UNIVERSITY FOR DEVELOPMENT STUDIES

DETERMINANTS OF ADOPTION OF IMPROVED MAIZE VARIETIES IN ZABZUGU/TATALE AREA IN THE NORTHERN REGION OF GHANA: A CASE STUDY OF OBATANPA

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BY

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THESIS SUBMITTED TO THE DEPARTMENT OF AGRICULTURAL EXTENSION AND RURAL DEVELOPMENT, FACULTY OF AGRIBUSINESS AND COMMUNICATION SCIENCES, UNIVERSITY FOR DEVELOPMENT STUDIES, IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTER OF PHILOSOPHY DEGREE IN INNOVATIONS COMMUNICATION

NOVEMBER, 2018

DECLARATION

Student

I hereby declare that this thesis is the result of my own original work and that no part of it has been presented for another degree in this University or elsewhere.

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I hereby declare that the preparation and presentation of the thesis was supervised in accordance with the guidelines on supervision of thesis laid down by the University for Development Studies.

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ABSTRACT

Farmers in the Zabzugu/Tatale experience low yield of maize due to lack of adoption of improved maize varieties, a situation that threatens food security. The study aimed at investigating the factors that influence farmers' adoption decisions of improved maize varieties in Zabzugu/Tatale area in the Northern Region of Ghana: a case study of Obatanpa. The analysis involved a cross-sectional survey with 240 randomly sampled household heads growing maize. Descriptive statistics and binary logistic regression were used to analyze the results. Extension effectiveness indicators ranked in 3-point likert scale (Very Effective, Effective, and Not Effective) were used to assess maize farmers' perception of effectiveness of extension delivery. It was established that there was high level (58.8%) of adoption of Obatanpa in the study area. Results of the logistic regression analysis shows that sex, household size, membership of FBOs, farm size, farmers' awareness of Obatanpa, access to credit and access to extension service had positive and significant relationship with adoption of Obatanpa. Only age, however, had inverse and significant relationship with adoption of Obatanpa. From the results of Extension Effectiveness Indicators, creation of awareness of agriculture extension agents, visiting farmers, organizing field meetings with farmers, and embarking on supervision by extension agents in the field were perceived by maize farmers as being effective and very effective. The study recommended that MoFA should mandate the formation of FBOs so that extension service expenditure could be minimized and farmers' access to extension could be eased; MoFA, in collaboration with development partners, should establish and maintain an efficient seed distribution system in the study area to ensure timely availability of certified seeds at a subsidized price. The government need to facilitate farmers' access to credit facilities at low or no interest to maize farmers. Methods of extension delivery regarded effective should be used to deliver extension messages.

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DEDICATION

This thesis is dedicated to my wife, Hassana; to my sons, Yaseen and Zakir; and to my daughter, Mariam Katari; and to my brothers, Abdul-Razak and Abdul-Karim for their immense understanding, love, care and emotional support.

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AEDP: Agricultural Extension Delivery Programme

ATS: Agricultural Technology System

AZ: Agricultural Zone

CIMMYT: International Maize and Wheat Improvement Center

CRI: Crops Research Institute

CSGA: Canadian Seed Growers Association

DADP: Delta State Agricultural Development Programme

GGDP Ghana Grains Development Programme

GR: Green Revolution

HYV: High-yielding Variety

IITA: International Institute of Tropical Agriculture

IRM: Imazapyr-resistant Maize

IT: Information Technology

MSV: Maize Streak Virus

NGO: Non-governmental Organization

QPM: Quality Protein Maize

REFLC: Research-Extension-Farmer Linkage Committee

REFILS: Research–Extension–Farmer–Input-Suppliers Linkage Committees

RELC: Research and Extension Linkage Committee

SARI: Savannah Agricultural Research Institute

SEM: Structural Equation Modelling

TAM: Technology Acceptance Model

UNDP: United Nations Development Program

USDA: United States Department of Agriculture

CHAPTER ONE

INTRODUCTION

1.1 Background

Maize is a staple food for a large part of the global population, much especially important to diets of several African countries and can be consumed in a variety of ways, including, but not limited to as porridge (such as grits, polenta, or ugali), popcorn, roasted kernels, as a vegetable (in the form of fresh, frozen, or canned sweet corn), or as flour or meal (cornbread, tortillas, chips, extruded snacks). It is also used to produce ethanol (for either drinking or as a fuel source for motor vehicles) and its by-products and grains as animal feed and biomass for energy, as a source of cooking oil, and for corn syrup and corn starch in food industry (World Atlas, 2016).

Maize has been in cultivation since prehistoric times and its domestication was probably very ancient. According to Collins (1912), teosinte (Euchlaena Mexicana) is the nearest known wild relative of maize, noting that the commonly accepted view regarding the origin of maize is some ancestor of this Mexican grass. According to Ranum et al. (2014), Native Americans transformed it into a better source of food which contains about 72% starch, 10%protein, and4%fat, supplying an energy density of 365 Kcal/100g. In a descending order, the United States, China, and Brazil are the top three maize-producing countries in the world, producing approximately 563of the 717 million metric tons/year (Ranum et. al., 2014).

According to World Atlas (2016), USA is the largest producer of maize in the world, producing about 377.5 million metric tons of corn (20% of which is exported) annually, with internal leading producer being Iowa State, followed by Illinois and Nebraska States. China follows suit, producing 224.9 million metric tons, 60% of which is used for animal feed, 10% for direct human consumption and the remaining 30% for industrial production of corn-based alcohols, sweeteners and cooking oils. As the third largest producer of maize in the world, Brazil produces 83.0 million metric tons annually, exporting 1.10 million metric tons and 5.37 million metric tons in 2015 and 2016 respectively. The rating follows by India (42.3 million metric tons), Argentina (40.0 million metric tons), Ukraine (39.2 million metric tons), Mexico (32.6 million metric tons), Indonesia (19.0 million metric tons), France (17.1 million metric tons), and then tenth largest producer in the world being South Africa (15.5 million metric tons) which emerged the African largest maize producer in 2014, producing 14,982,000 Tons. In the 2014 rating, Nigeria was the second largest producer producing 10,790,600 Tons, with Ethiopia producing 7,234,955 Tons; Tanzania, 6,737,197 Tons; Egypt, 5800000 Tons; Malawi, 3929000 Tons; Kenya, 3,513,171 Tons; Zambia, 3,350,671 Tons; Uganda, 2,763,000 Tons; and then Ghana was the tenth largest producer in Africa producing 1,762,000 Tons. The fiftieth and the lowest producer of maize in 2014 was Djibouti, producing 20 Tons, the lowest in the world, (World Atlas, 2016).

In Ghana, the major crops cultivated include numerous cereal, root and tuber, leguminous, fruit, vegetable and industrial crops, but maize is the most widely cultivated crop in Ghana, and accounts for a significant proportion of the daily caloric intake (Wood, 2013). Ghana produced 1,871,695 Tons in 2010, 1,683,984 Tons in 2011; 1,949,897 Tons in 2012; 1,764,477 Tons in 2013, then 1,762,000 Tons in 2014. Thus from 2010 to 2014, maize output in Ghana depreciated from 1,871,695 Tons to 1,762,000 Tons, (World Atlas, 2016). USDA (2016) data shows that Ghana maize output further depreciated from the 1,762 MTs in 2014 to 1,692 MTs in 2015, but slightly appreciated to 1800 MTs in 2016, thus increased by 6.38 percent. Nigeria maize output also depreciated from 7,515 MT in 2014 down to 7,000 MT in 2015; it then appreciated to 7,200 MT in 2016 but still below the 7,515 MT recorded in 2014.

South Africa continuous the lead as the largest producer of maize in Africa and tenth next to France in the World, producing 10,629 MT (greater than Nigeria's by 3,114 MT and Ghana by 8,867 MT) in 2014, depreciated to 8,214 MT (22.72%) in 2015 and then tremendously increased to 16,700 MT (103.31%) in 2016 which is 60,16 MT greater than a combination (10,684 MT) of maize output of Nigeria, Uganda (1,884 MT) and Ghana. The yield reduction in Africa in 2015 was partly due to the 2015 drought that hit the continent and the world at large. The limited use of irrigation facilities and high dependence on unfavourable climatic conditions for boosting enhancement of good harvest bring to bear the reduction of agricultural productivity. Amponsem (2015) noted that the percentage of cultivated land under irrigation in Ghana is estimated as 0.89% which is equivalent to 23,657 hectares, meaning that the remaining 91.1% of hectares is rain-fed, making climate change effects such as drought and flooding a critical threat.

Maize is the major staple crop produced and consumed as an important source of calories in Ghana, and has almost replaced traditional staple crops like sorghum and pearl millet in northern Ghana (Darfour and Rosentrater, 2016).According to Rondon and Ashitey (2011), the yearly average maize production in Ghana between 2007 and 2010 was 1.5 million metric tons. Estimating grain output in Ghana, maize accounts for 55 percent followed by paddy rice (23 percent), sorghum (13 percent) and then the lowest being 9 percent for millet.

Maize is also an essential component of poultry feed and to a lesser extent the livestock feed sector as well as a substitute for the brewery industry (Angelucci, 2012). It is the second largest commodity crop after cocoa and accounts for 50-60% of total cereal production, providing more than 45% of the agricultural cash income for smallholder farmers in the country, (DT Maize, 2012).

The results of Agricultural Production Survey for the Northern Regions (Brong Ahafo, Northern Region, Upper East and Upper West) of Ghana (2013-2014) conducted by Amanor-Boadu et al. (2015) shows that on household land holding basis, the average household land allocated to maize production in 2012 across the study area was 1.2 ha compared with about 0.8 for rice and soybeans collectively. Average maize household land in Northern Region was 1.4 ha compared to 0.9 ha in both Upper West and Upper East regions.

According to the survey, of 1,470 plots used by the respondent households in the production of these crops in 2012, maize was by far the dominant crop in the study area, produced on more than 500 plots. Rice and soybeans were in second and third positions respectively with nearly 300 plots and more than 200 respectively. However, in 2013, 1114 plots were allocated for maize, rice and soybeans. Of this number, about 58 percent of the plots (641) were planted to maize while approximately 16 percent and a little over 26 percent was planted to soybeans and rice respectively. In 2013 only 21 percent of the 641 plots planted to maize were for commercial purposes and the remaining 79 percent was for household consumption. On the other hand, 74 percent of soybean's 177 plots and more than 58 percent of the 292 plots allocated to rice were for commercial purposes. Thus, maize presented the lowest commercial motivation for production. This confirms that maize is a major staple food crop and grown for subsistent purpose by majority of the people in the Northern Ghana, as it has established an enormous position in the food basket of the population of the study area.

Maize has such a critical nutritional role to play because it is the most important staple food crop across sub-Saharan Africa where half of the population consumes this cereal in various forms (starch, flour and other industrial purposes). It is also widely fed as porridge to weaning children (2 to 3 months, until the children are completely weaned at the age of 15 to 24 months) and preschool children (3 to 5 yr) without protein supplements. The normal maize varieties commonly grown, particularly in Ghana and the sub-Saharan Africa as a whole, contain 10% grain protein, an amount that is deficient in two essential amino acids: lysine and tryptophan; yet the consumption of normal maize-based foods without adequate protein supplementation leads to widespread malnutrition (kwashiorkor, a fatal syndrome characterized by initial growth failure, irritability, skin lesions, edema, and fatty liver) especially among infants, pregnant women and lactating mothers (Twumasi-Afriyie et al. 2006).To respond to this problem, an inter-institutional and multidisciplinary research (the Crops Research Institute (CRI), Kumasi, Ghana in collaboration with the International Institute of Tropical Agriculture (IITA), Ibadan; the International Maize and Wheat Improvement Center (CIMMYT), Mexico; and the Sasakawa Global 2000 (SG 2000) was initiated in 1989 to produce a high and stable yielding quality protein maize (QPM) varieties which are high in these two essential amino acids, and to promote the production and consumption of these varieties in Ghana and other Countries.

This effort resulted in the development and release of Obatanpa, a medium term maturing QPM composite, in 1992 to help improve the protein nutritional status and the health of a large population of low-income groups in sub-Saharan Africa who depend on maize as a major component of their dietary protein intake (Twumasi-Afriyie et al. 2006).The high lysine content of QPM improves the absorption of Zinc and Ion in the human digestive system and may thus contribute to improved micro-nutrient status.

Obatanpa GH has been widely adopted by farmers and consumers in Ghana, covering more than 50% of the maize hectarage (650 000 ha) in the country. Amanor-Boadu et al. (2015) indicated that, in the Northern Ghana, Obatanpa was the dominant variety planted by the farmers, accounting for more than 76 percent of all the maize varieties planted in both 2012 and 2013. A distant second to Obatanpa was Okomasa, with under 11 percent of maize plots in 2012 and 12 percent in 2013. The remaining percentages were for other varieties. Obatanpa has good levels of resistance to the Maize Streak Virus (MSV), lowland rust (incited by Pucciniapolysora Underw.), and moderate levels of resistance to blight that is caused by Bipolarismaydis, (Twumasi-Afriyie et. al. 2006).

Maize is an important staple food consumed by majority of Ghanaians especially in the Northern Region (and for that matter Zabzugu/Tatale). In recent years the proliferation of poultry farms in the Northern Ghana places another demand on maize for poultry feed when already the brewery industry and to a lesser extent the livestock feed sector are also competing for maize (Kafle, 2010); there comes the need for increased production of maize to meet these competing demands, and farmers' adoption of high-yielding maize varieties can be the key. So understanding the adoption determinants of improved maize varieties is a matter of essence to policymakers and stakeholders in the agricultural sector. The same way, the valve (Extension Service) through which agricultural innovations are diffused is among the major influential components in agricultural technology lifecycle, and for that matter the effectiveness of the tools with which extension services are delivered to farmers is worth noting.

Improving productivity and quality requires a functioning system of technology generation and transfer and a means to implement these technologies. Agricultural research stations generate new ideas and technologies whilst extension personnel convey these to farmers and facilitate them in their adoption (Khan and Akram, 2012). Research and extension, as their major responsibility, provide these technologies to farmers. Research performs the tasks of technology generation based on feedback from farmers through extension. Extension services provide the proper institutional system to deliver these training to farmers. Extension services have a crucial role to play in promoting agricultural innovation to keep pace with the changing context, and improve the standard of living of the rural agrarian population and all other structures in food value-chain. Extension organizations devise an efficient extension model that focuses strongly on the dissemination and facilitation of the adoption of recommended technologies and practices to achieve its objectives. The importance of extension service to generation, dissemination and adoption of agricultural technologies cannot be overemphasized. The same way, the effectiveness of extension service delivery to farmers is a matter of essence to adoption of agricultural technologies, providing the indispensable need for investigating the effectiveness of agricultural extension services. Funding for extension services, the knowledge of extension agents and the suitability of the tools with which they deliver extension service greatly influence the effectiveness of extension service delivery.

In their research into the factors influencing agricultural extension officers' knowledge on practice and marketing of organic agriculture in North West Province of South Africa, Oladele and Tekena (2010) argued that the knowledge of extension officers greatly influence the effectiveness of extension service delivery since the results of extension programmes are critically dependent on the extension officers' knowledge about the various agricultural innovations they disseminate to farmers. Aphunu and Otoikhian (2008) noted that the ability to communicate, attitude to extension work, frequency of contact with farmers and field responsibility, which are examined from the viewpoint of the farmers are the prerequisites for extension agents' effectiveness.

The knowledge and information acquired is an output of an extension program whilst adoption of technologies is an outcome and the final impact is change in productivity, (Taye, 2013). White (2009) argued that tracing the causal chain of extension programme from inputs to outcomes and impacts guarantees a good job of a quality impact evaluation of an extension programme. Hence, the final outcome in extension programmes should be measured in terms of productivity. The success or failure of extension programmes are often premised on how many farmers are trained, how many farmers have adopted the technology or on whether the programmes have resulted in increased productivity. Thus the major focus of most studies on extension service delivery has been on farmers' behavioural change in terms of adoption and outputs, often neglecting the effectiveness of the methods with which extension personnel deliver extension services or even the efficiency of the extension personnel themselves. Meanwhile, the causal chain, as asserted by White (2009), not only includes the output (knowledge and skills acquired by farmers) and impact (change in productivity) but also the input (the knowledge of the extension agents, extension funding, the technology itself, and the tools with which the extension programme is delivered to farmers) as well. At the input side (the technology), for example, Asiedu-Darko (2013) noted that farmers' failure to adopt agricultural technologies is as a result of unattractiveness of some of the technologies, citing the incomplete husk cover of Obatanpa and the posture of some extension agents as a feature that makes the maize variety unattractive and a disincentive to effective dissemination of farming technology respectively. Effectiveness of extension delivery methods can be assessed from the viewpoint of extension agents and farmers. However, the best extension service is one which is driven by demand – a bottom-up communication that will make extension service address the needs of farmers.

This study investigated the factors influencing the adoption of improved maize varieties with particular attention on Obatanpa in Zabzugu/Tatale area. The study estimated the extent of adoption of Obatanpa, finding out the percentage of farmers who cultivated Obatanpa. It also found the demographic, socio-economic and institutional factors which significantly influence the adoption of Obatanpa. Doing this will help the study identify which areas policy-makers and development partners in the agricultural sector should direct their effort that will result in increased productivity and improve the livelihood of farmers. Tracing the causal chain of agricultural technology adoption failure, attention should be drawn to not only the farmers' challenges but also the extension service. This study, therefore, assessed maize farmers' perception of level of effectiveness of extension delivery in the study area since ineffective extension delivery has the greater likelihood of negatively affecting adoption. In totality, the contribution to be made by the study is not only what are indicated in the justification for the study but also it will contribute to knowledge in academic literature in the field of technology generation, transfer, and adoption.

1.2. Problem Statement

Obatanpa, being the dominant maize variety in the Northern Region as noted by Amanor-Boadu (2015), was introduced in Zabzugu-Tatale in 1992 to improve maize yields in the district. Obatanpa has the best yield, with a yield of 5 bags (500 kg) per hectare at minimum and 15 bags (1500 kg) per hectare at maximum on farmers' fields (Abdoulayi et al., 2012). A preliminary investigation in the districts shows that farmers accrue less than five bags per hectare from cultivating Obatanpa. The yield deficit could be attributed to lack of certified Obatanpa maize seeds usage, (district MoFA annual report, 2015). Several studies such as Morris et al., (1999); Akudugu et. al., (2012); Aidoo et al., (2014); Ragasa et. al., (2014), and Arhin (2014) conducted to check the problem of low output of maize in the Northern Region of Ghana have also attributed the problem to low or non-adoption of improved maize varieties. Yet there is paucity of detailed research carried out in the study area to examine the factors influencing the decisions of farmers to use Obatanpa. This study, therefore, focused on studying the factors that determine the adoption of Obatanpa in the Zabzugu/Tatale area.

1.3 Research Justification

The 2010 Population and Housing Census showed that, in Zabzugu District, agriculture industry engaged 23,444, representing 86.0%,the highest proportion of the employed population 15 years and older. 91.8% of the male population (with ages greater than or equal to15 years) is into agricultural industry compared to 80.5% of women. In Tatale/Sanguli, a vast majority (23,646) representing 90.1% of the people 15 years and older are engaged in the agricultural industry with both males and females with the former (92.0%) having a little higher proportion than the latter (88.2%) (Ghana Statistical Service, 2014). This shows that development activities that are channeled towards agricultural development will be of maximum benefit to the majority of people in the study area. This study focuses on providing policy recommendations that will lead to developing agricultural sector through productivity growth.

