farmers had positively significant relationships with the extent of adoption of improved cereal cultivation practices.

However, marital status, literacy, membership of FBOs and farm size of other crops were found not to be significant determinants of farmers' level of adoption.

Age

Age of farmers was found to be significant at 1% level of significant and negatively related to farmers' level of adoption of improved maize technology (see table 4.14).This implies that age significantly affect farmers' level of adoption. The negative sign of the coefficient of the variable 'age' (see table 4.14) indicate negative relationships. Thus younger farmers are more likely to adopt higher production recommendations in the improved maize technology compare with older ones.

Also as shown in the Table 4.15, the marginal effect of variable 'age' is 0.024 implies that for one unit increase in respondents' age will reduce the probability of a respondents being high adopter by 0.024.

Sex

Sex of respondents (measured as dummied; '1' if male or '0' otherwise) was found to be significant (1% level of significant) in determining farmers level of adoption of improved maize technology. Sex was found to be positively related to level of adoption, indicating that male farmers are more likely to be high adopters compare with their female counterpart. As shown in the Table 4.15, the marginal effect of the variable sex on level of adoption is 0.185, illustrate that the difference in probabilities between varying the variable sex to 1 and setting it to 0, given that all other explanatory variables are set at their sample means, increases the likelihood of male farmers being high adopters by 18.5%. Meaning that, if there is unit change in the variable sex, it will induce the likelihood of male farmers being higher by 18.5% more than that of female farmers.

Household Size

The variable household size was found to significant at 5% in determining farmers' level of adoption (see table 4.14). The positive sign of the variable household size, indicates that larger households are more likely to adopt more production recommendations (high adopters) compares with smaller household. This was expected because the improved maize technology is labour intensive and since farmers in the study area largely depend on members of their household for their farm labour requirement, larger household by way of number of persons in the household are more likely to uptake more of the production recommendations. As shown by the marginal effect (see table 4.15), one-unit increase in household size will increase the probability of respondent being classified as high adopter by 0.018.

Experience

The variable experience in maize farming, measured as the number of years a farmer have been engaged in maize, was also found to be significant (1% level significant) and positively related to level of adoption of improved maize technology (see table 4.14). Thus, farmers who are more experience in maize farming are more likely to be high adopters than less experience farmers. Also increasing farmer's experience by one-unit will increase the probability of a farmers being high adopter by 17.8% all other things being equal.

Farm size of maize

There was also positive and significant (at 1% level of significant) farm size of maize and level of adoption as shown in the Table 4.14. This implies, that farmers with larger farmers were more likely to have adopted more production recommendations (high adopters) than farmers with small farm holding. This was least expected because of the labour intensive nature of the technology, it was expected that farmers with large farm holding will not be able to access the needed labour to planting the production recommendations such planning in row, recommended fertilizer application method, recommended time for weed control among others.

However, the marginal effect of the variable 'farm size of maize' was found to be 0.0178 (see table 4.15) indicating that for every one-unit increase in farm size there will be 17.5% increase in the probability of a farmer being high adopter.

Household Annual Income

Household Annual income, as shown in the Table 4.14, was found to be significant at 1% and positively related to level of adoption. This means the high the household annual income is the more likely the farmer will be a high adopter. This was anticipated because adopting most of the production recommendations demand some expenditure of cash resources. Therefore, household with more income will be able to purchase fertilizer, improved and certified seeds, hire labour among other things, such can adopt more of the production recommendations.

With a marginal effect of the variable 'household annual income' being 0.3067896 (see table 4.15), it means that, one-unit increase in household annual income will induce about 31% increase the probability of the farmer being a high adopter.

Access to Credit

Closely related to household income, is credit. As shown in the Table 4.14, the probit analysis identified access to credit as significant (at 1% level of significant) and positively related to level of adoption of the improved maize technology. Meaning respondents who said they have ever taken credit for their maize farming were found more likely to be high adopters than otherwise. With the marginal effect of the variable 'access to credit' being 0.1420979, implies that, varying the variable access to credit from '0' to '1' will increase the probability of a respondent being high adopter by 14.2%, holding all other variables at their sample mean level.

Access to labour

As expected, farmers' access to labour was found to be significant (at 5% level of significant) and positively related to level of adoption of the improved maize technology. Thus farmers' with high access to labour were found more likely to adopt more of the production of recommendations. With the marginal effect of the variable 'access to labour' being 0.1208992 as shown in the Table 4.15, implies that varying the variable 'access to labour' from '0' to '1' will increase the probability of respondent adoption more production recommendation and such being high adopter by about 12%.

Extension Contact

Variable 'extension contact' measured as the number of extension agent visits or contact for the purpose of agricultural information dissemination within a production season, was found to be significant at 1% and positively related to level of adoption. Thus farmers with more extension contacts are more likely to adopt many of the production recommendations and be high adopters than those with less extension contacts.

The marginal effect of ‘extension contact’ is 0.0432256 (see table 4.15) indicating that, if there is one-unit increase in extension contact, the probability of the said farmer being high adopter will increase by 4.3%.