According to Arhin (2014), maize, in Ghana, accounts for more than 50 percent of the country's total cereal production; for this, the Ghana Grains Development Project and the Food Crops Development Project among others made major investments to improve maize yield, yet maize yield in Ghana remains one of the lowest in the world, much lower than the average for Africa south of the Sahara. Many variables affect maize productivity in Ghana: fertilizer application, rain patterns, maize varieties, but to Kafle (2010), farmers' varietal adoption decision of improved seeds is one of the most crucial factors affecting maize productivity. Hence, the outcome of the study will contribute to reveal the challenges facing maize cultivation and provide resourceful information that will help extension agents devise strategies for increasing the adoption of improved technologies.

The findings of this study will be helpful in refining the technology generation effort. One of the reasons for doing an adoption study is to provide evidence of the returns to a research or extension effort (CIMMYT Economics Program, 1993). A mismatch between what is expected and reality is an evidence of problem existence. The finding of this study will provide this reality so that policymakers and policy implementers will identify gaps existing between technology generation effort and what is expected for adoption of the technology generated. An analysis of farm and farmer attributes may provide feedback to research itself so that the research will refine the technology to suit the farmers' characteristics.

The findings will also provide information that will help extension assess the effectiveness of the tools of extension delivery so that suitable extension programmes can be designed to meet farmers' needs.

It will also recommend ways that will help improve the flow of information among research, extension and farmers, on the one hand, and policymakers on the other. Research side takes farmers' inputs (suggestions and complaints) through extension agents to improve performance. Extension, the intermediary, needs reliable information to exchange with research (technology developers) and farmers (technology users). Effective flow of information, which this study will provide recommendation for improvement, is indispensable to the success of agricultural system.

Maize is the popular staple food for the people in Zabzugu/Tatale area, followed by yam. So any activity resulting in increasing maize productivity (the main essence of this study) in the area means reducing food insecurity.

Maize yield has been very low in the Zabzugu/Tatale area – a situation that poses a threat to food security. Yet majority of literature has attributed low maize yield to lack of adoption of improved maize varieties; meanwhile no known study has so far been conducted into factors that influence farmers' adoption decision of improved maize varieties in the study area. So conducting this agricultural technology adoption studies will inform extension service and development partners about which angle to tackle the problem.

1.4.0 General Objective

To examine the factors that influence farmers' adoption decisions of the Obatanpa in Zabzugu/Tatale District.

1.4.1 Specific Research Objectives

1. To ascertain the level of adoption of Obatanpa by farmers in Zabzugu/Tatale.
2. To determine the factors which influence the adoption of Obatanpa by farmers in Zabzugu/Tatale.
3. To assess maize farmers' perception of level of effectiveness of extension delivery in Zabzugu/ Tatale.

1.5.0 General Research Question

What are the factors that influence farmers' adoption decisions of the Obatanpa in Zabzugu/Tatale-Sanguli District of Northern Ghana?

1.5.1 Specific Research Questions

1. What is the level of adoption of Obatanpa by farmers in Zabzugu/Tatale?
2. What factors influence the adoption of Obatanpa by farmers in Zabzugu/Tatale?
3. What is the perception of farmers about the level of effectiveness of extension delivery in Zabzugu/Tatale?

1.6. Hypothesis

Of the thirteen variables used in the regression model, three variables (dummy): awareness of Obatanpa seed variety, access to extension service, and access to credit were hypothetically tested.

H_0 : Farmers' awareness of Obatanpa, access to extension service, and access to credit do not influence adoption of Obatanpa.

H_A : Farmers' awareness of Obatanpa, access to extension service, and access to credit influence adoption of Obatanpa.

1.7. Limitation

One of the constraints of this study was difficulty in getting secondary data. Attempts to access data on population of maize farmers for the study were met with delays at both the Regional and District Directorates of Ministry of Food and Agriculture – a situation that slowed down the activities of the research.

Respondents' poor attitude in providing data also hampered the process of this research. Despite educational effort made towards creating maize farm households understanding of the purpose of data collection for this study, some respondents still had some level of mistrust and suspicion about providing answers to some items of the questionnaires; even in some communities there was poor turnout of respondents. However, notwithstanding this challenge, the expected sample size was met in each of the sampled communities in this study after revisiting such communities many times.

As mentioned earlier on, the population under this study has different characteristics in terms of language and religion. These differences placed upon the research another limitation: language barriers. Respondents comprised of Dagomba, Konkomba, Bassare, Zabarima and Kotokoli. It was difficult to find an enumerator with understanding and fluency in all the languages. This challenge placed upon this study a greater limitation that also slowed down activities of the research and raised the research expenditure. To overcome this challenge, the researcher hired enumerators who had fluency in two or more of these languages.

It is also important to recall that the enumerators recruited to help with the data collection were fully employed in their primary jobs as teachers and extension officers already working in the sampled communities, making the help they provided in the data collection effort an overload to their primary assignments. Therefore, it is not surprising that some challenges occurred, as some of the enumerators were discovered to have been producing inadequate services, forcing the project to let go of their services, and remedied the errors by replacing such questionnaires in the sample units they were administered.

1.8. Organization

This study comprises five chapters. Chapter one comprises the background of the study, hypothesis, limitation, and the significance of the study. Chapter two presents the literature review, giving its brief introduction, reviewing effectiveness of extension delivery, extension-farmer linkage, outlining the recommended agronomic practices for improved maize varieties, theoretical framework on adoption, conceptual framework of the study, empirical findings on adoption of improved technologies, why farmers adopt of agricultural technologies, challenges affecting technology adoption, and factors influencing adoption of improved maize varieties, and a brief conclusion of the chapter. Chapter three highlights the research methodology which describes the study area, the research design, the study population, data collection methods, the sample size determination, sampling procedure, method of data analysis, theoretical model, the empirical model, and the description of the variables used in the models. Chapter four discusses the results of the study. Chapter five presents the summary, conclusion and policy recommendation of the study and recommendation for further research.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

The literature on technology adoption is currently moving in three directions. These include (1) innovative econometric and modeling methodologies to understand adoption decisions, (2) examinations of the process of learning and social networks in adoption decisions and (3) micro-level studies based on local data collection intended to shed light on adoption decisions in particular contexts for policy purposes (Doss, 2003). This study focuses on adoption decisions of maize farmers in Zabzugu and Tatale/Sanguli Districts. The chapter has discussed effectiveness of extension delivery, extension-farmer linkage, recommended agronomic practices for improved maize varieties, theoretical framework on adoption, the conceptual framework, empirical findings on adoption of improved maize varieties under which other issues such as why farmers adopt agricultural technologies, challenges affecting technology adoption and factors influencing adoption of improved seed technology are reviewed including conclusion.

2.1 Empirical Findings on Adoption of Improved Technologies

Much attention has been drawn to adoption of technological innovations since Industrial Revolution when the economies of the world began stitching together, competition became intense, and manufacturing industries craved for raw materials and component parts to meet customer demands. The same way, adoption of technological innovations in agriculture has also been instigated by food insecurity that emanates from population growth, making agricultural technology adoption cohesive to the attention of development economists and policy makers since it is commonly believed that introduction of new technology increases productivity.

The generation and diffusion of high yielding and productive technology is the key to attaining high level of agricultural productivity (Asfaw et al., 2011). High quality and quantity of agricultural productivity is an answer to sustainable food security; yet no matter how a technology is promising, without its acceptance and sustained use, the technology will be useless. It is, therefore, essential to state that adoption of an innovation is a confluence at which the innovation's benefits are realized, and for that matter researching towards finding enabling environment for technology adoption is a matter of essence to development.

Adoption is defined as the decision to apply an innovation and to continue using it, (Rogers and Shoemaker, 1971). According to Feder et al. (1985) adoption can be classified into individual (farm level) adoption which is the degree of use of new technology in long run equilibrium when the farmer has full information about the new technology and its potential; or aggregate adoption behaviour where diffusion process is the spread of new technology within a region; implying that aggregate adoption is measured by the aggregate level of specific new technology with a given geographical area or within the given population. The decision of whether or not to adopt a new technology hinges upon a careful evaluation of a large number of technical, institutional and socio-economic factors.

Adoption of innovation has been exploited by different researchers and practitioners. In the field of medicine, for example, researchers conduct adoption studies on the likelihood factors that embrace or contravene a new practice. In a research into examining the Technology Acceptance Model (TAM), using Physician Acceptance of Telemedicine Technology among physicians practicing at public tertiary hospitals in Hong Kong, Hu, et al. (1999) found that TAM was able to provide a reasonable depiction of physicians' intention to use telemedicine technology. Perceived usefulness was found to be a significant determinant of attitude and intention, but perceived ease of use was not. In another adoption study, England et al. (2000) conducted a study into factors influencing technology adoption, on why health care has been one of the slowest sectors to adopt and implement information technology (IT) in Australia. They found that the complexity of health organisations and their fragmented internal structures constrained their ability to adopt organisation-wide IT.

In another study by Park (2009) on an analysis of the Technology Acceptance Model in understanding university students' behavioural intention to use e-learning in South Korea, using a sample of 620 university students, a structural equation modelling (SEM) technique was employed to include e-learning self-efficacy, subjective norm, system accessibility, perceived usefulness, perceived ease of use, attitude, and behavioural intention to use e-learning, and developed based on the technology acceptance model (TAM). The result proved that Technology Acceptance Model was a good theoretical tool to understand users' acceptance of e-learning. In the field of health, Phichitchaisopa and Naenna, (2013) examined the factors influencing adoption of healthcare Information Technology (IT) services in Thailand, using a structured questionnaire to collect data from 400 employees including physicians, nurses, and hospital staff members. Data were tested using structural equation modeling technique. The study found that the factors with a significant effect were performance expectancy, effort expectancy and facilitating conditions which were also found to have a significant impact on behavioral intention to use the acceptance healthcare technology. In addition, in Thai provincial areas, positive significance was found with two factors: social influence on behavioral intention and facilitating conditions to direct using behavior.

In organizational psychology (organizational behaviour, more specifically), managements' quest to meet challenges of their business environment (and competition, in particular) has provoked change for new ways to meet these challenges, instigating studies into ways technologies could be adopted for favourable business climate. In a research into the cognitive process that determined an attitude towards technology adoption, Au and Enderwick, (2000) found that compatibility; enhanced value; perceived benefits; adaptive experiences; perceived difficulty; and suppliers' commitment significantly influenced the dependent variable (technology adoption), but the study also found that the individual external environmental forces did not significantly influence the formation of a behavioural intention to adopt. Balash et al. (2011) in the field of education, conducted adoption studies into the factors affecting educational technology adoption in lecturers' teaching duty in one Iran University, Shahid Beheshti, using Assistant, Associate and Professors as the respondents.

Riddell et al. (2012), in another study, assessed the causal effects of education on technology use and adoption, using instrumental variables for schooling derived from Canadian compulsory school attendance laws. They found that education increased the likelihood of using computers in the job and that employees with more education have longer work experiences in using computers than those with less education. They, however, discovered that education did not influence the use of computer-controlled and computer-assisted devices or other technological devices such as cash registers and sales terminals.

In many developing countries, especially in Africa, majority of adoption studies focus on finding recommendation that will advise policy to come out with interventions to increase agricultural productivity since agriculture is the mainstay of their livelihood (Johnson, 2013;Ouma, 2014; Ogada et al., 2014; Simtowe et al., 2016). Agricultural adoption studies have been conducted into adoption of improved agricultural technologies – an area much prioritized due the fact that the majority of the population are poor and derive their livelihood from agricultural production, (Feder et al., 1985). In the field of agriculture, for example, Simtowe et al. (2016) conducted a research into the determinants of agricultural technology adoption under partial population awareness: the case of pigeonpea in Malawi. They used a sample of 400 households in Malawi to assess the patterns of diffusion and adoption of improved pigeon pea varieties and their determinants; they found the sample adoption rate of improved varieties to be 14 % while the potential adoption rate if the improved varieties were widely disseminated was estimated at 41 %. The adoption gap resulting from the incomplete exposure to the improved pigeon pea was 27 %. Adoption was also found to be high among female-headed households, older farmers and those with access to credit.

Simply put, adoption studies is a cosmopolitan or proliferate development activity that examine the progress or success of a practice in order to inform stakeholders the way-forward for development of organizations.

2.2 Determinants of Farmers' Adoption of Agricultural Technologies

The majority of existing literature on agricultural technology adoption is focused on Green Revolution (GR) technologies such as irrigation, fertilizer use, and the adoption patterns of high-yielding variety (HYV) seeds, (Parvan, 2011). The crop is the pivot of interest (quantity and quality of yield) for which other accompanying technologies are employed. The adoption of high-yielding-varieties (HYV) of crops by farmers in developing countries has been viewed as the solution to lower incomes in agriculture and food insecurity (Ibrahim et al, 2012). As also noted by Awotide et al. (2012), the adoption of high yielding varieties can significantly lead to increase in agricultural productivity in Africa and stimulate the transition from low productivity subsistence agriculture to a high productivity agro-industrial economy. In a study conducted into the welfare impact of adoption of improved cassava varieties by rural households in South Western Nigeria, Afolami et al. (2015) found that adoption of improved cassava varieties increases the annual income and the annual consumption expenditure of cassava producing households, thus increasing welfare in the South Western Nigeria. The same way, farmers' varietal adoption of improved maize is based on a wide range of selection criteria such as grain yield, grain size, color, and taste, flour quantity and quality, and maturity period, (Abdoulaye et al., 2012).

The issue of why innovations are adopted and the rate at which the innovations are adopted are surrounded by the characteristics of the innovation(as in the case of Scot et al., 2008 on factors influencing the adoption of an innovation: An examination of the uptake of the Canadian Heart Health Kit in Canada), the relative perceived benefits of the innovation (as in Akudugu et. al., 2012 on factors influencing the farm households' adoption decisions of modern agricultural production technologies in Ghana), and the adopter's demographic and socio-economic status (as in Fadare et al., 2014 on factors influencing adoption decisions of maize farmers in Nigeria). Farmers generally anticipate innovations to bring about high quality and quantity of yield. This expectation is centered on the relative advantage of the innovation itself. In his Communication of Innovation, Rogers (1983) noted that the relative advantage of an innovation elicit decisions to or not to adopt it. He defined relative advantage of an innovation as "the degree to which an innovation is perceived as better than the idea it supersedes". To Rogers (1983), the degree of relative advantage may be measured in economic terms, but social-prestige factors, convenience, and satisfaction are also often important components. Thus farmers will go in for innovations that will be relatively cost-effective and relatively high-yielding. What matters about why a farmer adopts a technology lies in whether or not he/she perceives it as being advantageous. In a study conducted by Akudugu et al. (2012) on what factors influence the farm households' decision to adopt modern agricultural production technologies in Ghana, it was discovered that the expected benefits to be derived from adopting a given technology positively related to the probability of adoption; that is, if farmers expect relatively higher benefits from adopting a modern agricultural production technology then they are most likely to adopt it and the vice versa. They also found that modern agricultural production technologies that are costly negatively related to their probability of adoption; so if the technology is costly to the farmer, there is low probability that he or she will adopt it.

Also, there is a greater likelihood that farmers will reject technologies with which they are incompatible (Rogers, 1983). Rogers defined Compatibility as "the degree to which an innovation is perceived as being consistent with the existing values, past experiences, and needs of potential adopters." Thus farmers will have a greater tendency of adopting innovations that are consistent with the prevalent values and norms of a social system and the vice versa.

Rogers also noted that the complexity of an innovation acts as either cohesive agent or repellent to adoption of the innovation. To Rogers (1983), if potential adopters perceive the technology not to be user-friendly, they are likely not to adopt it. Farmers will reject complicated innovations and go in for user-friendly ones. In the case of Obatanpa maize varieties if farmers find the variety not be convenient in use they are likely to reject it.

Farmers are risk-averse and they usually like to try a technology before deciding to adopt or reject. Triability of an innovation as defined by Rogers (1983)is "the degree to which an innovation may be experimented with on a limited basis. New ideas that can be tried on the instalment plan will generally be adopted more quickly than innovations that are not divisible." An innovation that is triable reduces farmers' uncertainty to adopt and the vice versa. If farmers see and fill how an innovation is used there will be a greater likelihood of them adopting the innovation. Rogers further argues that observability of an innovation exposes its attributes to potential adopters.

These factors: relative advantage, compatibility, complexity, triability and observability also serve as conditions for adoption, and they are themselves influenced by other factors such as education, farming experience, financial status and the efficiency of structures in agricultural organizations. Farmers with poor financial status, for example, may not be able to a technology which costs higher than they can afford even though the technology may be simple and observable. So, generally, these factors outlined by Rogers in his Communication of Innovation, in addition to quality and quantity of yield are only foundational factors but other auxiliary factors (such as institutional factors and the policy environment) will continue to debar adoption success, for which reason challenges affecting agricultural technology adoption is worth noting.

2.3 Challenges Affecting Technology Adoption By Farmers

Governments and non-governmental organizations continue to invest in agricultural technologies in order to ensure food security and stitch economic relations across the globe, yet Tiruneh et al. (2015) is of the opinion that low adoption levels of agricultural technologies by farmers undermine the impacts of national and international agricultural research.

Constraints to adoption affect a farmer's decision to adopt agricultural technology. The lack of a close working relationship between national agricultural research and extension organizations, and with different categories of farmers and farm organizations, is one of the most difficult institutional problems confronting ministries of agriculture in many developing nations, (Swanson, 2016). Swanson (2016) argued that research and extension organizations generally compete over the same scarce government resources and, frequently, leaders of these institutions do not see themselves as part of a broader system: the Agricultural Technology System (ATS). Instead, they try to increase the flow of resources to their individual institutions and to solve daily management problems, rather than ensuring that their respective organizations contribute to the broader goal of making sure that improved agricultural technology reaches all major classes of farmers.

Jack (2013) noted that agricultural technology adoption is constrained by a number of factors as market inefficiencies in terms of input and output, land, labour, credit, risk, and information. With input and output market inefficiencies, Jack (2013) indicated that problems with infrastructure and with supply chains, mixed by weak contracting environments, make it more costly for farmers to access input and output markets and access the benefits from technology adoption. Areas where land tenure is weak and property rights insecure, farmers may not have an incentive to invest in beneficial technologies and the vice versa; farmers with large lands may have the greater tendency to try the technology. With labour market inefficiencies, he noted that new technologies need different types and timing of labour input; more rewarding technologies (row planting, for example) have not been adopted because of its higher labour requirements in large farms; restrictions on labour mobility and high costs in the labour market greatly influence adoption opportunities. Non-availability of credit facilities for farmers, ineffective credit systems or high interest rates prevent farmers from investing in profitable technologies. Financial decisions may be difficult for farmers without high levels of financial literacy. Technologies that carry a small risk of a loss may not be worth large expected gains if risks cannot be offset. Psychological issues around risky decisions further lower levels of adoption.

If an individual does not know that a technology exists, does not know about its benefits or does not know how to use it effectively, then the technology will not be adopted – a consequence of information constraints. To Jack (2013), efforts to address these challenges can seek to improve the whole market (input and output, land, labour, credit, risk, and information), or can target individuals' capacity to adopt agricultural technologies in the face of market inefficiencies.

Constraints to agricultural technology adoption continue to hinder farmers from adopting more rewarding technologies since it has been the gap between the technology adoption requirements and that of the farmers'. Farmers in remote areas may not get access to information about certain beneficial agricultural technologies if they do not have access to radio, television or mobile phone network, or if extension agents lack logistics to reach and teach the disadvantaged farmers. In this situation the constraints to agricultural technology adoption may overlap, making the situation more complex. Kasirye (2013) noted that farmers with small farm sizes may be credit constrained, and such resource poor farmers may not be able to purchase key inputs. In a study into the Constraints to Agricultural Technology Adoption in Uganda, Kasirye (2013) found that farmers with low education and low land-holdings are less likely to adopt agricultural technologies and that limited adoption of agricultural technologies is as a result of supply constraints as in the case of the fact that the agricultural technologies are not readily available in agricultural markets; so sourcing such inputs from distant markets could reduce the profitability and eventual duration of adoption.