Table 4.14 Coefficients of probit regression

Variable	**Coefficient**	**Std. Err**	**Z**	**P>|z|**
Age	-0.2782659***	0.0994818	-2.80	0.005
Sex	0.6151916***	0.1856908	3.31	0.001
Marital Status	0.0667152	0.1126562	0.59	0.554
Literacy	0.1595935	0.1709878	0.93	0.351
HH Size	0.0530352**	0.0229694	2.31	0.021
Membership of FBO	-0.0214121	0 .1946384	-0.11	0.912
Experience	0.5312992***	0 .1971204	2.70	0.007
Farm Size of Maize	0.0529868***	0.0092625	5.72	0.000
Farm Size Others	-0.0290108	0 .0500002	-0.58	0.562
HH Annual Income	5.9434612***	0.1418081	4.80	0.000
Access to labour	0.3590858**	0.1634473	2.20	0.028
Access to credit	0.4228778***	0.151048	2.80	0.005
Extension contact	0.1286375***	0.0250573	5.13	0.000
_cons	-2.484537	0 .5102143	-4.87	0.000
Number of obs	395			
Log likelihood	-174.59856			
LR chi2(13); Prob> chi^2	190.71			0.0000
Pseudo R^2	0.532			

Source: Field survey data, 2016

Table 4.15 Marginal effect of probit regression

Variable	dF/dx	Std. Err	Z	P>|z|
Age	-0.0935048***	0.024386	-2.80	0.005
Sex	0.1849917***	0.0541277	3.31	0.001
Marital Status	0.022418	0.038105	0.59	0.554
Literacy	0.0545048	0.0601424	0.93	0.351
HH Size	0.0178212**	0.007897	2.31	0.021
Member of FBO	-0.0071735	0.065029	-0.11	0.912
Experience	0.1785308***	0.0488378	2.70	0.007
Farm Size of Maize	0.0178049***	0.0036772	5.72	0.000
Farm Size Others	-0.0097484	0.0168368	-0.58	0.562
HH Annual Income	0.3067896	0.0639145	4.80	0.134
Access to labour	0.1208992**	0.056116	2.20	0.028
Access to credit	0.1420979***	0.053497	2.80	0.005
Extension contact	0.0432256****	0.0094325	5.13	0.000
Number of obs	395			
Log likelihood	-174.59856			0.0000
LR chi2(13); Prob> chi^2	190.71			
Pseudo R^2	0.532			

Source: Field survey data, 2016

4.6 Effect of level of adoption on yield

This section presents results of analysis of effect of level of adoption of improved maize technology on yield. This section therefore addressed objective four of this study which sought to examine the effect of farmers' level of adoption of improved maize technology on yield of maize among maize farmers in the Bawku West District'.

4.6.1 Analysis of Variance of Yield of Maize By level of Adoption

To assess the effect of level of adoption on yield of maize, Analysis of Variance (ANOVA) was adopted to test the following hypothesis:

H_0: There is no significant difference in the yield of high adopters and low adopters of improved maize technology.

H_a: There is significant difference in the yield of high adopters and low adopters of improved maize technology.

Table 4.16a and 4.16b presents descriptive statistics and ANOVA table of yield of maize across level of adoption respectively. As shown in the Table 4.16a, the average yield of maize per acre of low adopters and high adopters respectively were 19.5 bags and 28.7bags. Those average farmers who adopted majority of the production recommendations were producing about 9bags more per acre than those who adopted lesser production recommendation. It can therefore be argued that adopting more of the production recommendation beings more returns in terms of yield.

Table 4.16aDescriptivestatistics of yield across level of adoption

Level of Adoption	N	Mean	Std. Deviation	Minimum	Maximum
Low adopters	226	19.51	3.47	5.10	26.80
High adopters	174	28.70	4.02	11.60	32.81
Total	**400**	**24.11**	**4.26**	**5.1**	**32.81**

Also as show in the table 4.16b, the analysis of variance conducted with F = 123.304 (df = 1.398) established significant difference between average of high adopters and low adopters. This implies that the null hypothesis is rejected in favour of the alternative. Thus there is significant difference in the yield of high adopters and low adopters of improved maize technology. While high adopters are producing at an average yield of 28.7bags per acre that of low adopters were producing at 19.5bags per acres. Thus low adopters are producing 9bags per acre lower than high adopters.

Table 4.16b: ANOVA table of yield of maize across level of adoption

Source of Variation	**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
Between Groups	1732.381	1	1732.381	125.304	0.000
Within Groups	5502.518	398	13.825		
Total	7234.899	399			

Source: Field survey data, 2016

4.6.2 Determinants of yield of maize

In order to assess the effect of level of adoption on yield in a multivariate analysis, a doubled log production function was applied, with multiple linear regression used as the empirical model. Descriptive statistics of the exploratory variables used in the multiple regression model is shown in the Table 4.13 and discussion in section 4.4.1. Also Table 4.17 presents the coefficients of the multiple regression analysis.

As shown in the Table 5.17, with F (14, 381) = 24.01 and Prob>F = 0, implies that the model is significant at 1%. Also with adj R – Square = 0.54, indicates that about 54% of the variation in the yield of maize is jointly explained by the model.

Out of the fourteen (14) independent variables entered in the model, nine (9) variables, including level of adoption, are found to be significant determinants of yield. As shown in the Table 4.17, the variables found to be significant are age, sex, household size, farm size of maize and experience. The others are farm size of other crops, access to labour, access to credit and level of adoption. Only sex and farm size of other crops were found to be significant at 5%, while the remaining seven (7) variables were significant at 1%.