In synthesis of the findings of 22 case studies conducted on adoption of maize and wheat technologies in Eastern Africa, Doss et al. (2003) found that lack of information on improved maize and wheat technologies in the parts of Mbeya District (Southern Highlands) of Tanzania, Kenyan Coast, Bale Highlands, and Ethiopia; high cost of inputs, lack of access to credit facilities, and lack of credit facilities for farmers were some of the constraints of adoption of improve maize and wheat varieties in the study areas of East Africa. Doss et al. (2003) indicated that many of the non-adopters reported that they were not aware of the existence of those improved varieties, and even in areas with available extension services, some farmers reported that they were not aware of the relative benefits of the improve seeds. For example, in Ethiopia, "lack of credit was a constraint for 26% of adopters of improved wheat varieties and 31% of non-adopters in the Bale Highlands, and for 5% of lowland and 12% of intermediate farmers in Sidamo and North Omo."

2.4 Factors Influencing Adoption of Improved Maize Varieties

The first step in creating a more successful agriculture development project is to gather comprehensive data on the factors by which highest rates of adoption can be explained (Parvan, 2011). Exploring factors that influence farmers' adoption will assist development agencies in the sector to identify areas to direct their efforts, building the appropriate incentives into their projects to overcome the farmers' limitations. Several studies have been carried out by researchers in the hard and soft technologies in agriculture to come out with best practices that can help increase quality and quantity of agricultural output thereby improving food security in the world. For suitability to the purpose of this study, attention is focused on improved seed technology and for that matter factors influencing the adoption of Obatanpa.

Improved maize variety adoption is much encouraged in the recommendations of literature, instigating studies into influential factors of adoption.

Doss et. al., (2003) conducted a 22 micro-level studies on agricultural technology adoption in Ethiopia, Kenya, Tanzania, and Uganda during 1996-1999. They established that technologies were adopted across Eastern Africa, yet they maintained that considerable scope remained to improve the productivity of smallholder agriculture in higher potential regions with high levels of adoption. They also found that a variable that had higher correlation with adoption was extension – a service which continued to play an important role in disseminating information on new varieties and how to manage them.

In another research, Teferi et al. (2015) studied the Factors that affect the adoption of improved maize varieties by smallholder farmers in Central Oromia, Ethiopia, collecting data from 300 randomly selected sampled maize producing households and analyzed data using logistic regression model to assess the determinants of adoption. Adoption of the improved maize varieties among households was found to be positively influenced by adult-literacy, family size, livestock wealth, access to output market and credit access for the new varieties. On the other hand, farmer associations, distance to main markets and fertilizer credit negatively influenced adoption. Thus, the finding of this study revealed that educating farmers, strengthening extension services, improving farmer associations and improving market opportunities are some of the measures that need to be taken to enhance adoption of improved maize varieties by farmers.

In a research into the determinants of adoption of improved maize varieties in Osun State in Nigeria on a sample size of 360 respondents, using descriptive statistics to estimate the level of adoption and double hurdle model to assess the determinants of adoption, Kuti (2015) found that about 320 respondents representing 89% of the total (360) sample were adoptors of improved maize varieties. Age of the household's head was found to be a statistically significant variable at 1% level with negative relationship. The coefficient of level of formal education of the household head was positive and statistically significant at 1% level. The coefficient of farming experience was positive and statistically significant at 1%. Household size was statistically significant and positively related to the probability of adoption at 5%. Total farm size of the respondent was positive and had statistically significant influence at 1% level on the adoption of improved maize varieties; and distance of the farmers' village to market centre was found to be statistically significant with negative relationship at 5% level.

Akinbode and Bamire (2015) studied the determinants of adoption of improved maize varieties in Osun State, Nigeria. Descriptive statistics and double hurdle model were used as analytical tools. Results showed 97.8% level of awareness of improved maize varieties while about 91% of the estimates were adopters and 8.8% were non-adopters. The results of the double hurdle model showed that level of education, farming experience, household size, and farm size had positive significant relationship with the probability of adoption of improved maize varieties. However, age and household's distance to market were inversely significant determinants of adoption of improved maize varieties in the study area. Age, level of education, household size, farm size, frequency of contact with extension agent, off farm income and membership of association determined use intensity of improved maize varieties.

In a research into the adoption of improved maize varieties and common bean varieties in Mozambique, Lopes (2010) also estimated the likelihood of household adoption of improved maize varieties using probit model. Household size, age of the household head and years of formal education were socio-economic factors found to have positively significant relationship with adoption of improved maize variety in the study area. Access to extension services and access to information about improved maize variety were also institutional factors that positively and significantly influenced adoption of improved maize variety.

Using logistic regression to analyze the factors influencing adoption of the recommended maize technology package in Makuyu Division and Murags South District of Kenya, Felistus (2009) found that gender, education, and income levels of the farmers had significant and positive relationship with adoption of the entire package. However, cost of the technology, complexity and high perceived risks had negative influence on adoption of the entire package. At 5 percent level of significance, high level of adoption of the entire package was found among female farmers. Fifty four percent of the adopters were females while fourty-six percent were males. This finding differs from the norm that, females are disadvantaged economically and may not afford costs involved in adoption of new agricultural technologies.

In the analysing of the effects of adoption of improved maize seed on household food security in Gwoza Local Government Area of Borno State, Nigeria, Idrisa et al. (2012), assessed the determinants of adoption of improved maize seed using probit regression model. The study revealed that education, yield of maize seed, access to extension contact and access to credit significantly and positively influenced the likelihood of the adoption of improved maize seed. The study also found that adoption of improved maize varieties reduced the incidence, depth and severity of food insecurity among farming households in the study area.

In another research, Tura et al. (2010) conducted a study into adoption and continued use of improved maize seeds in Central Ethiopia on a sample of 120 maize producing households, and analyzed data using bivariate probit model. The study revealed that household size, farm size, access to credit, off-farm income, and membership of FBO positively influenced adoption of improved maize varieties in Central Ethiopia. Only literacy of the household head inversely related to adoption of improved maize varieties in the study area.

Baruwa et al. (2015) also carried out a study to examine the adoption of improved maize varieties among farming households in Osun State, Nigeria. Multistage sampling procedure was adopted to collect data from 100 farming households in Ife Central and Ilesha East Local Government Areas with the aid of structured questionnaire. Both descriptive and inferential methods were used to analyse the data. Logit model was used to determine the factors affecting adoption and the intensity of adoption of improved maize varieties. Results indicated that the major factors significantly influencing the adoption of improved maize varieties in the study area were level of education of the farmers ($p<0.01$), farm size ($p< 0.05$), gestation period ($p< 0.05$), access to credit ($p < 0.01$). The level of education of the farmers and access to credit had positive relationship with adoption while farm size and gestation period of the seed negatively influenced adoption of improved maize varieties. Farming experience ($p< 0.05$) determined the intensity of adoption of improved maize varieties in the study area. The study recommended that to increase maize production in Nigeria through adoption of improved maize varieties, credit should be made available to farming households and dissemination of research outputs should be targeted at the women maize farmers and not just men. Also, improved maize seeds with early maturing varieties should be disseminated to farmers.

Monela (2014) also studied the access to and adoption of improved maize and rice among farmers in Mbeya and Morogoro Regions of Tanzania using binary logistic regression to analyze the impacts of improved seed related factors on the chances of farmers adopting the seeds. The analysis showed that access to land for maize and rice production and awareness of improved seeds exerted the highest positive impact on the chances of smallholder farmers adopting improved maize and rice seeds in the study area.

Ademiluyi (2014) also conducted a study into adoption of improved maize varieties among farmers in Bassa Local Government Area of Plateau State, Nigeria, using a logit regression model to analyze factors influencing adoption of improved maize varieties. The results of the logit model showed that age, access to extension agents, fertilizer, cooperative membership and output were significant. Age, yield, and cooperative membership had positive relationship with adoption of improved maize varieties. However, extension contacts and fertilizer use had inverse relationship with adoption of improved maize varieties.

In another study conducted on the adoption of improved maize varieties and its effects on yields among smallholder maize farmers in Eastern and Central Uganda. Mugisha and Diiro (2010) used a binary probit model to examine the determinants of level of adoption and OLS method to estimate the determinants of intensity of adoption and the effect of adoption on yield. The findings revealed that there was a higher (80%) level of adoption of improved maize varieties in Eastern and Central Uganda. The results of the regression indicated that extension advisory services were positively related to the adoption of improved varieties, suggesting that increased interaction between farmers and extension service providers results in an increased in the farmers' awareness and knowledge about the use of improved maize varieties.

Gregory and Sewando (2013) studied the determinants of the probability of adopting quality protein maize (QPM) technology in Tanzania and analyzed the data with descriptive statistics and a logistic regression analysis. The study revealed a low (30%) level of adoption and high (90%) level non-adoption. The regression results indicated that education of the household head, farmers' participation on demonstration trials, attendance to field days, and numbers of livestock owned positively influenced the rate of adoption of the technology. Access to credit, and poor QPM marketing problem perception by farmers negatively influenced the rate of adoption.

Kasirye (2013) examined the determinants of improved agricultural technologies adoption in Uganda with particular focus on improved seeds and fertilizer technologies, using a nationally representative panel data set of 1,600 farming households, collected by the Ugandan Bureau of Statistics in 2005/6 and 2009/10. Analysis from the probit regression model showed that farmers with low education and land holdings are less likely to adopt improved seeds and fertilizer, while peer effects play a big role in influencing farmers to either use improved seeds or fertilizer. Cattle keeping farmers in Western Uganda were more likely to abandon fertilizers and possibly resort to organic manure from livestock excreta.

Fadare et al. (2014) analyzed results of a study into the factors influencing adoption decisions of maize farmers in Nigeria, using a selected portion of the Nigeria Living Standard Measurement Survey data collected by the National Bureau of Statistics and the World Bank for 2010/2011 cropping season with descriptive statistics and probit model as tools for data analysis. The results show that 67.6% were non adoptors while the remaining 32.4% were adoptors of improved maize varieties. It was also found that higher level of education attained and farm size, as well as access to fertilizer and extension services were socioeconomic and institutional factors that would increase the probability of adopting IMV among farmers. However, marital status, sex of household head, herbicide use, membership of association, non-farm employment, household labour, and ownership of land exerted insignificant relationship with adoption of improved maize varieties in their study area.

On a cross-sectional data of 160 maize growing households, Mmbando and Baiyegunhi (2016) conducted a study into the socio-economic and institutional factors influencing adoption of improved maize varieties in Hai District of Tanzania, using logistic regression model. The empirical results from the study showed that off-farm income, access to extension services, access to credit, farmers' membership of groups /association and participation in on-farm trials/demonstrations were statistically significant factors influencing the adoption of IMVs. The results suggested that improving smallholder farmers' basic education, access to extension service and credit facilities, and the promotion of farmers' groups/association could increase adoption of improved agricultural technologies. Mmbando and Baiyegunhi (2016) recommended that there was the need for research institutes and extension services to increase on-farm trials/demonstrations on improved agricultural technologies, in-order to enhance farmers' awareness and adoption of technologies.

Mignouna et al. (2011) identified the adoption determinants and causal impact of adoption of imazapyr-resistant maize (IRM) on income and poverty among maize farming households in Kenya, using a logistic model and Heckman selection-correction model. Results from a randomly selected sample of 600 households consisting of 169 adopters and 431 non-adopters reveal that age of household head, education of household head, household size, membership of social group, access to extension services, and perception of IRM positively influenced the probability of adoption of the technology.

In another study of the drivers of adoption of improved maize varieties in Moist Transitional zone of Eastern Kenya using double hurdle model to estimate the determinants of adoption and intensity of use of improved maize varieties, Ouma et al., (2014) found that Ownership of livestock, extension visits, Membership of farmers group, and land size for crop production exerted a positive influence on adoption. However, they also realized that age had inverse relationship with adoption; thus increase in age resulted in decrease in the likelihood of a farmer adopting improved maize varieties. Ouma et al. (2014) assumed that this inverse relationship between age and adoption of improved maize varieties was due to the fact that as farmers grow older, there is an increase in risk aversion and a decreased interest in using new agricultural technologies such as improved seed. Young household heads on the other hand display a lower risk aversion and being at an earlier stage of a life cycle, are more likely to adopt new technologies that have better yields compared to the traditional technologies.

Also, in a study of inorganic fertilizer and improved maize variety adoption decisions by farmers in Kenya by Ogada et al. (2014), the level of education of the farm household head, access to agricultural credit, ownership of land and farm size positively influenced the adoption inorganic fertilizer and improved maize varieties in Kenya while distance to input markets exerted negative relationship with adoption. However, sex of the household head showed no relationship with adoption of inorganic fertilizer and improved maize variety.

Katengeza et. al., (2012) studied drivers of improved maize variety adoption in drought prone areas of Malawi to identify the determinants of adoption and adoption-intensity of improved maize varieties in Malawi by estimating a double hurdle model based on household-level survey data collected in the districts of Balaka and Mangochi in 2008. They found that labour endowment, access to rural credit, livestock wealth, access to agricultural extension, farm size and access to off-farm employment all significantly increase the likelihood of adoption of improved maize varieties. Households where the head had membership of a social group were also found to be less likely to have adopted. The intensity of adoption was found to be negatively related to livestock wealth and fertilizer use. Conversely, the age of the household head, the labour endowment of the household and the proportion of household members engaged in off-farm activities were factors that were found to be positively related to intensity of adoption. The study suggested the need to enhance adoption and intensity of adoption of improved maize varieties in Malawi among other things improving access to rural finance through credit and improving access to agricultural extension.

Similar studies have been conducted in some parts of Ghana. Morris et al. (1999) at Ghana Grains Development Project conducted a research into Adoption and Impacts of Improved Maize Production Technology in a randomly selected 20 districts in Ghana of which Damongo, Salaga, and Walewale were part; they found that (1) characteristics of the technology; (2) characteristics of the farming environment into which the technology is introduced; and (3) characteristics of the farmer making the adoption decision are adoption determinant factors of improved maize varieties.

Aidoo et al. (2014) also studied factors determining the use of certified maize seeds by farmers in Ejura-Sekyedumasi Municipality in Ghana and the results from the study showed that farm size, level of education, extension contact and access to credit were the main factors that significantly influenced the use of certified maize seed by farmers.

Salifu et. al. (2015) examined the determinants of farmers' adoption of improved maize varieties (IMVs) in the Beehi and Kpongu communities of the Wa Municipality involving across-sectional survey with 300 systematic sampled household heads growing maize, using a binary logistic regression model. The logistic regression analysis showed that age, marital status, level of education of household head, farmers' maize production experience and varietal characteristics were the most significant factors influencing adoption of improved maize varieties. Farmers' years of education and years of experience in farming maize had positive relationship with adoption of improved maize varieties in that as the years of education and experience increase, the farmers' likelihood of adopting improved maize varieties increased. Yet age had inverse relationship with adoption of improved maize varieties. However, farm labor, extension services and belonging to farm organization exerted insignificant influence on adoption.

2.5 Effectiveness of Agricultural Extension Delivery

Effectiveness of any tool answers two questions: Is the tool achieving its purpose? At what rate is it achieving its purpose? Thus effectiveness of any extension approach answers these questions. Complexities exist in evaluating agricultural extension approach, and this lack of simplicity arises from the fact that agricultural extension approach is not operating in isolation but as part of a social system that has a complex environment. Research institutions, extension, and farmers are in this system that is affected by government policies in allocation of resources.

The effectiveness of the extension approach in enhancing capacity building, technological adoption and ultimately improved agricultural output depends on key factors associated with the extension method used, the governance, capacity and management structures of the extension approach, as well as underlying contextual factors such as the policy environment, market access, characteristics of beneficiary communities and weather conditions (Directorate of Agricultural Extension Services, 2011). A careful choice of extension method serves the needs of the clientele. In planning learning situations and organizing teaching activities, the extension worker draws upon a variety of teaching approaches. Wilson and Gallup (1964) argued that the judgment exercised in selecting the most appropriate method for the particular teaching situation and the skill with which the working tool is used have a direct bearing upon the amount and quality of the learning resulting from the teaching effort.

In achieving objectives of extension programme, the teacher-learner situation frequently involves the associated use of two or more kinds of extension teaching methods since the learners (farmers) have different demographic and socio-economic characteristics. For example, using e-extension approach to disseminate information about improved maize variety may have a greater limitation of reaching rural farmers who lack access to television signal unless this signal is provided and a village TV show centre is established to serve other rural farmers who do not have televisions. This was emphasized by Phichitchaisopa and Naenna, (2013) in their study into the factors influencing adoption of healthcare Information Technology (IT) services in Thailand, when they found facilitating conditions to have a positive influence on adoption of healthcare information technology. They argued that infrastructure support, such as computer systems or knowledge are necessary for adoption. In addition, no matter how equipped are extension agents, they cannot influence adoption of agricultural technology that is too costly for poor farmers to access. This is to say that the effectiveness of any extension approach depends largely on its suitability to the farmers' geographical, demographic and socio-economic characteristics, the policy environment and the entire social system in which the approach is used. Extension agent-farmer ratio also greatly influences the effectiveness of extension delivery.

In a PhD research into farmers perception of extension methods used by extension personnel for dissemination of new agricultural technologies in four districts (Bannu, Mansehra, Mardan and Swat) of Khyber Pakhtunkhwa in Pakistan, Khan and Akram (2012) used a multistage random sample of 240 respondents (60 respondents from each district) to collect data which was analyzed using descriptive statistics, likert scale and logistic regression. The results of the study revealed that extension personnel contact with sample respondents was very poor as reported by 174 farmers. The data revealed that majority of sample respondents i.e. 151 perceived extension services as not effective. Regression analysis showed that contact with extension personnel influenced the effectiveness of extension services. The extension activities and methods used also remained dim and poor as reported by the respondents. The ranking of extension methods undertaken by extension personnel revealed that farm/home visit was perceived as very good and best method having rank ‘1’, followed by field days at ‘2’and demonstration plots at ‘3’ on the basis of their weighted score. It was concluded that respondents below 40 years were more responsive and alert. Majority of the sample respondents termed extension services as ineffective and the extension delivery methods (Farm/Home visit, Office calls, Demonstration plots, Field days, Farmers Trainings, Local Agriculture Fair, Workshop/Discussion) used for dissemination were also not effective. With these tools of extension delivery, a majority of sample respondents varying from 175 to 220, with varying frequencies in the four districts, reported that none of the seven activities was performed by the extension personnel. The remaining sample farmers, varying between 20 to 65, perceived performance of the seven activities by extension personnel into five levels i.e. very poor, poor, average, good and very good. The number of respondents varied under each level in Bannu, Mansehra and Mardan for the seven activities. In district Swat all 60 sample respondents reported that no activities were performed except farm/home visit where one regarded it as very poor and another as good. Again in district Mardan only one sample respondent reported that farm/home visit, office calls and demonstration plots were very poorly performed. In Bannu district sample respondents varying from three (3) to eighteen (18), graded farm/home visit, office calls and demonstration plots either very poor or poor: while one to six sample respondents graded local agriculture fairs, workshop/open discussion, farmers training, field days, demonstration plots and office calls as average; and in district Mansehra more sample respondents varying from 18 to 50, graded each of the seven activities under 3-5 level of effectiveness compared to the other 3 districts. In other words sample respondents from Mansehra district had greater and better exposure to the activities of extension personnel and therefore, more richly embedded with the know-how and do-how of practical knowledge. The overall data in the four (4) districts showed that majority of the sample respondents in the study area were not satisfied with the tools of delivery and deemed them as very poor, poor and average.

Also when Al-Rimawi et al. (2016) assessed vegetable growers' perception of effective extension methods and Information Communication Technologies for training vegetable growers in Jordan, using four point Likert-type scales to analyze data collected from a random sample of 98 vegetable growers, the methods of extension delivery that were found to be effective were farm visit, meeting groups of farmers, result demonstrations and farm tours. Field days, mass media/TV and radio, Mobile communication/SMS, printed materials, electronic materials, farm schools, and internet-provided extension were, however, perceived by the respondents as being ineffective method of extension delivery in the study area.