Also, as shown by the sign of the coefficients (see table 4.17) only farm size of other crops and age of farmers are found negatively related to yield, while the remaining seven (7) significant variables all affect yield positively. Thus farm size of other crops negatively influence yield. Meaning farmers who farm large acreage of other crops, part from maize, have low yield of maize compare with those who keep smaller farm sizes of other crops. This is understandable, because, if a farm cultivates more crops their time, labour and resource will be shared among the crops and that might affect the quality of agronomic practice he/she will undertake in the maize farm, and consequently yield of maize will be affected. Also age is significant and negatively related to yield, implying aged farmers were getting lesser yield compare with younger ones.

However, sex is significant and positively related to yield, implying that male farmers were having higher yield compare with female farmers. This could be due to gender insensitive land tenure and access system in northern Ghana coupled with the fact that male have better access to extension and other agricultural services compare with female farmers. Because of the male dominant and control land tenure system, female farmers are usually given poor and infertile lands to cultivate and this definitely will have negative effect on yield.

Also household size and annual income are significant and have positive effect on yield. Thus larger household and household with more income were getting better yield than those smaller and poor households. These were expected because larger households will have large labour pool to draw on for their farm activities. Also high income household were capable of obtaining the needed farm inputs such tractor services and chemical fertilizer for their farms. Similarly, access to credit and labour were both significant and have positive effect on yield of maize.

Also level of adoption, measured as if ‘high adopter = 1’ or ‘if low adopter =0’ is significant and have positive effect on yield. Thus high adopters were found more likely to higher yield compare with low adopters. This was anticipated because high adopters applied majority of the production recommendations disseminated, as part of the improved maize technology and as such are expected to produce efficiently and productively.

Table 4.17: Coefficient of multiple linear regression

Variables	Coefficient	Std. Err.	t	P>|t|
Age	-0.1050856***	0.0230451	-4.56	0.000
Sex	1.2765432**	0.64147900	1.99	0.042
Marital Status	0.0501912	0.1795776	0.28	0.780
Literacy	0.279645	0.3481293	-0.80	0.422
HH Size	0.6311119***	0.1669608	3.78	0.001
Member of FBO	0.1645739	0.3906754	0.42	0.674
Experience	0.1211668***	0.0232566	5.21	0.000
Farm Size of Maize	0.0492114**	0 .0201615	2.44	0.015
Farm Size Others	-0.1173383**	0.0471238	-2.49	0.014
HH Annual Income	0.1287453	0.7573252	0.17	0.865
HH Access to labour	2.2982176***	0.5847882	3.93	0.000
Access to credit	1.0213333***	0.2484667	4.23	0.000
Extension contact	0.0510123	0 .0446512	1.14	0.254
Level of Adoption	3.3296671****	0.6109481	5.45	0.000
_cons	2.46604	0.97162	2.54	0.009
Number of obs	**395**			
F(14, 381)	**24.01**			
Prob> F				0.000***
Adj R-squared	**0.54**			

Source: Field survey data, 2016

4.7 Constraints to Adoption of improved maize technology

This section presents findings addressing objective five of this study which sought to 'examine constraints to adoption of improved maize technology among maize farmers in the Bawku West District'.

Participants at the various focus group discussion held among maize farmers in the study area mentioned nine (9) key issues as constituting constraints to their adoption of the improved maize technology. This nine key constraint are poor access to information, high cost of inputs, incompatibility of some of the production recommendations, the complex nature of some the practices involved and poor farmer training. The rest were inadequate support from government, inappropriate technology, high labour demanding nature of the some of the production recommendations and poor access to support services. During the personal interview sessions, the 400 farmers surveyed were asked to rank the constraints listed in the focus group discussion according their severity to them.

Frequency distribution Analysis of their rank scores is presented in the Table 4.18, while the mean rank distribution is shown in the Table 4.19.

As shown in the Table 4.18, only 12.5% ranked poor access to information as their most severe (number 1) constraints to the adoption of the improved maize technology while 18.5% ranked it as their least severe constraint. Similarly about 19% of the 400 respondents ranked high cost of inputs as the most severe constraints to the adoption of improved maize technology while only 6.3% think the least severe problem.

Also only about 13% ranked issues of incompatibility of some production recommendations with farmers' own practice as their main constraint to the adoption of the improved technology, only 6.3% ranked it as their least severe constraint. Regarding complexity and difficulty in practicing some of the production recommendations, results of the analysis as shown in the Table 4.18, revealed that only 12.5% think it is their most severe constraint while about 19% ranked it as their 4thtopmost constraint.

Also about 26% ranked poor farmer training as the 5th top most constraint to their adoption of improved maize technology. While 18.5% ranked poor support from government as their 8th top most constraint, with another 18.5% ranking the high labour demand of the technology as their 3rd top most constraint to the adoption of the improved maize technology. Similarly, about 19% ranked poor access to support services as their 2nd top most constraint to the adoption of the improved technology.