Agricultural extension services play an essential role in agricultural development by contributing to improving the welfare of farmers and other people living in rural areas (Waddington et al., 2010). According to Akpalu (2013), extension service in the broader system of agricultural and rural development performs intermediary roles: (1) providing information for the government (research institutions) about the productive performance and farmers' potential and the appropriate ways research will respond to farmer requirements; (2) providing assistance to smaller-scale farmers to appropriately form FBOs to gain access to finance and other production requirements, and to market their produce through group action; and (3) providing assistance to rural communities seeking to better manage local agricultural and natural resources through new forms of organization, such as livestock associations, water-user associations and land-care groups. The primary responsibilities of agricultural extension services are mainly to create awareness among farming communities and to facilitate the improvement of the living standards of rural people through educational procedures (Khan and Akram, 2012).

Mostly extension services are actively engaged in promoting adoption of new technologies with farmers (CIMMYT Economics Program, 1993). If an extension service is recommending agricultural technology, according CIMMYT Economics Program (1993), it will be very useful to ascertain the number of farmers adopting the new practice; and for non-adoptors, it will be very instrumental to find out whether they find disadvantages with the new practice or whether the extension methodology used is not being effective in diffusing the technology among the farmers. Therefore, This study looked at farmers' perception of effectiveness of the tools with which extension services are delivered to farmers in the study area since Agbarevo (2013) argued that a major factor in the adoption process is how healthy extension activities are organized and delivered, and if adequate delivery activities are conducted with effective tools of delivery and personnel, then there will be a greater likelihood of high adoption and the vice versa.

Similarly, Waddington et al., (2010) argued that the effectiveness of the extension system in fostering capacity building, technological adoption and ultimately improved agricultural outcomes depends on the major factors relating to the advisory methods used, the governance, capacity and management structures of the extension system, as well as underlying contextual factors such as the policy environment, market access, characteristics of beneficiary communities and weather conditions.

In a study into Farmers' Perception of Effectiveness of Agricultural Extension Delivery Programmed (ADP) in Cross-River State, Nigeria, using a randomly selected sample of 180 farmers participating in extension programme in Cross River state, Agbarevo (2013) collected data using a structured questionnaire and analyzed data using the t-test of significance of difference between sample and population means. The study found that farmers were unanimous that extension delivery process was not very effective as the study found no significant difference between the population and sample means at 95% confidence level. The result shows that there exists a high (94.82 percent) level of awareness among farmers about the existence of extension agents; holding fixed meetings with farmers was (87.93 percent); effectiveness indicators were as follows: method demonstrations conducted (82.75%); result demonstrations conducted (79.31%); method/result demonstrations conducted(77.58%); while effectiveness in conducting of field days was (72.41%). Extension effectiveness in visiting farmers was 65.55%, while supervisory visits by extension officers from headquarters and zonal offices was 60.12%. However, extension delivery was poor in the following areas: research-extension-farmer linkage through On-Farm Adaptive Research (46.55%) and farmer training programmes that were executed (39.65%). The result showed that the poorest performance of Cross River was in the area of organizing farmer-training programmes in farmer training centres. Thus, the strongest links in the delivery process areas were found to be farmer visits, meetings between farmers and extension personnel, demonstration, while the weakest links were organization of Research-Extension-Farmer-Linkages, farmer training programmes and distribution of training materials. The study concluded that any evaluation of extension programme should be done in terms of rate of adoption, programme effect and impact relative to the effectiveness and efficiency of extension delivery process.

In another research into farmers' perception of the effectiveness of extension agents of Delta State Agricultural Development Programme (DADP) in Nigeria, Aphunu and Otoikhian (2008) found that respondents perceived extension agents to be vast in knowledge of subject matter and integrated theories with practicals. Respondents, however, were not impressed with extension agents' teaching and communication skills. Their findings also showed a significant relationship between the effectiveness of extension agents and the adoption of technologies. In another study into determinants of intra-household gender difference in access to agricultural extension service on improved maize variety in Toke-Kutaye District, Oromia Regional State in Ethiopia, Abebe (2016) assessed farmers' perception towards the performance of agricultural extension service received by collecting Likert-scale (1=very low, 2=low, 3=medium, 4=high, 5=very high) data on crop management, input delivery and utilization, market information as indicators of farmers perception towards the performance of agricultural extension service through semi-structured interview questionnaire. The overall mean scores of respondents' were computed to indicate perception towards the performance indicators. The perception score revealed that farmers' perception towards the performance of agricultural extension was different for women and men farmers.

In the same study, Abebe (2016) applied logit model to identify the determinants of intra-household gender difference in participating in agricultural extension service delivery. The regression result revealed that age, education, family size, farm experience, frequency of listening to the radio, distance from Farmers Training Center and Development Agent's gender significantly affected participation in agricultural extension service.

In another study into perception of farmers on extension services in North Western part of Nigeria: the case of farming households in Kano State, Ibrahim et al. (2014) assigned ranks to each methods used by extension service in innovation dissemination among farmers in a 5 point Likert scale (1, 2, 3, 4 and 5 scores varying respectively with v.poor, poor, average, good, and v.good). The weighted scores of each method determine its rank as obtained by multiplying the frequency of responses from each column. The result indicates that radio was ranked 1 with mean (m = 23.80) and standard deviation (SD = 27.25), farm and home visit ranked 2 with m = 18.40 and SD = 18.24, print materials ranked 3 with m = 19.40 and SD = 15.14.

In another study into farmers' perception of effectiveness of Agricultural Extension delivery towards aquaculture development in Ebonyi State of Nigeria, collecting data on a multistage sample of 168 fish farmers and analyzing data using mean and standard deviation, Egbe and Eze (2014) found that in the area of farmers training programmes, ineffectiveness was perceived in the Training and visits of farmers, Organization of field meetings, Organization of methods, techniques and result demonstrations, and Organization of research linkage workshops. Only Training on efficiency of production, processing and storage was effective in farmers' training programmes. In the dissemination of information, awareness creation through electronic media and use of interpersonal contacts to pass technical information were effective tools of extension delivery except use of printed media to circulate information which farmers in the study area perceived as being ineffective. Egbe and Eze (2014) argued that the inability of extension officers to deliver effectively on training program might be due to high ratio of an extension worker to farmers.

Also in Moaba's (2016) study into farmers' perception of agricultural extension service delivery in Germiston Region, Gauteng Province of South Africa, collecting data on a purposive and simple random sample of 78 respondents. A 4 and 3 point Likert-type scale method score was used to determine farmers' perception of effectiveness of extension methods. Data were analyzed using descriptive statistics such as mean, frequency counts, percentages and standard deviation. Results showed that farmers' perceptions of farmer training (M=3.6, SD=±0.5) and demonstrations (M=3.6, SD=±0.48) werebe highly effective in the study area. Study groups (M=3.1, SD= ±0.79), farmers days (M=3.0, SD=±1.12), individual farm visits (M=2.8, SD=±0.92) and on-farm trials and research (M=2.5, SD=±0.98) were perceived to be effective. The study further revealed that the following extension methods were perceived to be slightly effective by farmers, workshops (M=2.1, SD=±1.05), print materials (M=2.1, SD=±1.02) and office calls (M=1.9, SD=±0.98); and telephone calls (M=1.5, SD=0.73), however, was perceived to be ineffective by famers in the study area. Moaba (2016) argued that it was imperative to ensure that methods regarded to be effective were mainly used to deliver extension messages and that extension officers should be encouraged to do away or minimize the application of extension methods perceived to be slightly or not effective. Continuation with such methods may results in non-participation of farmers to extension activities since it has been considered to be non-effective.

From the review of effectiveness of the tools of extension delivery, it was observed that very little of empirical studies had been done, as the above had been thoroughly gleaned and insufficient to produce a macroscopic outlook of the problem situation across the global agricultural literature, and for that matter, the local setting.

2.6 Extension-Farmer Linkage

The rapid changing of the agricultural sector in the developing world with increasing number of challenges makes the sector so complex, resulting in a consequential demand placed on extension services which have a crucial role of promoting agricultural innovation to keep pace with the changing context, and improve livelihoods of the dependent poor have also increased significantly (Asiedu-Darko, 2013) .

Asiedu-Darko (2013) noted that extension service is one of the most important tools to resolving the problems of the small farm sizes and inefficient farm management – problems that result in poor improvement in the agricultural sector.

For research to be effective there must be an efficient mechanism whereby its findings can be used by the end users (farmers). The process of making research findings accessible to farmers is the function of extension, (Directorate of Agricultural Extension Service, 2011). If extension service is going to be beneficial, then the number of extension visits must positively impact on the quantity and quality of yield. Effective communication between extension agents and farmers will facilitate adoption. Farmers expect accurate and timely information about agricultural technology to create their awareness of research findings and stimulate their interest in adopting a technology. The role of research and extension services is to provide adequate, specific and objective technical and management information and advice in direct response to the needs of their clients (farmers)(Directorate of Agricultural Extension Service, 2011). Thus extension is acting as a safety valve through which research findings and developed technologies are transported to farmers.

Extension agents do not operate in isolation; they are engaged in a systemic relationship with agricultural research institutions, farmers and farmer organizations in such a way that each component in the system is indispensable to the purposive functioning of the system. The main aim of establishing this systemic relationship is to ensure information sharing that will lead to increasing agricultural productivity by farmers who are mostly the objects of technologies. Mwagi and Kariuki (2015) noted that extension agents are intermediaries between technology developers (researchers) and users of that technology (farmers) and that farmers at this end expect easy access to and smooth flow of extension services to them – a service that will serve their needs.A study conducted by Asiedu-Darko (2013) on 105 respondents made up of Research Scientists, Technical Officers and Extension agents recommended that there was the need for active involvement of farmers in the extension delivery and building the competence of extension agents to enable them deliver on their given roles. Extension agents monitor changes in farming practices, assess the adoption of new technology and provide feedback to research.

Effective extension delivery depends on the other actors in the agricultural system. To ensure that research focuses on priority and transparent financial support mechanism for demand-driven agricultural Research and Development (R&D) within Ghana and the West African Sub-Region, a suitable mechanism that seeks to compliment on-going and future R&D activities carried out under the country's agricultural policy are put in place to optimize dissemination of improved technologies in the country's top agricultural priorities (CSIR and MoFA, 2013).

According to Cerdan-Infantes et al. (2009), improving productivity and quality requires a functioning system of technology generation and transfer and a means to implement these technologies; and that extension services can provide the proper institutional system to deliver these trainings to farmers. In Ghana, this could only be done efficiently by strengthening the activities of Research Extension Linkage Committees (RELCs) at the national and regional levels to identify and prioritize farmers' problems for solution through research and extension as well as policy dialogue, (CSIR and MoFA, 2013); and it is believed that research, extension and farmers are the three main pillars of agriculture system and their effectiveness largely depends on the strong linkages among them (Sewnet et. al., 2016). Research and Extension Linkage Committee (RELC) and Research–Extension–Farmer–Input-Suppliers Linkage committees (REFILS) are some of the participatory approaches for improving linkages between research and extension, and to ensure that farmers' problems reflect in research planning and activities. They are formal structures that institutionalize interactions between public research and extension institutions to generate demand-driven and participatory research programmes and extension activities; the membership of regional

RELC/REFILS is composed of five representatives/co-coordinators from farmers' groups, researchers, extension agents, subject matter specialists, local government and the private sector. While the activities are mainly at the regional level, they are supported by a multi-stakeholder national (or federal) co-ordinating committee for formulating policies and sourcing funds to support RELC/REFILS activities (Ragasa, 2013).

However, results from the study by Ragasa (2013) conducted into the perceptions of stakeholders about effectiveness and inclusiveness of research-extension-farmer linkage in Ghana and Nigeria showed that the scope and effectiveness of these linkage committees was limited as majority of researchers and extension agents who were interviewed were not involved in these committees, and most of the extension agents in Ghana reported they were unaware of RELCs. The inadequate functioning of RELCs is as a result of poor coordination due to lack of clarity as to which of the two implementing institutions (CSIR and MoFA) in separate ministries is responsible for providing leadership and harmonising the activities of the platform (SEND GHANA, 2016).

Kumar et. al. (2002) also reviewed literature on factors affecting linkages among research, extension and farmers in India. They concluded that organizational factors (the size and goals of organization and organization climate), Psychological factors (the attitude, job satisfaction), external factors of the organization, lack of mechanism to stitch research, extension and farmers together, have been the causes of poor or weak linkage between research, extension and farmers.

The effectiveness of the extension approach in enhancing capacity building, technological adoption and ultimately improved agricultural output depends on key factors relating to the extension method used, the governance, capacity and management structures of the extension approach, as well as underlying contextual factors such as the policy environment, market access, characteristics of beneficiary communities and weather conditions; effectiveness may be also influenced by the degree of feedback and the mechanisms of delivery of information from farmers to the research and extension system – the role of farmers in formulating demand and their ability to exercise voice (Directorate of Agricultural Extension, 2011).

2.7.0 Recommended Agronomic Practices for Improved Maize Varieties

The yield potential of an improved seed is heavily dependent on its agronomic practices. A certified seed, be it hybrid or improved, that is isolated from its agronomic practices from cropping to harvesting will yield below standard as compared to those that are followed by their agronomic practices (Ragasa et al, 2013). They stated that maize-related activities by national research institution are on improvement of varieties and testing, and several trials on agronomic practices have been conducted on improved land preparation, row planting, fertilizer use, herbicide use, pest and disease control, and water management, among others.In a research into the adoption of maize production technologies in Southern Highlands of Tanzania, Bisanda et. al. (1998) noted that adoption should not be limited to only using a new certified seeds but also must include following the extension service recommendations that go with its cultivation. Thus, it can easily be argued that adoption of an improved seed technology must go beyond the use of the improved seed to include the agronomic practices that accompanies the technology if the potential yield of the improved seed is to be realized. It is worth noting that improved seed technology has both hardware (seed) and software (pesticide use) components, for example, such that a new crop variety cannot be fully utilized without having a complementary set of agronomic practices (software component). Ragasa et al. (2013) outlined the following agronomic practices for certified maize seed:

2.7.1 Certified Seed

CSIR trials have shown that certified seed has higher germination rates and higher yields than farmer-saved seed. For example, in 2005, certified Obatanpa seed afforded a 7 to 9 percent higher yield than farmer-saved seed in Kwadaso and Ejura experimental plots. If farmers cannot buy fresh certified seeds, OPVs can be recycled for up to two seasons (three seasons of planting in total). Hybrid seeds have to be bought fresh for every season. CSIR and MOFA also recommend buying fresh Obatanpa seed every season to maintain its nutritional value, but if that is not possible among farmers, the seed can be recycled for up to two seasons (three seasons of planting in total). The seed to be stored for the next cropping season must be selected from the middle of the plot to minimize crossing (Ragasa et al. 2013).

There are many important reasons for using of certified seed. According to Canadian Seed Growers Association (CSGA) (2016), the reasons to use certified seed include the following:

Clean seed: Certified seed is grown and processed under rigorous production requirements with strict limits on weeds and other crop kinds.

Varietal purity: Certified seed uses strictly monitored quality management systems to maximize varietal purity – making sure that farmers get the specific variety they opt for. Other varieties and off-types are guaranteed to be minimized.

Guaranteed quality assurance: Inspections in the field and at the processing plant ensure that all quality assurance requirements are met and documented. The seed farmers' expectation is what they get.

Access to new opportunities: Many end-users require specific varieties for their products. Using certified seed can open the door to new opportunities and greater sales by providing officially recognized proof of the parent seed varietal identity.

Traceability: Food safety and traceability are important considerations in agriculture. Farmers and seed dealers can be sure of the seed product if they know its origins. Certified seed is the key to that knowledge: production of this seed is carefully controlled under a quality assurance system right from the beginning.

New genetics: Improved traits such as better yield, pest resistance, drought tolerance, herbicide tolerance, and much more are delivered to farmers in certified seed. Years of research and development went into these traits and they can only be reliably accessed through certified seed.

Substance behind your word: The blue tag is proof that the certified seed is used to maintain the value traits of the crop. It gives assurance to farmers that what they look for is what the seed producer/dealer is delivering to them.

Maximize other inputs: Certified seeds go with its agronomic package of inputs and soil management that are known to the end user. Planting certified seed means farmers are not wasting time, and the ever-increasing investment required for modern crop production, on seed that won't reliably produce a top crop.

Access to premium markets: Certified seed is the only input that can get the farmers more than just higher yields. It can be your ticket to premium markets. like tofu soybeans or high stability canola and other identity-preserved (IP) markets.

A better deal on crop insurance: In some cases, certified seed allows farmers get a better deal on crop insurance premiums. Insurers know that certified seed means a crop with reduced risk.

In a study to determine the seed quality and field performance of farmer-saved seeds of the most popular quality protein maize (QPM) variety, Obatanpa, compared to the certified seed of the same variety, Asiedu et. al., (2007) found that germinating seedlings of the certified seeds did not show any fungal growth, but farmer saved seeds showed profuse fungal development and stunting. Seedling counts showed 9 and 21 per cent reduction in certified and farmer-saved seeds, respectively; but plant counts before harvest showed 12 and 23 per cent reduction respectively. Plants originating from certified seeds flowered at the predetermined date of 55 days, but the farmer-saved seeds flowered about a day or two later owing to reduced vigour. Lodging was less in plants originating from certified seeds, particularly in the trial planted at Ejura (transition zone) compared to Kwadaso (forest zone). The advantages of certified seeds reflected on 47 per cent increase over the farmer-saved seeds, indicating that certified seeds, relative to farmer saved seeds, increase maize productivity and resultant farmers' incomes – reflecting one of the stated importance of certified seed mentioned by CSGA (2016) such as better yield, pest resistance, drought tolerance, and herbicide tolerance. However, according to Sugri et al. (2013), critical constraints facing the seed industry in Ghana include seed availability, seed access, lack of information and high fertilizer requirement (farmers' side), and (at the side of seed producers) low patronage of certified seed, long distances to regional seed processing centres and lack/outmoded of shelling, drying, sorting, grading and packaging equipment, and threatening access to isolation fields.

2.7.2Fertilizer Use

According to Ragasa et al. (2013), recommended rates of fertilizer application depend on the agro-ecological zone, soil type, and cropping history. Compound fertilizer (for example, NPK 15-15-15 or NPK20-20-0) 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) (Ragasa, 2013). Sulfate of ammonia (N21 S24) or compound fertilizer (NPK20-20-0 orNPK20-20-20) is recommended as a side-dress applied four to five weeks after planting at the soil surface (except for sloping fields). 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.

Morris et al. (1999) stated that chemical fertilizer comes in many different formulations, some of which are not well-suited to addressing a given soil nutrient deficiency and that it can be applied at different rates, using different methods, and at different points in the cropping cycle. Furthermore, soil nutrient deficiencies tend to be location-specific, so the optimal fertilizer treatment often varies between neighbouring farms, between different fields located within the same farm, and even between plots within the same field. Morris et. al. (1999), however, mentioned that fertilizer is constrained by high prices, making the economically optimal application rate varying with changes in the relative prices of fertilizer and grain.

Fertilizer use is, according to Morris et al. (1999), determined by a number of factors that include farmer characteristics (age, gender, and level of education), resource ownership (farm machines and implements, size of land own), land tenure (owned land and rented land), cropping intensity (the number of cropping years on the same piece of land), commercial orientation and access to technology.

2.7.3 Crop Protection

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 (Ragasa, 2013). Examples of formulations of herbicides that have been tested and are available in Ghana are Roundup (360 grams/liter of glyphosate) and Roundup Turbo (450 grams/litre glyphosate). If the grassy weeds are standing tall, they should be slashed down to about 30 centimetres and allow for regrowth before glyphosate is applied. 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 lassoatrazine to the soil immediately after planting. The recommended rate is about 4 litres of lasso-atrazine per 15-liter sprayer per hectare. It kills weed seeds that have yet to germinate or have just germinated. If both glyphosate and lasso-atrazine are applied well, there may be no need for any hand-weeding until harvest. If weeds emerge after planting, it is recommended to apply 1 liter per hectare of Gramoxone or adjust the rate for other available formulations (MOFA/CRI/SARI 2005). Striga, a parasitic weed common in Ghana, cannot be controlled by chemical, and the recommended controls are (1)rotation with nonsusceptible crops (such as cotton, groundnut, and soybean varieties such as Janguma and Quarshie) to stimulate suicidal germination of Striga seedlings; (2) fertilizer application because well-fertilized maize is less affected by Striga than an unfertilized crop (a 20 percent urea solution can be applied directly to the Striga seedling); and (3) use of Striga-resistant varieties. Stem borer, a major insect affecting maize plots, can be controlled by combining pesticide application and cultural practices, such as not planting during the minor season if the plot is heavily infested during the major season or clearing nearby grass to minimize crop loss from stem borers. Streak virus is a major disease affecting maize plots and can be controlled by planting streak-resistant varieties (Ragasa, 2013).

2.7.4 Plant Density, Spacing and Row Planting

Row widths in corn production continue to decrease as time moves forward. This is likely due to agricultural technological revolution over the years. For example, the fertility difference of two farm lands in different locations will not have the same yield if all other things being equal without fertilizer application in any of those farms. In 2006, row widths employed by producers, according to Abendroth and Elmore (2006), typically varied from 15 inches to 38 inches, with most producers at 30 inches; adding that numerous advantages exist with narrower row widths; these include using the same planting equipment for corn and soybean, reduced weed competition, increased shading of the soil, increased light interception per plant, and less in-row crowding. Plant populations continue to increase every year (400 plants per acre per year). Using wide row widths force more plants to be in a concentrated area, whereas narrower rows allow better dispersement, (Abendroth and Elmore, 2006).

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 Ghana Grains Development Program (GGDP) (Ragasa et. al. 2013). 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. Farmers had been used to plant 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. Yields fell only slightly when surviving plants per hill increased from one to two, but the decline became more rapid when the number exceeded two per hill, especially at low plant densities. Sangoi (2001) also noted that, at high plant densities, efficient conversion of intercepted solar radiation to grain may be limited by apical dominance, protandry, and delays in ear differentiation, asynchronous flowering and barrenness.

Depending on the germination test, planting two seeds per hill is recommended for those with an 85 to 100 percent germination rate and three seeds per hill for a 70 to 84percent germination rate; it is recommended to get better seeds if the germination rate is lower than 70 percent. The recommendations emphasized planting in rows to help farmers calibrate plant population densities and achieve plant spatial arrangements that facilitate subsequent crop management operations, such as weeding and applying fertilizer, (Ragasa et al., 2013).

In addition to stressing the importance of row planting, Ragasa et al. (2013) offer there commendations focused on reducing the distances between rows and holes, which were expressed in terms of the length of the cutlass that most farmers use for planting: 75 to 90 centimeters between rows or lines (depending on the variety) (about 1.5 of a cutlass length) and 40 centimeters (two-thirds of a cutlass length) between plants within rows or lines.

2.8 Theoretical framework on adoption

This study adopted Rogers' Diffusion of Innovation Theory . According to Rogers (1995) diffusion theories have their origins in the explanation of the adoption of technological change by farmers. To Rogers (1995), four factors influence adoption of an innovation and these factors are

(1) the innovation/idea itself,
(2) the communication channels used to spread information about the innovation
(3) time,
(4) and the nature of the society to whom it is introduced.

Innovation refers to any concept, technology, practice or system that is new to any individual or group individuals, (Botha and Atkins, 2005). The theory thus explains how the innovation/idea/product (Obatanpa, for example) gathers momentum and diffuses (or spreads) through a specific population or social system (maize farmers in Zabzugu and Tatale/Sanguli districts, for example) over time. The innovation has certain characteristics (yield quality, yield quantity, resistance to pests and diseases, drought resistance, maturity period etc.) and appropriate channels (farmer to farmer extension, government/NGO extension service etc.) through which it can successfully diffuse in a social system/population (individual/farmer groups for a single or multiple crops/animals in a particular geographical location) in a period of time. The social system itself contains certain characteristics (demographic, socio-economic, institutional factors) that either serve as lubricants or knocking agents for diffusion of the innovation.

Based on these four influential factors of adoption of an innovation, Rogers (1995) argued that diffusion theory is not a solitary, all-encompassing theory but, rather, it is made up of several theoretical perspectives that relate to the overall concept of diffusion. Rogers (1995) noted that four major theories that deal with the diffusion of innovations are The Innovation-Decision Process Theory, The Individual Innovativeness Theory, The Rate of Adoption Theory, and the Theory of Perceived Attributes briefly explained below:

Innovation-decision process theory

According to Nutley et al, (2002), the innovation-decision process theory is based on time and five distinct stages:

1) Knowledge/awareness stage. Potential adopters must first learn about the innovation.

2) Persuation stage. They must be persuaded as to the benefits of the innovation.

3) Adoption decision. They must decide to adopt the innovation.

4) Implementation. Once they adopt the innovation, they must implement it.

5) Confirmation. They must confirm that their decision to adopt was the appropriate decision. Diffusion results once these stages are achieved (Rogers, 1995).

Individual innovativeness theory

Nutley et al (2002) say the individual innovativeness theory is based on who adopts the innovation and when. Rogers (1995) noted that a bell-shaped curve is used to illustrate the percentage of individuals that adopt an innovation: innovators, early adopters, early majority, late majority, and laggards.

Rogers (1995) also pointed out that as well as the determinants of apportion at the individual level, there are a variety of external or social conditions that may accelerate or slow the diffusion process such as:

1) whether the decision is made collectively, by individuals, or by a central authority;

2) the communication channels used to acquire information about an innovation, whether mass media or interpersonal;

3) the nature of the social system in which the potential adopters are embedded, its norms, and the degree of interconnectedness;

4) the extent of change agents'(advertisers, development agencies, etc.) promotion efforts.

Rogers (1995) affirmed that the theory of rate of adoption, best presented by an S-curve on a graph, holds that adoption of an innovation grows slowly and gradually in the beginning, then to a period of rapid growth that will taper off and become stable and eventually decline. Another aspect of importance is time. Innovations are seen to be communicated across space and through time. To Rogers (1995), in the theory of rate of adoption, time is significant in the diffusion of innovations in three main ways:

1) Firstly, the adoption of an innovation is viewed as a mental process that evolves over time starting and initial awareness and initial knowledge about an innovation which evolves into an attitude towards that innovation. This influences the decision of whether to adopt or reject the innovation.

2) Secondly, the rate of adoption amongst individuals differs throughout the social system. This starts of slowly with only a minority of people adopting the innovation increasing over time eventually reaching the rate where enough individuals have adopted the innovation and the rate of adoption becomes self-sustaining.

3) Thirdly, time is involved in the rate of adoption or rather the relative speed that members of a social system adopt innovations. This is often measured as the number of members of the system that adopt the innovation in a given time period.

The theory of perceived attributes is rooted in the belief that individuals will adopt an innovation if they perceive that the innovation has relative advantage over an existing innovation or the status quo; that the innovation is compatible with existing values and practices; the innovation is devoid of complexities; the innovation must have trialability; and that the innovation must offer observable results (Rogers, 1995).

It is, therefore, a statistical myopia to view Rogers' Diffusion of Innovation as a single theory since it has different perspectives. It will be possible to see more than one of the Rogers' diffusion of innovation theories in one study. For example, a research may try to find out what attributes (quality yield, grain color, flour, high yielding, drought resistance) of a technology (improve maize variety) influences its adoption in a sample population, and at the same time trying to find out the rate of adoption of the innovation in question in the same population. Theory of rate of adoption and the theory of perceived attributes are going to road-map the conceptual framework of such a study.

This study sees it essential to settle on the Individual innovativeness theory. Rogers (1995) argued that there are a variety of external or social conditions in the social system/among adoptor categories that may accelerate or slow the diffusion process. Rogers (1995) argued that individuals in the social system adopt innovations in direct proportion to their socioeconomic status; with each added unit of income, farm size, and other socioeconomic status variables, an individual is expected to become more innovative. Rogers (1995) also argued that this direct proportion of socioeconomic status to adoption results in widening income gap and for that matter change agents should also focus finding strategies to breach the income gap, emphasizing that an innovation has little effect until it is distributed to all members of a system and put to use by them.

Adopting Rogers' Theory in this study is by drawing analogies that in adoption of Obatanpa (innovation) quantity and quality of yield may be the attributes maize farmers expect of the seed; the decision to meet this expectation of the seed is also influenced by the characteristics (demographic, socio-economic and institutional) of the adopters and how the Obatanpa is communicated (the role of extension) among farmers (members) in Zabzugu/Tatale (social system). In this study, demographic factors, socio-economic factors, household specific factors, and institutional factors (extension service) are independent variables predicted as factors influencing the adoption of Obatanpa among maize farmers in Zabzugu/Tatale.

Apart from the demographic, socio-economic and institutional factors, noise (barriers to communication), that has the greater likelihood of preventing an innovation from reaching the social system, exists in the communication channels. The social system also consists of culture, opinion leaders and other heterophily that may serve as knocking agents to the diffusion of innovation in it. For a technology diffusion to be successful, it needs a technology transfer strategy that will negotiate the resistance in the communication channels and the social system.

The focus of diffusion is to pollinate members of the social system with a new idea or product that will result in a change in behaviour that is more profitable/beneficial than the former behaviour/practice. For the diffusion to be promising, the person(s) must perceive the idea, behaviour, or product as new or innovative. The relative speed at which an innovation spreads (diffusion) is greatly influenced by the channels through which the innovation is communicated. The channels may contain noise (friction/resistance/heterophilly) in which situation the communicator (extension agent) must adopt a communication strategy that will best achieve the purpose and that will also appeal to different adopter categories (innovators, early adopters, early majority, late majority and laggards). The process by which a person adopts an innovation, and whereby diffusion is accomplished, include awareness of the innovation, decision to adopt /reject the innovation, initial use of the innovation to test it, and continued/discontinued use of the innovation(Rogers, 2003)

2.9.0 Conceptual Framework of the Study

A conceptual framework, according to Regoniel (2015), defines a researcher's understanding of how variables are interconnected in a study. The conceptual framework (depicted in figure 1) in this study provided a pictorial representation of how independent variables (institutional, demographic, and socio-economic) are interconnected and how they are linked to the dependent variable(s): adoption and non-adoption of Obatanpa. Avoiding conceptual framework can create constrictions on the dependent variable(s). The conceptual framework seeks to outline the independent variables that affect adoption of Obatanpa among maize farmers in Zabzugu/Tatale.

This study was limited to the following variables: Sex, Marital Status, Years of experience in farming maize, access to extension service, Access to credit, Farmer awareness of Obatanpa seed, Access to certified Obatanpa seed, Off-farm income, Formal education, Farm size (hectors), Household labour size, Access to radio and TV, and Membership of farmer association as depicted in figure 2.1.

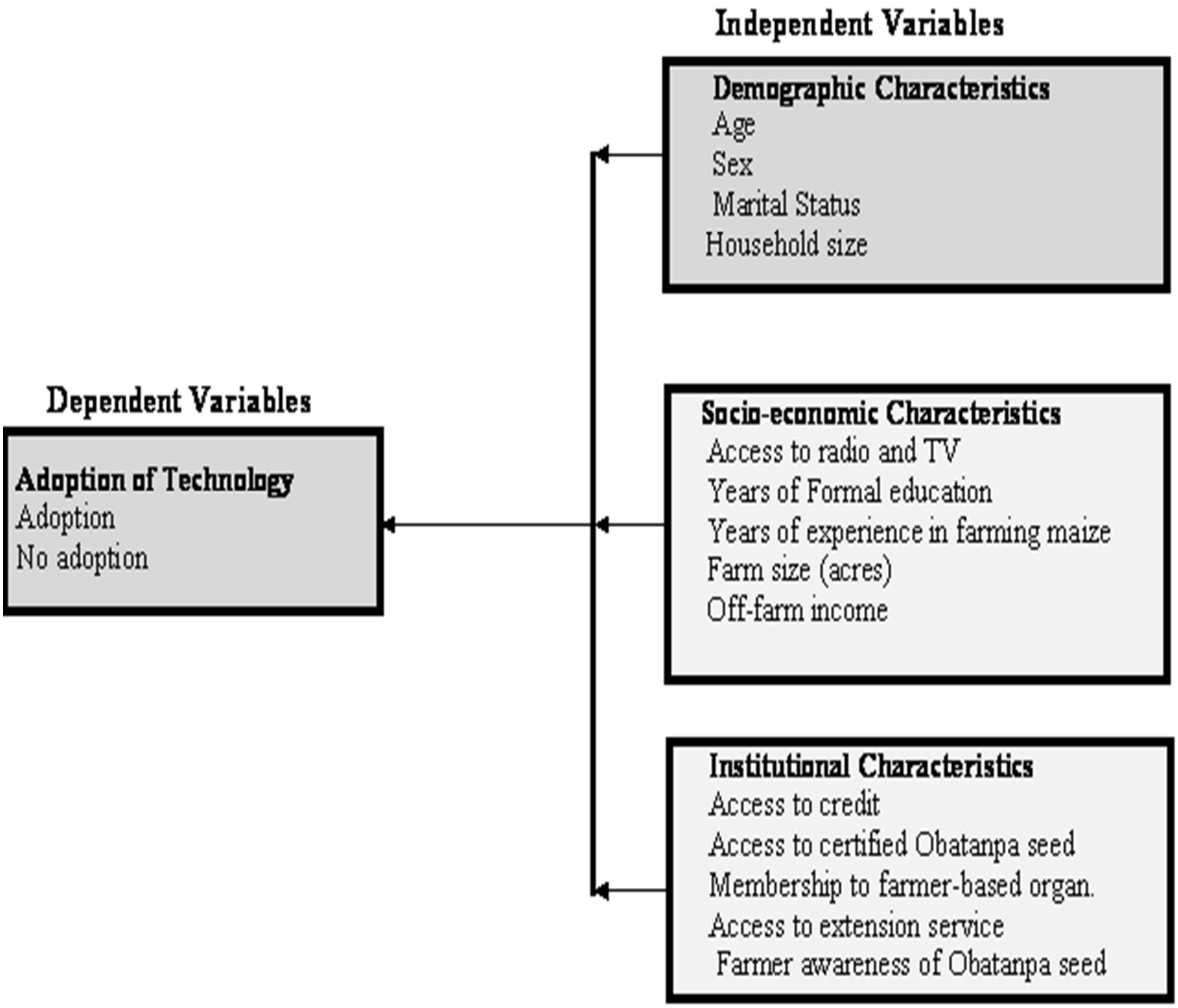

Figure 2.1: Conceptual Framework of Variables Understudy
Source: Author's construct (2016)

2.9.1Conclusion

The effectiveness of improved maize technology adoption depends on the effectiveness of extension delivery, the level at which extension services are linked to farmers, the recommended agronomic practices accompanying the use of improved maize varieties. In addition to these determinants, other factors such as socio-economic, demographic, and institutional factors cannot be over-emphasized, yet the literature points out that that many other constraints hinder technology diffusion (the role of extension) and adoption (farmer perspective). Theoretical framework on adoption centered on Individual Innovativeness Theory by Rogers (1995) sets as the premise on which the conceptual framework was based, supported by empirical findings on adoption of improved maize varieties.

CHAPTER THREE

METHODOLOGY

3.0 Introduction

This chapter focuses on methodology of the research. The study area is essentially deliberated, looking at the population and the population characteristics outlined in the 2010 Population Census and the 2012 Composite Budget of the Zabzugu-Tatale District. It describes the relief and drainage system and agricultural potential and activities and the boundaries of the study area. The chapter also describes the research design, the study population that specified the category of farmers under study. It also looked at the methods of data collection, explaining how the sample size was determined, the sampling procedure used.

The chapter also looked at the methods of data analysis, which described the theoretical basis of the study (Evarret Rogers' Diffusion of Innovation, 1995); and the empirical model for each of the research objectives: level of adoption (descriptive statistics), determinants of adoption (logistic regression), and effectiveness of extension delivery using extension effectiveness indicators by Agbarevo (2013) in percentages. Variables used in the Logistic Regression model and the Extension Effectiveness Indicators are also described in this chapter.

3.1 Study Area

The study area is made up of two districts: Zabzugu and Tatale-Sanguli districts; but per this study, they are combined as Zabzugu/Tatale because of the fact that they share common characteristics: ethnic composition, climatic condition, seasons, cultivated crops, rain pattern, and their major occupation is agrarian. The population of the study area is 123,854 (60,039 for Tatale/Sanguli + 63,815 for Zabzugu District) according 2010 Population and Housing Census, (Ghana Statistical Service, 2014).

According to Zabzugu-Tatale District Assembly Composite Budget (2012), the Zabzugu/Tatale District Assembly was carved out of the former Eastern Dagomba District (Yendi) in 1988, and established by the Legislative Instrument 1449. It is one of the eastern corridor districts in the Northern Region of Ghana. The district is located in the eastern flank of the Northern Region and covers an area of 2,332sq kilometers. It shares boundaries with the Republic of Togo to the East, Yendi District to the West, Nanumba North and South, and Nkwanta Districts to the South, and Saboba and Chereponi Districts to the North.

The district has undulating land with hills found in the Sheini/Kandin areas along the Ghana-Togo border. River Oti and streams in the district serve as drainage systems. The district experiences two main seasons during the year – the dry and the raining seasons. The dry season starts from late October to early May. Farming activities noted for this period are: harvesting of rice, cassava, Yam, drying of food stuffs, preparation of farmlands and raising of yam mounds. This season is also noted for hunting and burning of bushes for game. Most fire disasters occur during this period. The second season, the raining season, span from late May to early October. The annual average rainfall is 1,200mm. The onset of the rains is characterized by strong storms which sometimes result in removal of roofing, rendering many people homeless. The heavy rains especially from July to September render most roads in the district deplorable, constraining the transport of fresh farm produce.

Soils in the district are generally sandy loam with alluvial deposits in the lowlands. It is a very rich soil which results in the growth of yam, cassava, maize, groundnuts, millet, sorghum, rice and other foodstuff.

The vegetation of the District is guinea savannah, though some areas in the southern aspect fall within the transitional zone. Economic trees such as Dawadawa, Teak, Kapok and Mango can be found. There are also tall grasses, shrubs, and thorny species.

The major ethnic groups in the district are Dagombas, Kokombas and Basare, while the minor ones are Kotokole, Hausa, Zabarima, Fulanis, and Ewes. The Ewes are mainly settler fishers along the major River Oti, while the Fulanis are herdsmen for the indigenous people. Dagombas celebrate Damba, Fire (Bugum) and Eid festivals while the Bassare and Konkomba celebrate the Yam and Christmas festivals (Ghana Statistical Service, 2014).

The area is made up of about 98% agrarian with the people engaged in crop production and animal rearing. The main crops cultivated by farmers in the district are: yam, maize, millet, sorghum, cassava, groundnuts, cowpea and soya beans. Cattle, Goats and Sheep and poultry are the animals reared in the district. The small ruminants are often sold during the lean season (May to July) to meet the food needs of households. However, the constraints in their agricultural occupation are high cost of fertilizer, low prices of farm produce, unreliable rainfall pattern, inadequate credit for production, marketing and processing, inaccessibility of some communities during rainy season, high post harvest losses in crops, incidence of diseases and pests both in livestock and crops, indiscriminate bush fires, and inadequate shelter for small ruminants and poultry.