Table 4.18: **ncy distribution of rank score of constraints**

Constraint	**k of Constraints**																	
			2		**3**		**4**		**5**		**6**		**7**		**8**		**9**	
		%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
Poor access to information	'	12.5	50	12.5	50	12.5	50	12.5	25	6.3	25	6.3	50	12.5	25	6.3	75	18.8
High Cost of inputs	5	18.8	75	18.8	50	12.5	25	6.3	50	12.5	25	6.3	25	6.3	50	12.5	25	6.3
Incompatibility	)	12.5	75	18.8	50	12.5	25	6.3	50	12.5	25	6.3	75	18.8	25	6.3	25	6.3
Complex nature of the tech	)	12.5	25	6.3	50	12.5	75	18.8	50	12.5	75	18.8	25	6.3	25	6.3	25	6.3
poor training and capacity	'	6.3	25	6.3	25	6.3	75	18.8	100	25.0	25	6.3	25	6.3	25	6.3	75	18.8
Inadequate support from govern.	5	6.3	25	6.3	50	12.5	75	18.8	25	6.3	50	12.5	25	6.3	75	18.8	50	12.5
Inappropriate technology	5	6.3	25	6.3	75	18.8	25	6.3	50	12.5	25	6.3	100	25.0	50	12.5	25	6.3
Too labour demanding	5	6.3	75	18.8	25	6.3	25	6.3	0	0	150	37.5	25	6.3	25	6.3	50	12.5
Poor access to support services	5	18.8	25	6.3	25	6.3	25	6.3	50	12.5	25	6.3	50	12.5	100	25.0	25	6.3

Source: Anal Field survey data, 2016

To assess the level agreement among scores assigned by the respondents, a Kendall's coefficient of concordance test (W) was conducted. The results of the Kendall's test (Chi-Square (df = 8) = 87.233; Asymp. Sig. = .000; Kendall's W = 0.47) shows that the test is significant at 1%, and also with W = 0.47 indicates that about 47% of the respondents were in agreement with regard to their ranking of the constraints. Thus 47% the ranks assigned by the respondents are in agreement.

Also the mean rank score as shown in the Table 4.19, indicates that high cost of inputs was ranked the top most constraint to farmers' ability to adopt the improved maize technology. This finding was expected because the implementations of most of the production recommendations in the package of the improved maize technology require expenditure of financial resources to purchase farm inputs such as agrochemical, improved certified seeds and hiring tractor services among others. Due to the fact that most of these agro-inputs are imported and due to the volatility of the Ghanaian cedi, the price of these inputs have been increasing year after year. This makes it difficult for farmers to access these much needed inputs because the price of farm produce have not been witnessing commensurate increase over the years (MOFA, 2012). With the government commitment to revitalize the fertilizer subsidy, which has seen fertilizer prices subsidized by 50%, it is expected that this constraints will be eased to facilitate farmers' adoption of the improved maize technology.

Also incompatibility, complex nature of the technology and poor access to information were ranked 2nd,3rd and 4thtop most constraints to the adoption of the improved maize technology respectively. While inappropriate nature of some of the production recommendations, poor training and capacity of farmers and inadequate support from government were respectively rank as 7th , 8th and 9th constraints to the adoption of the improved maize technology. They were the three least constraints to farmers' adoption of improved maize technology.

Table 4.19 Mean Rank Scores

Constraints	Mean Rank	Ranks
Poor access to information	5.03	4th
High Cost of inputs	4.19	1st
Incompatibility	4.50	2nd
Complex nature of the tech	4.63	3rd
poor training and capacity	5.38	8th
Inadequate support from govern.	5.44	9th
Inappropriate technology	5.37	7th
Too labour demand	5.22	5th
Poor access to support services	5.25	6th

N = 400; Chi-Square (df = 8) = 87.233; Asymp. Sig. = .000; Kendall's W= 0.47

Source: Field survey data, 2016

With regards to the view of extension administrators and field officers in the District, the following constraints were highlighted:

- The extension directorate lack adequate funds to execute all planned activities hence making some strategies recessive. Logistics are very few, some even not in good condition and no funds to keep the minimum contacts/visits to farmers (lamentation of District Director of Agriculture).
- Inappropriateness of some maize technology packages affect adoption. Farmers at time see them as time consuming, difficult to comply, labour sensitive or do not have needed match resources (view expressed by extension officer).
- Illiteracy is one of the factors that affect adoption and about ninety percent of farmers in the Bawku West District are illiterates. This slow down the ability of farmers to get access to or understand concepts, new ideas or technologies (Observation by District Extension officer).
- It is at time not easy to get access to farmers, some farmers are not regular to meeting or farmer fora nor do they owe phones, listen to radio or television, hence they are somehow cut off and do not get information or first-hand information of maize technologies (lamentation of extension officer).

- Staffing is a challenge so far as extension delivery in the District is concern. The District has twenty four operational areas with nine AEAs. With this it very difficult to well deliver the extension mandate (lamentation by District Extension officer)

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.0 Introduction

This chapter presents summary of major findings of the study conducted to assess farmers' perceptions and level of adoption of improved maize technology among maize farmers in the Bawku West District of the Upper east region of Ghana. The chapter also presents conclusion drawn from the findings and recommendation made based on the findings.

5.1 Summary of Main findings of the study

The farmers surveyed mainly engaged in on-farm livelihood activities such as growing cereals crops, mainly maize, rice and millet, leguminous crops mainly soybean and groundnut and some vegetable such as pepper, okra and leafy vegetables. The respondents are within their youthful age range with majority (51%) being younger than 36 years. Also most of them do not have formal educational background.

The farmers interviewed are from large household with average household size of 9 persons which served as their main source of farm labour. The respondents are very much experienced in maize farming with an average of 20 years' experience in cultivating maize. The farmers surveyed can be described as medium scale farmers, cultivating an average of 12 acres (5ha) of maize and about 5 acres (2ha) of other crops. Thus in total the average farm size for all crops being cultivated by the farmers surveyed is about 7ha compare with average farm holding in Ghana being 2ha.

Six (6) factors are identified as underlying dimension characterizing farmers' perceptions towards improved maize technology. These dimensions are inaccessibility issues, inappropriateness of some production recommendations, issues of complexity, incompatibility issues, cost and affordability issues and issues of poor capacity of farmers to adopt some of the production recommendations. In general maize farmers surveyed are concerned with what they perceived as inaccessibility of some certified seeds and other inputs and information needed to adopt the improved maize technology. They are also concerned about the difficulties and complexities of implementing some of the production recommendations such planning in line at the recommended distance, applying fertilizer at the recommended rate and time among others. Farmers viewed some of the production recommendations as inappropriate in their case. There is also concerns about the cost of some of the inputs require to implement the production recommendations. They perceived the cost of certified and improved seeds, fertilizer and tractor services as high.

The improved maize technology being disseminated to farmers in the District, is made up of a package of fifteen (15) production recommendations which maize farmers are expected to apply. Results of analysis of how often farmers' surveyed applied these production recommendations, reveals that, only 29% of them always used improved and certified seeds, with majority following the recommended ploughing method and planting distance. Also majority of the respondents always followed the recommended fertilizer application and weed control. In general close to half (44%) of the respondents followed more than half of the fifteen (15) production recommendations in the improved maize technology package.

Results of assessment of determinants of level of adoption of the improved maize technology in a probit regression model, nine (9) variables were found to be significant determinants of farmers' level adoption. The significant variables are age, sex, household size, experience in farming maize and maize farm size. The others are household annual income, access to labour, access to credit and extension contact. While sex, household size, experience, maize farm size, access to credit and labour, household annual income and extension contact were found to have positive effect on level of adoption, age of farmers had negative effect on level of adoption. However, marital status, literacy, membership of FBOs and farm size of other crops were found not to be significant determinants of farmers' level of adoption.

Results of Analysis of Variance (ANOVA) conducted found significant difference in the yield of high adopters and low adopters. The average yield of maize per acre of low adopters and high adopters respectively were 19.5 bags and 28.7bags. Those average farmers who adopted majority of the production recommendations were producing about 9bags more per acre than those who adopted lesser production recommendation. It can therefore be argued that adopting more of the production recommendation brings more returns in terms of yield. The high adopters are producing at an average yield of 28.7bags per acre that of low adopters were producing at 19.5bags per acres. Thus low adopters are producing 9bags per acre lower than high adopters.

Results of multivariate analysis of factors affecting yield identified nine (9) variables, including level of adoption, out of the fourteen (14) independent variables entered in the model, to be significant determinants of yield. The variables found to be significant are age, sex, household size, farm size of maize and experience. The others are farm size of other crops, access to labour, access to credit and level of adoption. Only sex and farm size of other crops were found to be significant at 5%, while the remaining seven (7) variables were significant at 1%. Also only farm size of other crops and age of farmers are found negatively related to yield, while the remaining seven (7) significant variables all affect yield positively. Thus farm size of other crops negatively influence yield. Meaning farmers who farm large acreage of other crops, part from maize, have low yield of maize compare with those who keep smaller farm sizes of other crops.

However, sex is significant and positively related to yield, implying that male farmers were having higher yield compare with female farmers. Similarly, household size and annual income are significant and have positive effect on yield. Thus larger household and household with more income were getting better yield than those smaller and poor households. Also level of adoption, measured as if 'high adopter = 1' or 'if low adopter =0' is significant and have positive effect on yield. Thus high adopters were found more likely to higher yield compare with low adopters.

Participants at the various focus group discussion held among maize farmers in the study area mentioned nine (9) key issues as constituting constraints to their adoption of the improved maize technology. This nine key constraint are poor access to information, high cost of inputs, incompatibility of some of the production recommendations, the complex nature of some the practices involved and poor farmer training. The rest were inadequate support from government, inappropriate technology, high labour demanding nature of the some of the production recommendations and poor access to support services.

High cost of inputs was ranked the top most constraint to farmers' ability to adopt the improved maize technology. While incompatibility, complex nature of the technology and poor access to information were ranked 2nd, 3rd and 4th top most constraints to the adoption of the improved maize technology respectively. While inappropriate nature of some of the production recommendations, poor training and capacity of farmers and inadequate support from government were respectively rank as 7th , 8th and 9th constraints to the adoption of the improved maize technology. They were the three least constraints to farmers' adoption of improved maize technology.

5.2 Conclusion

Six (6) factors namely **inaccessibility issues**, **inappropriateness** of some production recommendations, **issues of complexity**, **incompatibility issues**, **cost and affordability issues** and **issues of poor farmers' capacity** are the underlying constructs characterizing farmers perceptions towards the improved maize technology.

Many of the farmers surveyed in this study followed more than half of the fifteen (15) production recommendations in the improved maize technology package being disseminated in the District.