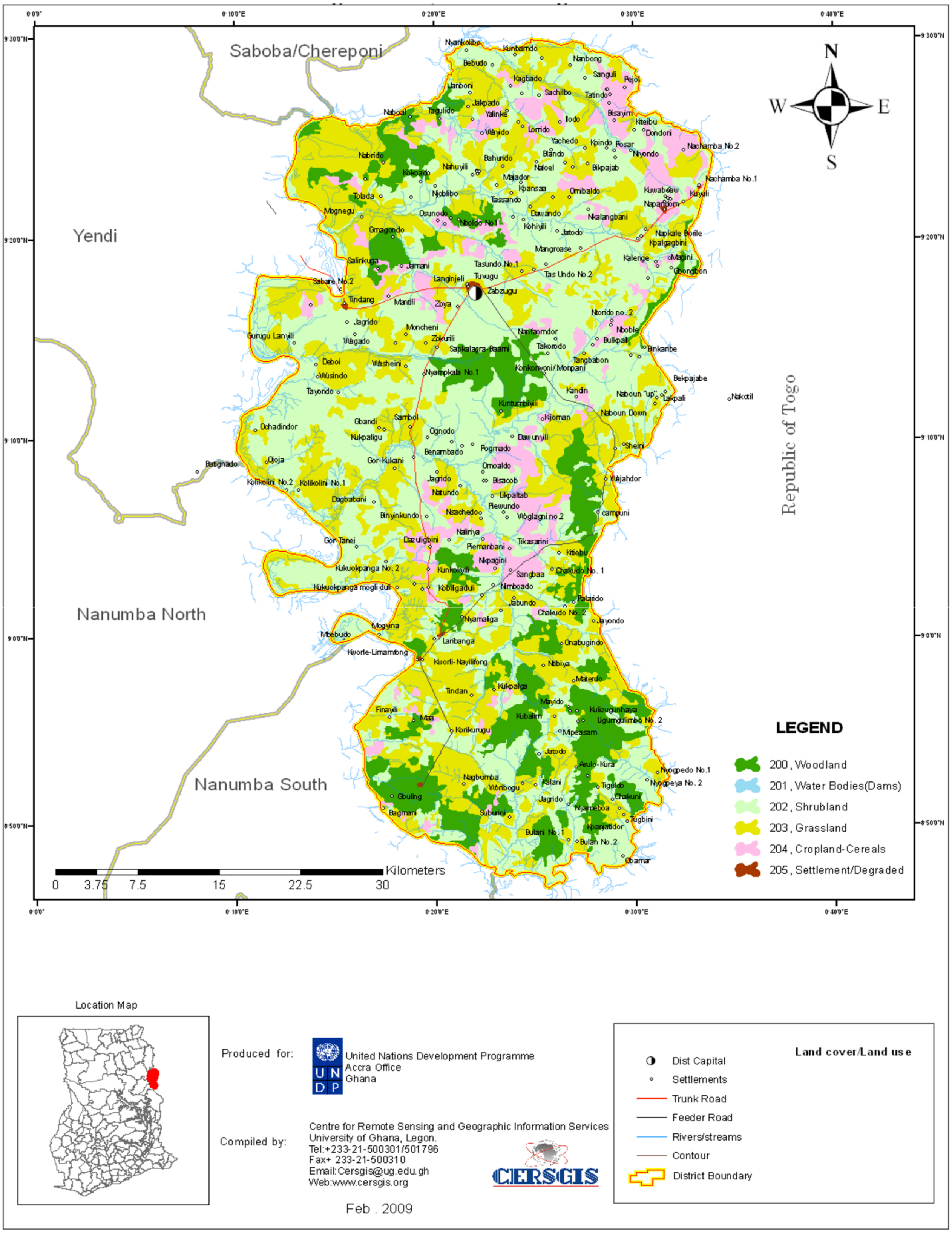

Figure 3.1 Map of Zabzugu/Tatale
Source: UNDP Ghana, Human Development Report (2011)

The practice of indiscriminate and intensive felling of trees for fuel wood as well as charcoal burning as economic activities (mainly by women) in the district adversely affects the vegetation. Inappropriate farming such as the slash and burn method, over cropping as well as bush burning/fire are seriously affecting the natural vegetation.

The activities of the Fulani Herdsmen in the last two decades particularly in farming areas severely affect the vegetation, leading to deforestation and desertification in the areas. In addition, the emergences of new settlements and expansion of existing one as well as settlement of migrant Fulani in the district further affect the natural vegetative cover in the district.

3.2.0 Research Design

This study used a cross-sectional survey. According to Orrico (2016), a cross-sectional research designs are made up of three distinctive features: no time dimension, a reliance on existing differences rather than change following intervention; and, groups are selected based on existing differences rather than random allocation. The cross-sectional design can only measure differences between or from among a variety of people, subjects, or phenomena rather than change.” This study is to measure how the dependent variables (adoption and non-adoption of Obatanpa) are influenced by the independent variables.

The cross-sectional survey research design was, therefore, suitably chosen due to the fact that it is focused on finding relationships between variables at one moment in time and capable of using data from a large number of subjects and are not geographically bound. More to the point, cross-sectional designs focus on studying and drawing inferences from existing differences between people, subjects, or phenomena (Orrico, 2016); and this study sought to draw inferences from existing relationships and differences among adopters and non-adopters in terms of the independent variables (socio-economic, for example) in the study.

The types of data collected were purely primary. Data collected included the socio-economic variables such as sex, age, level of education, number of years of cultivating Obatanpa, access to extension service, other income generation activity, access to credit, access to land, access to radio and television, farm size. The data also included the awareness of Obatanpa, the farmers' access to Obatanpa, belonging to farmer-group.

3.2.1 The Study Population

The population for the research included all households producing maize in Zabzugu and Tatale/Sanguli District. In this study, the two districts (collectively having 17,463 registered maize farmers) are combined into one as Zabzugu/Tatale District on grounds that the time that the Obatanpa was introduced, they were one district (Zabzugu/Tatale District); and still, no significant agrarian disparities exist between them. They share common farm characteristics, rain pattern, and have common culture.

3.2.2 Data Collection Methods

Primary data was sourced from maize farmers in the study area through structured questionnaire. Enumerators who could understand the farmers' language were recruited to support in the questionnaires administration. All responses from the questionnaires were then coded into Microsoft excel and transported into Stata14.0 for quantitative analysis. Literate farmers answered the questionnaires themselves and handed them over to the enumerators. The questionnaire elicited primary data on respondents' personal and household characteristics (sex, age, marital status, household size, years of formal education); socio-economic factors (access to radio and television, ownership of mobile phone, membership of farmer-based organization, and access to credit); farm and farmer characteristics (farm size, years of maize farming experience) and access to extension services. The questionnaire also elicited data on farmers' perception of the effectiveness of extension delivery using Extension Effectiveness Indicators (Awareness, Visit, Field meeting, Regularity, Field days, Demonstrations, Supervision, Extension-Farmer Linkage Workshop, Farmer Training) measured in three-point scale (Not effective (1) Effective (2) Very effective (3).

3.2.3Types of Data Used

The research employed both primary and secondary sources of data. The primary data employed was obtained through a cross-sectional survey conducted in twenty-six (26) maize producing communities and 240 maize farmers of Zabzugu Tatale District in the Northern Region during the 2015 farming season.

Additionally secondary data relating to demographic issues such as population size and other information were obtained from journals, books, reports, Ministry of Food and Agriculture (MoFA), Ghana Statistical Service and the internet.

3.2.4 Sample Size Determination

In determining the sample size which will be more representative of the population, the research followed Cochran, 1963 formula as below;

$$n = \frac{\widehat{p}(1-\widehat{p})z^2}{e^2} \quad (1)$$

Where n represents the sample size, $\hat{p}$ is the population proportion or sample proportion, z is the z-score obtained from the standard normal distribution table at a given level of confidence and e is the margin of error.

An acceptable margin of error often used in survey research falls within 4% to 8% at 95% level of confidence. In that regards, the research allowed a level of precision of 4.4% at 95% level of confidence. The population proportion was arrived after taking the percentage of Maize farmers to the total population of the two Districts under study. According to the district MoFA office, there are a total of 17,463 registered maize farmers in 2014/2015 season. Zabzugu and Tatale-Sanguli District has a total population of 123854 people (63,815 and 60,039 respectively). The population proportion was therefore arrived at 14.1% by dividing . This is expected to yield the larger sample size that is representative of the true population. From the standard normal distribution table, the confidence level had a z-score of 1.96. The sample size can therefore be computed as;

$$n = \frac{0.141(1-0.141)1.96^2}{0.044^2} = 240.3361$$

The research, from the computation, used 240 respondents, (i.e. 240 maize farmers).

3.2.5 Sampling Procedure

It was necessary to draw a sample that would fairly represent the districts population of maize farmers. A three-stage, randomized sampling procedure was used. The three stages involved selection of (1) zones, (2) communities, and (3) maize farmers. These farmers were selected as follows:

Stage 1: Study area was stratified into ten (10) Agricultural Zones (AZs), and five zones were selected through simple random sampling (lottery) method;

Stage 2: four (4) communities were randomly selected from each of the 5 AZs to make up twenty (20) communities.

Stage 3: Then a total of 240 respondents (sample size) were selected from these communities based on equal allocation. Twelve (12) respondents were selected in each of the communities from the list of farmers (sample frame) obtained from the respective zonal extension officers. This made up the sample size of 240 maize producing households in the study area. The communities selected for the study included the following; Zabzugu, Laagbani, Gumpila, Kworli, Woribogu, Sabare, Nakpali, Kuntumbiyili, Mantili, Tatale, Nachamba No. 1, Kuyoli, Nakpali-borle, Bidiribombe, Bekunjib, Bilando, Bachadoo, Sanguli, Nagbindo and Nanbone.

3.2.6 Method of Data Analysis

Data were analyzed using appropriate descriptive statistics to estimate the level of adoption of Obatanpa maize varieties in the study area, estimating means of adopters and non-adopters and other accompanying dummy and continuous variables(objective 1).Regression model (logit regression)was used to analyze the second research objective. Variables identified in the second objective were analyzed using Stata 14.0 to check their level of significance in terms of marginal values of the variables used in the conceptual framework. Extension effectiveness indicators (adapted from Misra, 1997) was used to estimate the farmers' perception of the effectiveness of extension delivery tools by computing the exact statistics in percentages using stata 14.0.

3.3 Theoretical Model

According to Hall and Khan (2002), technology adoption is the choice to acquire and use a new invention or innovation. Roger et al., (2003), describes the adoption or acceptance of a new product or innovation according to the demographic and socio-economic characteristics of defined adopter groups. Rogers (2003) proposed that adopters of any new innovation or idea can be categorized based on the mathematically based Bell curve or a Classical Normal Distribution, illustrating the process of adoption over time, depicting the adopter groups: innovators (2.5%), early adopters (13.5%), early majority (34%), late majority (34%) and laggards (16%). Each adopter's willingness and ability to adopt an innovation depends on their awareness, interest, evaluation, trial, and adoption. This means that farmers can fall into different categories for different innovations—a farmer might be an early adopter of hardware technology (sheller), but a late majority adopter of software technology (zero tillage). The bell curve or Classical Normal Distribution is shown in figure 3 below.

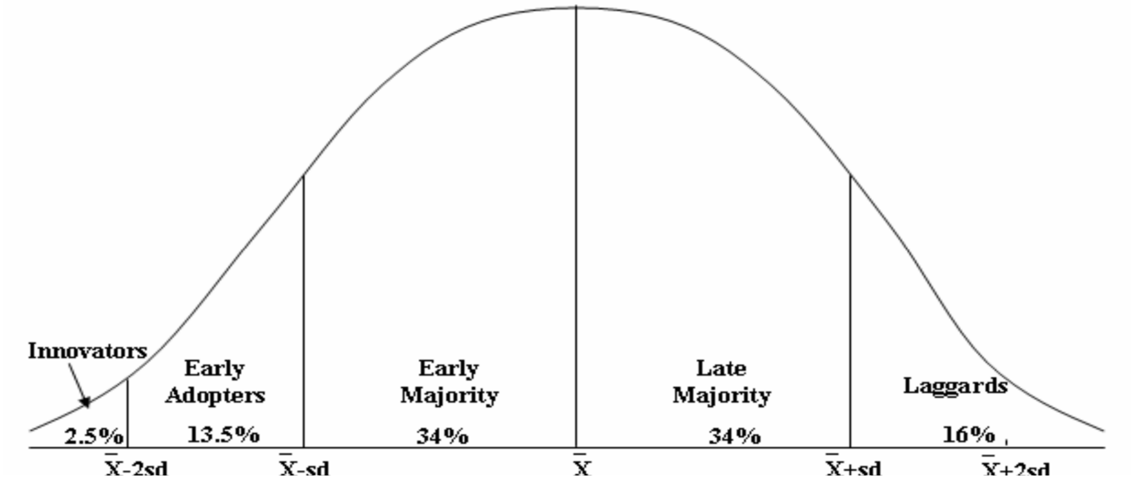

Figure 3.2: Adopter Categorization on the Basis of Innovativeness

(Source: *Diffusion of Innovations, fifth edition* by Everett M. Rogers (2003).

The objective of adoption surveys is to explain how each variable influences adoption, allowing implementing actors to refine their strategies based on a wide body of empirical and qualitative results (Parvan, 2011).Variables such as demographic and socio-economic factors continue to influence adoption of agricultural innovations. These factors among others work as adhesives or repellents between farmers and their decisions to adopt agricultural technologies, making it very necessary to assess/measure the extent to which those factors influence adoption. Since adoption has two options, binary choice is always suitable in measuring adoption. The most often used model for binary choice model is Logit, Probit. Analysis was done using binary logistic regression model to assess the influence of the independent variables on adoption of Obatanpa maize varieties in Zabzugu and Tatale/Sanguli Districts.

According to Salifu et. al. (2015), adoption of technologies, in the field of agriculture, is measured as a binary response variable: 0 = non-adoption of innovation and 1= adoption of innovation. To Sunding and Zilberman (2000), one measure of the adoption of a high-yield seed (such as Obatanpa) variety by a farmer is a discrete variable indicating whether this variety is being used by a farmer at a certain time; another measure is what percentage of the farmer's land is planted with this variety. In technology adoption studies, limited dependent variable models such as Logit, Probit continue to have extensive applications in obtaining information from the non-normal distribution of such data. According to Agresti (2007), logistic regression model is the most popularly used model in statistical situations where the independent variables are categorical or mix of continuous and categorical; the goal of logistic regression, to Agresti (2007), is to identify a suitable model that describes the relationship between a binary dependent variable (adopt/not adopt) and a set of independent or explanatory variables.

Per this study, Logistic Regression model (Agresti, 2007) was, therefore, useful as the question was whether a farmer adopted or did not adopt Obatanpa as stated below:

$$\log it(p_i) = \log\left(\frac{p_i}{1-p_i}\right) = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_k x_k$$

where Logit (p_i) = l*n* (odds (event), that is the natural log of the odds of an event occurring,

pi= prob (event), that is the probability that the event will occur,

1 – p_i = prob (non-event), that is the probability that the event will not occur,

b_0 = constant of the equation,

b_1 to b_k = coefficients of the independent (predictor, response) variables,

k = number of independent variables.

x_1 to x_i = independent variables entered in the model.

3.4.0 Empirical Model

This section outlines how variables are measured to answer the research objectives in this study. The level of adoption of Obatanpa, the determinants of adoption of Obatanpa, and the effectiveness of extension delivery among maize farmers in the study area are the issues of focus.

3.4.1 Measure of Level of Adoption of Obatanpa

Alternative ways of measuring level of adoption of improved maize varieties is either by estimating the percentage of farmers growing the maize variety in question, by estimating the percentage aggregate maize area cultivated, or by measuring the percentage of maize output in a defined period of time, or the intensity of use of the variety with its complementary agronomic practices, (CIMMYT Economics Program, 1993). For example, in a study of the welfare impact of adoption of improved cassava varieties by rural households in South Western Nigeria by Afolami et. al. (2015), a farmer was defined as an adopter if he or she was found to have grown at least one of the introduced improved cassava varieties for at least one season prior to the year the data for the study were collected and still had the variety on his/her farms in the year the data were collected. This study adopted the model used by Afolami (2015) based on the assumption that for a farmer to make decision on whether or not to adopt the improved maize variety, they must have first examined the derived benefit from the adoption or otherwise of the improved maize variety. Therefore, in this study, adopters of Obatanpa refer to the proportion of farmers who cultivated Obatanpa maize for at least one season before the year (2015/2016) the data were collected and still cultivated Obatanpa in the data collection year (2015/2016) farming season.

A farmer was adopter if he or she was found to have cultivated either fresh Obatanpa maize seeds from improved seed dealer or have recycled Obatanpa with the year 2015/2016 season inclusive. The adoption variable was coded 1 if a farmer cultivated an Obatanpa and 0 if he or she did not cultivate Obatanpa. The level of adoption was established using descriptive statistics to by comparing the means of farmers using Obatanpa as against non-users of Obatanpa.

3.4.2 Adoption Decision Model (Adoption of Obatanpa)

The statistical model and the variables that were used are presented below.

$$\log it(p_i) = \log\left(\frac{p_i}{1-p_i}\right) = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_k x_k$$

Where:

pi= prob (event), that is the probability that the event will occur,

x_1 = Sex

x_2 = Marital Status

x_3 = Years of experience in farming maize

x_4 Frequency of extension contact

x_5 = Access to credit

x_6 = Farmer awareness of Obatanpa seed

x_7 = Access to certified Obatanpa seed

x_8 = Off-farm income

x_9 = Formal education

x_{10} = Farm size (hectors)

x_{11} = ownership of land

x_{12} = Membership of farmer Based Organization

x_{13} = Access to radio and TV

3.4.2.1 Definition of Variables Used in the Adoption Model

The demographic and socioeconomic factors that are likely to affect the maize farming household head's decision to adopt Obatanpa have been succinctly defined per the area of focus of this study.

Table 3.1 shows the list of variables used in the adoption model. It contains the name, type and contextual definition of the variables.

Sex

The sex of the household head is a dummy variable that takes the value of1 if the head of the household is male, and 0 if female. Including this variable in the study was to estimate the gender distribution of respondents and their likelihood of adopting Obatanpa.

Table 3.1: Description of Variables used in the Logit Model

	Variables (Xi)	Type	Definition
1.	Sex	Dummy variable	Sex of household head,1 male and 0 otherwise
2.	Marital status	Dummy variable	1 if married and 0 otherwise
3.	Years of farming experience	Number	Number of years of experience in maize farming
4.	Access to extension service	Dummy variable	1 if a farmer has access to extension service and 0 if otherwise
5.	Access to credit	Dummy variable	1 if a farmer has access and 0 otherwise
6	Awareness of Obatanpa	Dummy variable	1 if a farmer is aware of Obatanpa and 0 if not aware
7	Access to certified Obatanpa	Dummy variable	1 if a farmer has access and 0 if otherwise
8	Off-farm income	Dummy variable	
9.	Formal education	Continuous variable	Number of years a household head spend in formal school
10.	Farm size	Number	Total area of land cultivated by farmers in Hectors
11.	Age	Continuous variable	The age of the household head
12.	Membership of farmer association	Dummy variable	1 if a member of farmers' association and 0 otherwise
13.	Access to radio and TV	Dummy variable	1 if farmer owns a radio, 0 otherwise

Age

Age (measured in years) is a continuous variable. As the farmer advances in age, his/her output also improves because of experience he has gathered over the years of working on the field and that also makes them get addicted to the old practices and are unwilling to change. It is also believed that older farmers have higher access to land than that of younger farmers. They also have higher household labour. As the farmer advances in age, the desire to effectively adopt agricultural innovations reduces. At younger ages, farmers have more strength and zeal to adopt agricultural innovations to increase productivity from small pieces of land they have they have access to. Therefore age is expected to have negative relationship with adoption of improved maize varieties.

Experience in Maize Farming

Experience in maize farming refers to the number of years a farmer has cultivated maize. Farmers' decisions to adopt an improve seed technology is sometimes influenced by how long they have been into cultivation of that the seed. If all other things being equal, a farmer with higher number of years of experience in cultivating maize will have a greater tendency of adopting an improve maize variety and the vice versa. Thus the higher a farmer's number of years of experience in maize cultivation, the higher the likelihood of the farmer adopting Obatanpa. The variable was measured numerically as continuous one.

Marital Status

Marital status refers to the respondent's marital status as at the time data was collected. The question on marital status was asked only of persons engaged in maize farming. Married persons are usually responsible for the upkeep of the family and have the tendency of maintaining food supply for homes all year round. Based on this, married persons may have a greater likelihood of adopting improved maize varieties than the single. Marital status was measured as a dummy variable where a maize farmer, whether male or female, was allocated 1 if he/she was married and 0 if single whether divorced, widowed or never married.

Household Size

The household size refers to a household head in addition to other persons living under the household head. According to the 2010 Population and Housing Census, a household head is generally the person who has economic and social responsibility for the household (Ghana Statistical Service, 2014). Larger household size is predicted to have greater tendency to adopt Obatanpa than small household size has. This was measured as continuous variable.

Years of Formal Education of Household Head

Level of education was measured in terms of the number of years of formal schooling the respondents had at the time of data collection since it is expected that access to agricultural extension service is influenced by education and all collectively impact adoption of improved maize varieties (Abebe, 2016). Educated farmers have the greater ability to perceive, interpret and respond to new information much faster than their counterparts without education, because more educated farmers are typically assumed to be better able to process information and search for appropriate technologies to alleviate their production constraints. So if a farmer’s level of education is relatively high, it means he/she is more exposed to information about innovations than those with little or no education. Same way higher exposure to information about innovations consequentially result in higher level of adoption and the vice versa. Following Abebe (2016), a farmer’s level of education was measured in terms of the number of years of formal schooling. The data was coded in terms of the number of years (continuous variable) a farmer spent in school with 0 to mean no formal education at all.

Membership of Farmer-Based Organization (FBO)

This variable is included in the study because it has been shown that farmers within an FBO learn from each other how to grow and market new crop varieties (as indicated in Rogers' Diffusion of Innovation theory). A farmer-based organization is a network of farmers who inter-depend among themselves in sharing information and learning from one another. It is also assumed that innovations are diffused faster among members of an FBO than among farmers who are exterior to the FBO. In this study, a farmer's FBO membership is measured as a dummy variable that takes the value of1 if the farmer is a member of an FBO, and 0 if otherwise. The expected sign on the coefficient on membership of farmer-based organization is positive.

Off-farm Income

Off-farm activities are sources of additional income which has the likelihood of encouraging or discouraging investment in agricultural technologies. In this study the main off-farm activities were casual labour, salary employment, masonry, carpentry, fitting and petty business. Information on off-farm income was on whether a farmer earns additional income apart from farm income irrespective of the amount he or she earns. If a farmer earned off-farm income, he/she was allocated with one (1) or zero (0) if otherwise.

Farmers' contacts with extension agents

Extension contact was measured as a dummy variable: 1 if the farmer has been in contact with any extension agent, 0 otherwise. Contact with extension agents is expected to have a positive effect on adoption based upon the innovation-diffusion theory. Such contacts, by increasing farmers' access to information, have a greater likelihood of stimulating adoption. An assumed positive relationship exists between extension visits and the probability of adoption of a new technology.

Access to Certified Obatanpa

Lack of access to certified seed may be due to non-availability or non-affordability of the seed, all of which can lead to low or poor adoption. In the context of this study, a farmer has access if Obatanpa is available and he/she can afford to pay for its cost and has actually used it in the year the data was collected. Access to certified Obatanpa is dummied with 1 if a farmer has access to certified Obatanpa and 0 otherwise.

Access to Credit

The failure of Diffusion of agricultural technologies is often blamed on constrained access to credit (Gregory and Sewando, 2013; Feder et. al, 1985) – a condition often possible in adoption of indivisible or lumpy technologies such as machinery (Rafael, 2006). Access to credit is expected to have a positive effect on adoption, especially among poor farmers. Per this study, a farmer is determined to have access to credit if he/she received credit either in the form of cash for maize cultivation, borrowed Obatanpa seeds, hired labour on credit, or received tractor services on credit for payment after harvest. Access to credit was measured as a dummy variable: 1 if the farmer has access to credit or 0 if otherwise.

Access to Radio and TV

Radio is a medium of communication often very popular among rural people especially where television signal is either not available or poor. A research conducted by Mele (2011) discovered that rural radio stations made good use of rice videos to build rice farmers' capacity by promoting the videos to farmers through frequent announcement and showing the videos at village market centers on market days. Farmers can get information about availability and sources of improve seeds, other agro-inputs and weather through the radio. Access was measured as a dummy variable: 1 if the farmer has access to radio and TV or 0 if he/she has no access.

3.4.4 Measuring Effectiveness of Extension Delivery (Farmers Perspective)

The effectiveness of extension services is highly dependent on the ability of extension workers who are competent since the whole extension process is dependent on them to transfer information from extension organizations to the clients (Al-Sharafat et al., 2012); and as well, competent extension workers with ineffective tools of extension delivery are of no use to the extension system. Evaluation of the achievement of extension delivery programmes, most often, focuses on the demand side of extension (farmers) such as farmers' behavioural change in terms of adoption, increased use of production inputs, yield, income and impact assessment; and when the indices on these variables are low, farmers are blamed for not responding to extension delivery programmes. Yet objective evaluation of the success of extension delivery programme must include the supply side of extension services. Therefore, the effectiveness and efficiency of the tools with which extension personnel deliver extension services, cannot be overlooked since this may, in fact, be a greater reason for success or failure of extension programmes (Agbarevo, 2013)

This study adopted the measures proposed by Misra (1997) to evaluate the effectiveness of extension delivery in the study area. According to Misra (1997), extension performance indicators reflect extension's operational and technical efficiency. Misra (1997) grouped extension performance indicators into two categories: effectiveness indicators and efficiency indicators. Extension effectiveness indicators are also further divided into single indicators and unitary or composite indicators. A single indicator will reflects an aspect of extension performance, while a unitary or composite indicator will reflect two or more aspects of extension performance.

Misra (1997) noted that it may be useful to construct a unitary or composite indicator to provide a consolidated view of extension effectiveness to management since management is often interested in having an overall view of extension effectiveness. Of these two types of effectiveness indicators, this study adopted single indicators as the focus is on the effectiveness of the individual tools of extension delivery postulated by Misra (1997).

Table 3.2: Extension Effectiveness Indicators

No.	Indicator	Description
1	Awareness	Number of farmers
2	Visit with farmers	Number of visits by village extension worker, say per month
3	Field meeting	Number of meetings held with village extension workers.
4	Regularity	Number of meetings held by village extension worker with farmers on fixed days (percentage)
5	Field days	Number of field days organized by village extension worker (monthly, quarterly, and annually (average)
6	Demonstrations	Number of (a) method demonstrations (b) Result demonstrations (c) method-cum-result demonstrations organized by village extension worker monthly, quarterly and annually.
7	Supervision	Number of supervisory visits from Agricultural Extension Officers to village extension worker in the field per month (average)
8	Extension-Farmer Linkage	Number of extension-farmer linkage workshops organized yearly (average)
9	Farmer Training	number of farmers trained in farmer training centres/farmer training workshops organized

Misra (1997)

Adoption focuses on behavioural changes in the farmer, while learning situations focus on extension personnel and their activities; so another ways of evaluating agricultural extension programmes is measurement of the learning situations provided, which is extension delivery mechanism or process as means of measuring extension effectiveness, (Agbarevo, 2013). Agbarevo, (2013) argued that the effectiveness of extension personnel in conducting their activities can be used to assess success of extension delivery programme because if appropriate teaching/learning situation is provided, it follows that the farmers' learning (cognitive and/or behavioural) would take place.

Such teaching/learning situations, note by Misra (1997), are effectiveness indicators such as the level of awareness of extension services created among the farmers, number of visits paid by the village extension worker, percentage of scheduled meetings held between farmers and extension workers, number of field meetings held, regularity of meetings held by village extension worker, number of field days organized by village extension worker , monthly or quarterly, number of demonstrations organized by the village extension worker within specified time frame (monthly, quarterly, annually), number of supervisory visits, number and regularity of research-extension linkage workshops and farmer training sessions. The effectiveness of the tools of extension personnel was defined by farmers' perception about the effectiveness of the indicators as shown in Table 3.2.

Evaluation of extension programme, according Suvedi and Stoep (2016), basically involves measurement of indicators by collecting quantitative and qualitative data. They indicated that quantitative methods, which are accepted as credible and applicable to large populations, particularly for generalizability, measure a finite number of pre-specified outcomes and are suitable for large-scale projects that mean to judge effects, attribute, cause, compare or rank, classify, and generalize results. The effectiveness indicator was ranked as 'effective', 'very effective' and 'not effective'. Data was analyzed with exact statistics using stata 14.0 and presented in frequency and percentage table.

CHAPTER FOUR

RESULTS AND ANALYSIS

This section discusses the findings of the study. It discusses the demographic and socio-economic characteristics of respondents, the determinants of adoption of improved maize varieties and farmers' perception of the effectiveness of the methods of extension delivery. Findings are compared to relevant literature reviewed under this study.

4.1 Demographic and Socio-Economic characteristics of respondents

This section discusses the demographic and socio-economic characteristics of respondents in the survey. Table 3 shows the descriptive statistics of farm and farmer characteristics. These characteristics provide the basis for analyzing the respondents' likelihood of adopting improved maize varieties. The study solicited responses from 240 respondents as the sample size for the survey. As indicated in Table 3, the mean value for sex is 0.92, indicating higher (92 percent) male respondents over females who constituted only 8 percent of the sample. There was no any intent for gender comparison, any way; and for that matter the respondents were selected at random irrespective of sex, but it was observed that majority of maize producing households in the study area were headed by males.

The Table 4.1 also shows that respondents who were married represented 85.4 percent of the sample size, and the remaining 14.6 percent were single. Married couples are usually more responsible in terms of provision of food and shelter for the household which makes married household heads tend to dominate the respondents.

Table 4.1: Descriptive Statistics of farm and farmer characteristics

Variables name	Variable description	Measure	Mean	Standard deviation	Min.	Max.
Adoption	Farmer has adopted Obatampa maize seed variety	1 = yes, 0 = no	0.588	0.493	0	1
Sex	Sex of the farmer	1 = male, 0 = female	0.92	0.277	0	1
Marital status	Marital status	1 = married, 0 = single	0.854	0.354	0	1
Age	Number of years lived	Years	31.97	14.33	18	72
Experience	No. of years in maize farming	Year	10.047	6.599	3	36
Household size	No. of persons in a household	Number of people	12.446	6.598	2	35
Years of education	Number of formal schooling years completed	Years	2.142	4.936	0	21
Membership of FBO	Belonged to a farmer based organisation or not	1 = member of FBO, 0 = not a member of FBO	0.254	0.436	0	1
Farm size	Hectares of farm plots cultivated	Hectares	11.038	8.406	1	55
Awareness of Obatanpa seed variety	Have information Obatanpa o not	1 = aware, 0 = not aware	0.938	0.243	0	1
Access to credit	Needed credit and was able to get	1 = access, 0 = no access	0.138	0.345	0	1
Access to certified Obatanpa		1 = available, 0 = not available	0.479	0.501	0	1
Access to extension service	Received at least one extension visit by a farmer on maize production	1 = access, 0 = no access	0.492	0.501	0	1
Access to TV and Radio		1 = access, 0 = no access	0.171	0.377	0	1

The minimum and maximum ages of respondents were 18 and 72 years respectively, with an average of 31.97 years. This shows that the majority of respondents were in their active years; which implies a positive relationship between age and risk aversion as argued by Ouma et al. (2014).The minimum and maximum number of years of experience in maize farming among respondents was 3 and 36 years respectively and the average number of years of experience is 10 years. More so, the respondents' average household size was about 13 persons, with the least household size being 2 persons and maximum being 35 persons.

With years of formal education, the minimum and maximum values were 0 and 21 years with the mean of 2.1 years, indicating that the majority of the respondents had lower number of years of education. Similarly, Fadare et. al., (2014), and Salifu et. al. (2015) found low education among maize farmers in Nigeria and Ghana respectively. However, this was contrary to the higher literacy (65%) among the sampled maize producing households found in the studies of Teferi et al. (2015) and Akinbode & Bamire (2015).

Also there was low membership of FBOs among the sampled maize producing households in Zabzugu/Tatale District. The mean value for FBO membership as indicated in Table 4.1 was 25.4 percent while the remaining farmers with non-FBO membership were 74.6 percent. However, Teferi et al., (2015) found a relatively higher (about 56%) of maize producing households belonging to farmer-based organizations. Yet farmers with FBO membership have greater access to credit than non-FBO members. In his study into the determinants of access to credit and its impact on household food security in Karaga District in the Northern Region of Ghana, Abdul-Jalil (2015) re-emphasized the need for farmers' participation in FBO membership, indicating that being a member of farmer-based organization could increase the amount of credit accessed by farmers by 0.0583 at 1% level compared to farmers who did not belong to FBOs.

This, therefore, means that a farmer, as Rafael (2011) also attested, without FBO membership will have a less likelihood of getting access to credit which will then, consequentially, militate against other fertile conditions of successful adoption of improved maize variety. Farmers within an FBO learn from each other how to grow and market new crop varieties (Rogers, 1995). It is also assumed that innovations are diffused faster among members of an FBO than among farmers who are exterior to the FBO.This replica effect of FBO membership on access to credit was obvious in this study as Table 4.1 shows a corresponding farmers' low (14.2 percent) access to credit, leaving 85.8 percent without credit access.

As further seen in Table 4.1, the mean value for farmers' access to extension service is 0.492, meaning that 49.2 percent of maize producing households in the sample of the study had access to extension service. The mean values for awareness of Obatanpa and access to credit 0.938 and 0.138 respectively give an indication that Extension agents performed relatively well in facilitating farmers' awareness of Obatanpa, but performed poorly in assisting farmers to form farmer groups and to have access to credit. Similarly, maize farmers' membership had not been encouraged. These areas of poor performance must be improved to promote adoption.

It is also shown that access to certified Obatanpa is below average as only 47.9 per cent of the sampled respondents are reported to have access to certified Obatanpa seed, leaving 52.1 percent with no access. If more than half of maize producing households lack access to certified Obatanpa, it also means that more that have of the farmers do not use certified Obatanpa seed. Meanwhile, literature shows that farmers using certified maize seed has higher yield than non-users of certified maize seeds. For example, in the study of the determinants for use of certified maize seed and the relative importance of transaction costs in Kenya, Bernard et. al. (2010) found that farmers using certified seeds obtained 56 percent higher yields as compared to non adopters (685 Kgs/acre for adopters and 440 Kgs/acre for non adopters). Also in a study of maize seed quality factors from five agro-ecological zones in Ghana and their impact on growth and grain yield, Kebede (2016) noted that seeds from certified seed system give higher percentage value than farmer-saved seed system. After running laboratory purity analysis, Kebede (2016) found that Coastal Savannah had 95.10%, Semi-deciduous 94.57%, Transitional 94.53%, Guinea Savannah 94.13%, and Rainforest zones 93.73% yield higher from cultivating certified maize seed than farmer-saved seeds. In addition the germination tests were showed that, certified seed system was recorded the highest normal seedlings across the study zones. It was recommended that to maintain optimal plant population and increase maize yield, certified seeds should be available to the farmers. This among other factors, have contributed to low yield of maize in the study area.

Table 4.1 also shows that maize farming households had very low (17.1 percent) access to Television and Radio, leaving the remaining 82.9 percent without access. The low access to Television and Radio in the study area shows that very few of the respondents are likely to receive extension services through Television and Radio, and for that matter, Radio and Television contributed insignificantly to the 93.8 percent of awareness of Obatanpa.

4.2 Level of Adoption of Obatanpa

This study measured the level of adoption of Obatanpa by estimating the percentage of farmers who grew Obatanpa per the adoptor definition in this study.

About one hundred and forty-two (142) respondents representing 58.8% , as shown in table 3, were found to be adoptors of the improved maize variety (Obatanpa) in the study area. The level of adoption established by this research indicates that more than half of the maize farmers in the study cultivated Obatanpa seed during the 2015/2016 farming season. This may be as a result of the higher level (93.8%) of awareness of Obatanpa either created by

MoFA extension agents, village extension agents or through farmer-to-farmer extension. The level of adoption established by this study is consistent with the results of a study conducted in Eastern and Central Uganda by Mugisha and Diiro (2010) in which there was about 80% level of adoption of improved maize varieties. Also, Akinbode and Bamire (2015) found high (91%) level of adoption of improved maize varieties in Esun State in Nigeria. Conversely, the findings of Gregory and Sewando (2013) and Fadare et al. (2014),showed low (30%) and (32.4%) level of adoption of quality protein maize (QPM) technology in the Northern zone of Tanzania and improved maize varieties in Nigeria respectively. These differences in the levels of adoption are likely to arise from the differences in socio-political environments across those countries

4.2. Determinants of Adoption of Obatanpa

This section presents the results of the regression analysis of the factors determining adoption of Obatanpa. Sex, age, marital status, years of experience in farming maize, access to extension service, access to credit, farmer awareness of Obatanpa seed, access to certified Obatanpa seed, off-farm income, years of formal education, Farm size (hectors), membership of farmer based organization, and access to radio and TV are predictor (independent) variables that determine farmers' decision to adopt Obatanpa in the study area. Manifold literature has both consistent and contradictory findings with the results in this section.

The logit model for analyzing the tendency of adopting Obatanpa seed variety is statistically significant at 1% level, implying that the model is generally a good fit for the data. Among all the variables that significantly influence adoption of Obatanpa seed, only age of a farmer was found to inversely influence farmers' decision to adopt Obatanpa. The rest had positive effects on adoption. The pseudo R square for the model was 0.8454 and the likelihood Ratio Chi-Square test was 275.04. This implies that 84.54% of variations in the dependent variable are explained by the explanatory variables. Thus, the independent variables offer a good explanation for maize farmers' decision to adopt Obatanpa seed variety in the study area. The regression analysis using Stata 14.0 shows that most of the variables were consistent with hypothesized relationships and their tests of significance help to indicate their importance in explaining farmers' adoption decisions.

Table 4.2: Factors affecting adoption of improved maize seed variety (Obatanpa)

Variables	Marginal effects	Standard Error	z
Sex	0.729***	0.285	2.56
Marital status	0.249	0.295	0.84
Age	-0.021**	0.009	-2.46
Experience	0.009	0.011	0.80
Household size	0.041***	0.014	2.88
Years of education	0.006	0.010	0.61
Membership of FBO	0.149*	0.078	1.90
Farm size	0.063***	0.022	2.85
Awareness of Obatampa seed	0.874***	0.104	8.14
Access to credit	0.247**	0.095	2.60
Access to Obatanpa seed	0.189	0.117	1.62
Access to extension service	0.357**	0.142	2.51
Access to TV and Radio	0.101	0.075	1.35
Number of observations	240		
LR chi2(13)	275.04		
Prob> chi2	0.0000		
Pseudo R2	0.8454		
Log likelihood	-25.1417		

***, ** and *denote 1%, 5% and 10% respectively
Source: Author`s Computation (2016)

From the results in Table 4.2, sex of the farmer household head has a positive marginal effect which implies that when a household head is a male, the probability or the tendency of adopting Obatanpa seed variety increases. The value of 0.729 means that, the probability of a farmer adopting the Obatanpa seed variety increases by 72.9%, if the farmer household head is a male. However, in the findings of Felistus (2009) in Kenya, sex had positively significant relationship with adoption but female-headed households had the greater tendency of adopting improved maize variety package than male-headed households at 5% level of significance. In the findings of Fadare et. al., (2014) and Ogada et al. (2014) sex of household heads had no significant relationship with adoption of improved maize varieties in Nigeria. It is interesting to note that the differences may arise from how gender (male and female) was included and even how this discreet variable (sex) was defined.