Age of farmers, sex, household size, experience in farming maize and maize farm size. In addition, household annual income, access to labour, access to credit and extension contact are significant determinants of farmers' level of adoption of the improved maize technology.

The study found significant relationship between level of adoption and yield of maize. It is therefore concluded that level of adoption of the improved maize technology significantly affect yield of maize. Adopting more of the production recommendations in the package of the improved maize technology guarantee high yield and productivity.

Beside level of adoption, age, sex, household size, farm size of maize and experience. In addition to farm size of other crops, access to labour and access to credit are significant determinants of yield and farm productivity among the farmers surveyed in this study.

Nine (9) key issues namely poor access to information, high cost of inputs, incompatibility of some of the production recommendations, the complex nature of some the practices involved and poor farmer training. In addition to inadequate support from government, inappropriate technology, high labour demanding nature of the some of the production recommendations and poor access to support services are the constraints limiting farmers' level of adoption of improved maize technology.

High cost of inputs was ranked the top most constraint to farmers' ability to adopt the improved maize technology. While incompatibility, complex nature of the technology and poor access to information were ranked 2nd, 3rd and 4th top most constraints to the adoption of the improved maize technology respectively.

Also inappropriate nature of some of the production recommendations, poor training and capacity of farmers and inadequate support from government were respectively rank as 7th, 8th and 9th constraints to the adoption of the improved maize technology. They were the three least constraints to farmers' adoption of improved maize technology.

5.3 Recommendations

Based on the farmers of this study, the following recommendations are made:

1. Effort through farmer education should be made by the ministry of food and agricultural at the district level towards eliminating the negative perceptions held by farmers towards the improved maize technology. The perceptions that some of the production recommendations are complex and difficult to apply and that they are inappropriate and incompatibility negatively affect farmers' adoption. Therefore the need to change these perceptions in order to facilitate the adoption of these production recommendations.
2. Also the central and local government, and other stakeholders in agricultural development should work towards stabilizing cost of agricultural inputs, most particularly agrochemical and certified seeds, to enable farmers acquire these inputs which are critical in the adoption of the improved maize technology.

3. Access to agricultural information and extension services is very low in the study area and have been identified as constraints to the adoption of the improved maize technology among farmers. It is therefore recommended that extension service delivery to farmers should be strengthened to facilitate farmers' adoption of the improved maize technology.
4. Also, the uptake of the production recommendations among female farmers were found to be low compare with their male counterparts because of female farmers generally lack access to extension services and information on the improved maize technology. It is therefore recommended that extension service delivery should critically consider gender concerns and mainstream these concerns in implementing extension project and information delivery.
5. It is recommended that research should be carried out into the compatibility and complexity of these production recommendations constituting the package of the improved maize technology. This will help provide information on best ways to simplify the procedure of applying these recommendations

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APPENDIX A

QUESTIONNAIRE FOR FARMERS’ PERCEPTIONS AND ADOPTION BEHAVIOUR AND TECHNOLOGY UTILIZATION

TOPIC:

FARMERS’ PERCEPTIONS AND ADOPTION BEHAVIOUR TOWARDS IMOROVED MAIZE TECHNOLOGY AMONG MAIZE FARMERS IN THE BAWKU WEST DISTRICT

DEPARTMENT OF AGRICULTURAL EXTENSION, RURAL DEVELOPMENT AND GENDER STUDIES

FACULTY OF AGRICUSINESS AND COMMUNICATION SCIENCES

UNIVERSITY FOR DEVELOPMENT STUDIES

Questionnaire No ……… Date……...........…. Interviewer NAME ………………………..…

Zone ………………………… Community …………………………………………………..

Introduction

This information is being sought from you as part of a research ‘analysing farmers’ perceptions and adoption behaviour of maize technology among maize farmers in the Bawku west District. This study is in partial fulfilment of an award of Mphil in Innovation Communication from the department of agricultural extension, rural development and gender studies. For each question, write the code number corresponding to the response in the right column next to that question. Your answers are confidential

	Section 1: Personal Information		
No	**QUESTIONS AND FILTERS**	**CODING CATEGORIES**	**SKIP**
1.1	SEX	Male …………………..… (1) Female ………………..….(2)	
1.2	How old are you?	> 25 years ……….….….(1) 25 – 35 years ……..…….(2) 36 – 45 years ……..….…(3) 46 – 60 years …..……….(4)	

		< 6o years ……….……..(5)	
1.3a	What level of formal schooling have you completed?	No formal education ......(1) Basic Level ……………..…(2) Secondary level ……..….(3) Tertiary Level …………..…(4)	
..3b	Can you read and/or write	Yes ……………………..(1) No ………………………(2)	
1.4	Marital Status	Married …...……………(1) Single …………….……(2) Divorced ………………(3) Windowed ……………..(4) Separated ………………(5)	
1.5	Household Size ……………………………		

1.6 Household age structure

	> 15 years	15 – 65 years	65+ years
Male			
Female			
Total			

1.7	What is/are your occupation?	Salary worker …………..(1) Farmer …………………(2) Trader …………………..(3) Artisan …………………(4) Other (specify)………….. NB: Multiple choices possible	
1.7	What is your main source of your income?	Salary work... …………..(1) Farming…...……………(2) Trading……...…………..(3) Artisanship…..…………(4) Other (specify)…………..	

1.8a	In your own estimation, how secure is your main source of income?	Very Secure …………….(1) Somehow secure ...……..(2) Not secure at all ………..(3)	If option 1, skip to 1.9
1.8b	Why did you think your main source of income is not secure? …………………………………….. …………………………………………………………………………………………..		
1.9	What is your annual income?	> 2,000gh …………………..(1) 2, 000 – 4, 000 ……………….(2) Above 4, 0000 ……………….(3)	
..10	Do you belong to any farmer based organization?	Yes ……………………..(1) No ………………………(2)	

Section 2: Agricultural Activities

2.1 Please list the type of crops you been growing over the years?[1]

S/N	Type of crops grown	Farm size (ha)	Experience in growing the crop (years)
1	Maize		
2			
3			
4			
5			
6			
7			
8			
9			
10			

2.2a	What type of seed did you used for your maize farm last season?	Certified seed ………………(1) Traditional seed ……………(2) Other seed (specify) ………	If option (1), Skip to 2.3
2.2a	Why didn't you used the certified seed	Is not available ……………..(1) Is expensive/unaffordable …(2) Is not reliable ………………(3)	

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[1] also ask for the farm size for each crop and the experience in growing it

		I don't know of it …………(4) Others (specify) …………….	
2.3	Where did you source your maize seed for planting?	Certified seed producers …….(1) Previous harvest ……………..(2) From the open market ……….(4) From colleague …………….(5) Other (specify) ……………..	
2.4a	Please list the type of maize variety (ies) you have been growing? …………………………………… …………………………………………………………………………………… ……………………………………………………………………………………		
2.4b	What problem do you have with the maize variety you have been growing?	Low yielding ………………. (1) Drought susceptibility ……...(2) Disease susceptibility ………(3) Low quality/market value ….(4) Others (specify) ……………..	
2.5a	Have you ever change the variety of maize you are growing	Yes ……………………..(1) No ………………………(2)	If no, skip to 2.5c
2.5b	If Yes to question 2.5a, why ……………………………………………………………… ………………………………………………………………………………….. …………………………………………………………………………………..		
2.5c	If no to question 2.5a, why ……………………………………………………………… …………………………………………………………………………………… ……………………………………………………………………………………		
2.6	What is the main source of land for your maize farm	Family land …………………..(1) Own land ……………………..(2) Purchase/leased ………………(3) Communal land ………………(4) Share cropping ……………….(5) Others (specify) ……………..	
2.7	Size of your maize farm last season? …………………..ha		

2.8	Source of labour for your maize farm	Family labour ………………..(1) Hire labour …………………..(2) Communal labour ……………(3) Other (specify) ……………	

2.9 Indicate the cost you incurred on the following in your maize farm[2]

s/n	Cost elements	Quantity[3]	Cost (GHC)
1	Maize seed		
2	Land preparation		
3	Planting		
4	Labour[4]		
5	Weed control		
6	Fertilizer		
7	Harvesting and handling		
8	Transportation		
9	Others		

.10a	Do you keep livestock	Yes ……………………..(1) No ………………………(2)	If no, skip to 2.11

2.10b Type of livestock and their number

S/N	Type of livestock	Stock (current number)
1		
2		
3		
4		
5		
6		
7		

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[2] cost should be per ha, otherwise indicate the farm size

[3] when applicable

[4] indicate labour unit (either number of persons engaged or man-hours)

8		
9		
10		

.10c	Do you usually sell your livestock?	Yes ……………………..(1) No ………………………(2)	If no, skip to 1.9e
10d	If yes, what do you usually sell your livestock to do?	Buy farm inputs ………………(1) Pay my children school fees ….(2) Buy food ……….…………….……(3) Perform social activities ….….(4) Pay medical bills …………….(5) Others (specify)…………..	
.10e	How much did you get from the sale of your livestock within the past 12 months? …………………………………………..		
.10f	Do you usually use the animal droppings to fertilizer your farmlands?	Yes ……………………..(1) No ………………………(2)	

.11 What was the output from your maize farm in the last season

Q'tyharvested (bag)	Q'ty consumed (bag)	Q'ty given to friends/relative (bag)	Q'ty sold (bag)	Price sold (bags)

2.12	How much money did you make from the sale of crops? …………………………GHC		
2.13a	Have you ever taken credit to invest in your maize farm?	Yes ……………………..(1) No ………………………(2)	If no, skip to 2.13d
2.13b	If yes to question 2.13a, where did you borrowed from?	Bank ……………...…………..(1) NGO ……………...………..(2) IMFs …………………………(3) Friends/relatives …………….(4)	

		Money lenders ………………(5) Other (specify) ………………….	
2.13c	If yes to question 2.13a, What form of credit did you took?	Financial (money) …………….(1) Input credit …...………………(2) Others (specify) ……………….	
	Section 3: Source of Agricultural Information		
.1a	Where do you usually source your agricultural information from?	MOFA extension officers ……(1) NGOs extension officers …….(2) Colleague/friends/relatives …..(3) Others (specify) ………………	
.1b	Which of the sources of agricultural information is your main source of information on maize	MOFA extension officers ……(1) NGOs extension officers …….(2) Colleague/friends/relatives …..(3) Others (specify) ………………	
.1c	What type of information do you normally received from the source?	Crop varietal information ……(1) Planting/land preparation …….(2) Weed control information ……(3) Disease prevention …………..(4) Harvesting and postharvest ….(5) Marketing information ……….(6) Financial assistance...................(7) Soil fertility information...........(8) Others (specify) ………………..	
3.2	How will you describe your access to agricultural information?	Very accessible ………………(1) Somehow accessible …………(2) Not accessible at all	
3.3	How many extension visit did you received from extension officer last season? ……………………………………..		
	Section 4: Maize Technology		
4.1a	Have you ever been trained in maize production?	Yes ……………………..(1) No ………………………(2)	If no, skip to 4.2

4.1b	If yes to question 4.1a, what were you trained on? (explain in detail)		
4.1c	If yes to question 4.1a, who provided the training	MOFA ……………………… (1) NGO …………………………(2) Others (specify) ………………	

4.2 Which of the following improved varieties of maize are you aware of, or have used

Improved Variety	Aware of (have seen and/or heard[5]	Planted before[6]	Source [7]
Obatanpa			
Aburohemaa			
Abeleehi			
Aburotia			
Akposoe			
Mamaba			
Comp 4			
Comp W			
Dobidi			
Etubi (hybrid)			
Golden Crystal			
Golden Jubilee (yellow)			
Laposta			
Okomasa			
Aziga (yellow)			
Comp 4			
Pan 53			
Pan 12			

4.3 To what extent do you follow the following production recommendations in maize production (tick the appropriate box in each row)

Production recommendation	Always	Sometimes	Not at all
Improved certified seed			
Ploughing			
Ridging			
Harrowing			
Zero tillage			

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[5] if a farmer is aware '1' otherwise '2'

[6] if planted before '1' otherwise '2'

[7] if you have planted it before, where did you got the seeds

Planting in row with recommended planting distance ( )			
1stFertilizer (compound) application at the recommended rate and time			
2nd Fertilizer (top dressing) at the recommended rate and time			
1st weeding (recommended time)			
2nd weeding (recommended time)			
Ripping			
Drying of cobs to right moisture content			
Drying of maize to right moisture content, that is 20 degree celcius			
Marketing			
Post harvest loses			

Section 5: Perceptions towards maize technology

Indicate the extent to which you agree or disagree with the following statements, using the scale below

Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree
1	2	3	4	5

s/n	Statements	Rank
1	Certified maize seeds are not easily accessible in this area.	
2	Certified maize is very expensive and beyond what I can afford	
3	I have trust/confidence on maize seeds I select from my previous harvest	
4	Certified seed growers always deceive us to buy their seeds	
5	What I have been hearing about this ‘certified seed’ is not good.	

6	I easily forget their differences in use and function	
7	Recommended planting distances for certified seed is difficult to practice	
8	Recommended planting distances for certified seed is time consuming to practice	
9	I don’t have the necessary farm tools or implements to comply with the cultural practices recommended for certified seed	
10	Tractor services are expensive and beyond what I can afford. Tractor service providers are not easily accessible so I don’t rely on them.	
12	I don’t have access to credit to expand my farm.	
13	Loans payment terms are highly unbearable	
14	The group mode of credit disbursement is not safe and suitable for me	
15	Loans processes is very cumbersome	
16	The consequences of defaulting a loan is too strict	
17	I do not fully understand the concept of crop insurance	
18	The premium for crop insurance policy is too high	
19	I hardly encounter disasters so insuring is waste of money.	
20	I am not sure the insurance companies will keep to their terms	
21	Mixed farming practices is the best for to cope with uncertainties in crop production	
22	I always use manure from my livestock to fertilise my my maize farm.	
23	I often relied on bullocks/bulls to plough my farm land.	
24		
25	Keeping of livestock do not allow me to have enough time for my maize farm.	
26		
27	I control weeds manually on my maize farm because I don’t know how to use chemicals to control them.	
28	I control weeds manually because I can’t afford to buy weedicides to control them.	
29	I don’t use weedicides to control weeds because it’s difficult to follow recommended measurement and spray rates.	
30	I don’t use chemicals to control weeds because I have being hearing they can destroy the soil.	
31	I need a lot of labour to harvest on time, so that’s why I always harvest some maize late.	

32	Maize shelling and threshing machines are difficult to access here that’s why I thresh my maize late.	
33	I don’t use the tractor to thresh because I can’t afford to pay.	
34	I don’t have access to a combine harvester to harvest my maize.	
35	The rain at times wet and destroys my maize when drying because I don’t use a tarpaulin or have enough tarpaulin.	
36	I don’t normally keep records of my farm activities.	
37	Records are not important to me, that’s why I don’t keep records.	
38	I don’t have access to extension staffs to enable me discuss problems with my maize for solution.	
39	Record keeping attracts cost and I can’t afford to pay for the service.	
40	I keep records because the Banks ask for it any time I need a loan.	
41	I don’t know the raining days to pre-plan, hence it affect some of my farming activities at times.	
42	I don’t have access to information concerning seasonal rainfall pattern or raining days.	
43	Maize farming is capital intensive but minimal profit margin, that’s why I don’t farm maize commercially.	
44	I don’t have access to enough land and that’s why I don’t farm commercially.	