The marginal effect of the age of the farm household head is negative which implies that, age is inversely related to the households' decision to adopt Obatanpa seed variety – adoption decreases with increase in age. This means that, households that are headed by relatively young people have a higher possibility of adopting Obatanpa seed variety. The value of -0.021 means that, if a farmer household head age increases by one year, there is tendency that farmer adopting Obatanpa seed variety will reduce by 2.1%.

This result is consistent with the findings of Mignouna et al., (2011) in Kenya; Ouma et. al., (2014) in Eastern Kenya; Kuti (2015) in Osun State in Nigeria**,** and Salifu et. al. (2015) in Wa Municipality in Ghana. Their findings showed that the age of the respondents had an inverse relationship with adoption, which implies that, older people have a lower possibility of adopting improved maize variety.

Among the reasons given for this inverse relationship between age and adoption of improved maize varieties by Ouma et al. (2014) is that as farmers grow older, there is an increase in risk aversion and a decreased interest in using new agricultural technologies such as improved seed and the vice versa. However, contrary to this finding is that of Akinbode & Bamire (2015); Ademiluyi, (2014) in which age rather had positively significant relationship with adoption of improved maize varieties among farmers in Bassa Local Government Area of Plateau State and in Osun State respectively in Nigeria. Also inconsistent with findings in this study are that of Teferi et al., (2015); Mignouna et al., (2011); and Lopes, (2010) in which age had directly significant relationship with adoption of improved maize varieties among maize farming households in Ethiopia, Kenya and Mozambique respectively.

Also, household size had a positive marginal effect, which implies direct relationship between household size and farmer's decision to adopt Obatanpa seed variety. In this case, if the household size increases, the probability of a farmer adopting Obatanpa increases. The marginal effect of 0.041 implies that, if a household size is increased by one person, the probability of a farmer to adopt Obatanpa increases by 4.1%. This finding confirms that of Teferi et al., (2015); Akinbode & Bamire, (2015); Kuti, (2015); Mignouna et al., (2011); Lopes, (2010); and Tura et al. (2010) which showed a direct relationship between household sizes and farmers' decision to adopt improved maize varieties. To Akinbode and Bamire (2015), households with larger household size have higher farm labour that propels following agronomic practices (such as row planting e.t.c) that accompany cultivation of improve maize varieties.

Similarly, membership of farmer based organization of a farmer household head had a positive marginal effect and significant even at 10%. The value of 0.149 implies that, when a farmer is a member of FBO, the probability of adopting the Obatanpa seed variety is

14.9%.This findings agrees with the results of Tura et al., (2010); Mignouna et al., (2011); Kasirye, (2013); Ouma et al., (2014); Ademiluyi, (2014); and Mmbando & Baiyegunhi (2016) which show that membership of farmer-based organizations increases a farmer's likelihood of adopting improved maize varieties. Farmers' membership of FBOs creates for them an avenue for exposure to improved agricultural technologies and also provides access to credit, and other fertile grounds for adoption of agricultural technologies. NGOs and government organizations in agricultural sector, SEND Ghana and SPRING in the study area for example, often targeted their efforts at farmer groups in diffusing agricultural technologies; credits are often given to farmers through the farmer groups. On the contrary, Katengeza et. al., (2012) and Teferi et al., (2015) found maize farmers' membership of FBO to have inverse relationship with adoption of improve maize varieties in Malawi and Ethiopia respectively. Salifu et. al. (2015) and Fadare et al., (2014) found no significant relationship between membership of farmer-based organization and adoption of improved maize varieties.

Also, farm size had a positive marginal effect and is highly significant at 1%. This means that, farm size has a direct relationship with farmer's decision to adopt Obatanpa seed variety. The value of 0.063 implies that, when a farmer increases his farm size by a hectare, the probability of the farmer taking the decision to adopt Obatanpa seed variety increases by 6.3%. Consistent with this finding are the results of Kasirye, (2013); Fadare, (2014); Ogada et. al. (2014); Ouma et. al., (2014); Kuti (2015); Tura et al. (2010) and Katengeza et. al., (2012) that indicated that farmers with large farm size had the greater likelihood of adopting improved maize varieties. Farmers having large farm size have the opportunity to try improved maize technology in some parts of their farmlands before fully adopting if the need be, contrary to farmers with small farm size who fear to risk their small acres to the fate of innovations the do not know. On the contrary, Baruwa et al. (2015) found farm size to have inverse relationship with adoption of improved maize varieties among farming households in Osun State, Nigeria.

Furthermore, farmers' awareness of Obatanpa strongly influences their decision to adopt the Obatanpa. The variable was found to have positive marginal effect and is significant at 1%. The value of 0.874 shows that, a farmer who is aware of the variety has 87.4% greater probability of adopting Obatanpa than a farmer who is not aware, and this finding is in line with that of Monela, (2014); and Lopes, (2010) indicating that a farmer's awareness of improved maize varieties, among other factors, had a positive relationship with adoption of the improved maize varieties.

Access to credit by a farmer had positive effects on adoption and significant at 5% level. The marginal effect value 0.247 implies that maize farmers who had access to credit had 24.7% greater probability of adopting the improved seed variety than their counterparts who had no access to credit. This finding is in line with the findings of Aidoo et al. (2014), Tura et al. (2010), Ogada et al., (2014); Katengeza et. al., (2012); Idrisa et al., (2012); Teferi et al., (2015); Baruwa et al. (2015), and Mmbando & Baiyegunhi (2016). It, however, contradicts with the findings of a study conducted in Tanzania by Gregory and Sewando (2013) which indicated that access to credit negatively influenced the adoption of improved maize varieties in that country.

Access to extension service also had a positive marginal effect 0.357and significant even at 5%. It showed a direct relationship between farmer's access to extension service and adoption of Obatanpa seed variety. Farmers who had access to extension service had 35.7% greater probability of adopting Obatanpa than a farmer who had no access. This finding confirms that of Doss et. al., (2003); Mugisha and Diiro, (2010); Mignouna et al., (2011); Katengeza et. al., (2012); Idrisa et al., (2012); Gregory and Sewando, (2013); Aidoo et al., (2014); Fadare et. al, (2014); Ouma J. et. al., (2014); Akinbode and Bamire (2015); and Mmbando & Baiyegunhi (2016) which indicated a direct relationship between access to extension services and farmers' decision to adopt improve maize varieties. Contrary to this finding is the result of a study into adoption of improved maize varieties among farmers in Bassa Local Government Area of Plateau State, Nigeria by Ademiluyi (2014), which indicated an inverse relationship between extension service and adoption of improved maize varieties. However, in the finding of a study into the determinants of farmers' adoption of improved maize varieties (IMVs) in the Beehi and Kpongu communities of the Wa Municipality in Ghana by Salifu et. al. (2015), extension service had insignificant relationship with adoption of improved maize varieties, meaning that whether farmers' access to extension service increased or either, the farmers' likelihood of adopting improved maize varieties remained the same.

4.3. Farmers' Perception of Effectiveness of Extension Delivery Tools

This section presents the results of the analysis of farmers' perception of the effectiveness of of the tools with which extension services are delivered in the study area, following the measures of extension effectiveness indicators proposed by Misra (1997) and subsequently used by Agbarevo (2013) to evaluate farmers' perception of the effectiveness of agricultural extension delivery in Cross-River State, Nigeria. The indicators used were the level of awareness of extension services created among the farmers, number of visits paid by the village extension worker, percentage of scheduled meetings held between farmers and extension workers, number of field meetings held, regularity of meetings held by village extension worker, number of field days organized by village extension worker, monthly or quarterly, number of demonstrations organized by the village extension worker within specified time frame (monthly, quarterly, annually), number of supervisory visits, number and regularity of research-extension linkage workshops and farmer training sessions/farmers.

Farmers' perception of the effectiveness of extension delivery was analysed using descriptive statistics and presented in frequencies and percentages in Table 4.3.

Table 4.3: Measurement of extension delivery effectiveness using effectiveness indicators

No.	Effectiveness indicators	Measure	Scores of the indicators		
			Not effective	Effective	Very effective
1	Creating of awareness of extension service	Frequency	5	59	176
		Percentage	2.08%	24.58%	73.33%
2	Visiting farmers	Frequency	96	103	41
		Percentage	40%	42.92%	17.08%
3	Organizing field meetings regularity with farmers	Frequency	58	154	28
		Percentage	24.17%	64.17%	11.67%
5	Organization of field days	Frequency	177	43	20
		Percentage	73.75%	17.92%	8.33%
6	Organization of demonstrations	Frequency	161	63	16
		Percentage	67.08%	26.25%	6.67%
7	Embarking on supervisions by extension agents in the field	Frequency	103	122	15
		Percentage	42.92%	50.83%	6.25%
8	Organization of extension-farmer linkage workshops	Frequency	179	59	2
		Percentage	74.58%	24.58%	0.83%
9	Farmer training programme	Frequency	170	53	17
		Percentage	70.83%	22.08%	7.08%

Source: Field Survey, 2016

The results show that there exists a very high level of awareness among farmers about the existence of agriculture extension agents as 95 percent of farmers perceived awareness creation about existence of extension agents to be effective. This shows that extension agents played their primary role of awareness creation about the need for farmers to seek extension advisory services, a finding consistent with that of Agbarevo's (2013) and Egbe and Eze (2014) in which awareness creation about existence of extension agents was perceived very effective in Cross-River State and Ebonyi State respectively in Nigeria. It is, however, worth noting that awareness creation about the existence of extension agents is not necessarily done by only extension agents but also the non-governmental organizations in the rural development sector and those farmers who have benefitted from extension service.

Extension visits to farmers was found to be effective with 42.92% of the farmers responding that it was effective; 17.08%, very effective and 40% not effective; thus, 60% perceived farmer visits to be effective and very effective. Similar findings were made by Agbarevo's (2013),Al-Rimawi et al. (2016) and Moaba's (2016) in their research in farmers' perception of agricultural extension delivery in Cross River State of Nigeria, Jordan, and South Africa respectively where farm visit by extension agents were found to be effective methods of extension delivery. On the contrary, Ibrahim et al. (2014) in Nigeria; Khan & Akram (2012) in Pakistan; and Egbe & Eze (2014) in Nigeria found that visiting farmers was ineffective tools extension delivery.

However, extension delivery was poor in the following areas: field days, organization of demonstrations, extension-farmer linkage and farmer training programme. The poorest performance in extension delivery was field days where 73.75% of the respondent responded that extension delivery in field days was not effective. In the findings of Khan & Akram, (2012) in Pakistan; Egbe & Eze, (2014) in Nigeria; and Al-Rimawi et al., (2016), field days was a found to be poor method of extension service delivery. On the contrary, performance in field days was found to be effective tool of extension delivery in Agbarevo's (2013) study into Farmers' Perception of Effectiveness of Agricultural Extension Delivery (AEDP) in Cross-River State, Nigeria.

Organization of demonstrations was also another ineffective method of extension delivery as 67.08% of respondents perceived it as being ineffective tool of extension delivery in the study area. Similar to this finding is that of Khan & Akram, (2012) and Egbe & Eze (2014) in which organization of demonstration was perceived ineffective method of extension service delivery in Pakistan and Nigeria respectively. However Agbarevo's (2013), Al-Rimawi et al. (2016), and Moaba's (2016) found that organization of demonstrations were effective tool of agricultural extension service delivery in their research into farmers' perception of agricultural extension delivery in Cross River State of Nigeria, Jordan, and South Africa respectively.

The ineffective extension-farmer linkage workshops was also found to be in line with the results of Agbarevo (2013) in Nigeria, Khan & Akram (2012) in Pakistan, Egbe & Eze (2014) in Nigeria and Moaba (2016) in South Africa who also found that extension-farmer linkage was perceived by farmers as ineffective tool of extension delivery in their study areas. The ineffective farmer training found from farmers' perception is also found to be in line with Khan &Akram (2012) and Agbarevo (2013), but contradicts with Moaba (2016) in whose research findings farmer training programmes were perceived very effective tool of extension service delivery in South Africa. These areas of ineffective extension delivery are a source of serious concern as these indicators constitute the strong pillars of extension delivery, as Sewnet et al. (2016) also emphasized that research, extension and farmers are the three main pillars of agriculture system and their effectiveness largely depends on the strong linkages among them (Sewnet et. al., 2016). Cerdan-Infantes et al. (2009) also argued that improving productivity and quality requires a functioning system of technology generation and transfer and a means to implement these technologies; and that extension services can provide the proper institutional system to deliver these trainings to farmers. In Ghana, Research-Extension-Farmer Linkage Committee (REFLC) is responsible for ensuring this. Policy attention needs to be drawn to these areas of ineffectiveness.

Literature has contradictory perception about effectiveness of the extension delivery tools postulated in this study, and this situation reflects the geographical, institutional and socio-economic contexts in which the extension methods are delivered. Agricultural extension service, therefore, requires regular examination of farmers' geographical, institutional and socio-economic characteristics to determine the appropriate and effective tools with which extension service could be disseminated at the right time and space. This will facilitate farmers understanding and maximize their benefits of extension advisory services, leading to assist farmers achieve high income and improve living standard through agricultural production in the study area and the country as a whole.

CHAPTER FIVE

SUMMARY, CONCLUSION AND POLICY RECOMMENDATIONS

5.1 Introduction

This chapter summarizes the major findings of the study and draws conclusions from the results of the study. Based on the findings, policy recommendations are also suggested for stakeholders' future interventions in maize production sector. Recommendations for further study are also proposed to researchers in agricultural technology adoption studies.

5.2 Summary

This study was carried out to assess the determinants of adoption of Obatanpa by farmers in Zabzugu/Tatale. The sample size of 240 maize farmers was drawn from 17,463 registered maize farmers in the study area using Cochran's (1963) formula. This research focused on ascertaining the extent to which the variety had been adopted using descriptive statistics (means). Logit regression model was the analytical tool for analyzing the determinants of adoption of Obatanpa. The software used was Stata 14.0. The effectiveness of the key agent of diffusion of agricultural innovation – extension – was also evaluated from maize farmers' perspective using descriptive statistics.

The study revealed 58.8% level of adoption of Obatanpa as against 41.2% of non-adopters. From the analysis of the determinants of adoption decisions of Obatanpa in Zabzugu/Tatale using logistic regression model, adoption had significant relationship (positive) with sex, household size, membership of farmer based organization, farm size, farmers' awareness of Obatanpa, access to credit, access to extension service. Age was the only independent variable that negatively influenced adoption of Obatanpa. The rest of the independent variables (years of experience in maize cultivation, number of years of formal education, access to certified Obatanpa, access to radio and TV, off-farm income) were insignificant in explaining adoption of Obatanpa.

Maize farmers' awareness of Obatanpa, access to extension services, and access to credit were significant at 1%, 5%, and 5% levels respectively with 88%, 20%, and 30.79% probability of a farmer adopting Obatanpa. The null hypotheses that farmers' awareness of Obatanpa, access to extension service, and access to credit have no significant impact on the adoption of Obatanpa were, therefore, rejected.

From the results of extension effectiveness indicators, of all the variables determined therein, creation of awareness of agriculture extension agents, visiting farmers, organizing field meetings with farmers, and embarking on supervision by extension agents in the field were perceived by maize farmers as being effective and very effective. However, organizing field days and demonstrations, organization of extension-farmer linkage workshops and farmer training programmes were perceived by maize farmers as being ineffective.

5.3 Conclusion

The study concludes that the extent of adoption of Obatanpa in the Zabzugu and Tatale-Sanguli is high but the descriptive statistics shows that majority of the respondents do not have access to certified Obatanpa, meaning that even the farmers who use Obatanpa, very few of them may be using certified Obatanpa. This situation may be the contributing factor to low yield per hectare of maize in the study area even though other factors determining adoption are not alien to the low yield per hectare.

Access to credit is among the factors that influence the adoption of Obatanpa. Increase access to credit has a corresponding increase in adoption of Obatanpa in the study area. Credit enables producers to access inputs such as improved seedling, fertilizer, hired labour, acquire other farm tools that may be needed in the production process. It is, therefore, necessary for farm household heads to have access to credit to help improve their farming activities.

Household size positively influenced adoption of Obatanpa – meaning that small household sizes has less likelihood of adopting Obatanpa due to insufficient farm labour they may be constrained with. Since some recommended agronomic practices (row planting, for example) accompanying cultivation of improved maize varieties can be labour intensive, access to credit can enable labour-constrained farm households to hire labour.

It is also important to note that age, in this study, has inverse relationship with adoption. This means that a farmer's likelihood of adopting Obatanpa decreases as his or her age increases. Literature has contradictory findings about age-adoption relationship: for example Mignouna et al., (2011) in Kenya; Ouma et. al., (2014) in Eastern Kenya; Kuti (2015) in Osun State in Nigeria**,** and Salifu et. al. (2015) in Wa Municipality in Ghana found age to have inverse relationship with adoption of improved maize varieties contrary to the findings of Akinbode & Bamire, (2015); Ademiluyi, (2014) all in Nigeria; Teferi et al., (2015); Mignouna et al., (2011); and Lopes, (2010) in Ethiopia, Kenya and Mozambique respectively in which age had positive relationship with adoption of improved maize varieties. The significant inverse relationship of age-adoption in Wa Municipality by Salifu et al. (2015) in Ghana and the finding of this study in Zabzugu/Tatale all in the northern Ghana mean that adoption of improved maize varieties in northern Ghana is high among the youth.

Adoption of Obatanpa, from the study, had positive relationship with access to extension. This means that an increase in a farmer's access to extension services increases their likelihood of adopting Obatanpa. Extension service is, therefore, a driver of adoption as extension's core mandate is to educate farmers about good agricultural practices that will lead to the improvement of the farmers' livelihood.

Access to credit significantly and positively influenced the adoption of Obatanpa in the study area. This means that an increase in a farmer's access to credit in the study area positively influence their likelihood of adopting Obatanpa as credit enables farmers to access inputs such as improved seedling, fertilizer, labour, acquire other farm tools that are needed in the production process.

FBO membership had a positively significant relationship with adoption of Obatanpa. This means that an increase in farmers' membership with FBO will result in an increased likelihood of adopting Obatanpa in the study area. Truly, farmers within an FBO learn from each other how to grow and market new crop varieties. It is also assumed that innovations are diffused faster among members of an FBO than among farmers who are exterior to the FBO. The same way, extension cost is relatively low when directed at FBOs than individual farmers. Financial institutions also find it easy and less risky giving credit to farmers who are members of FBOs than individual farmers.

In evaluating farmers' perception of effectiveness of the tools of extension service delivery, awareness of the existence of extension agents, visiting farmers, organizing field meetings with farmers, and embarking on supervisions by extension agents were perceived by farmers as being effective. Organizing demonstration by village extension worker, organization of field days, organization of extension-farmer linkage workshops, and farmer training programmes were, however, perceived by maize farmers as being ineffective.

These ineffective areas of extension delivery are a matter of concern to policy. Such ineffective areas are hinged on ineffective extension-farmer linkage – a confluence where vital agricultural information is related between farmers and extension, and where informational inputs about farmers' challenges, suggestions, and performance of existing technologies are sourced by extension as feedback to research. Based on this, it is essential to wrap up that the ineffective areas of extension delivery in the study area are hinged on poor extension-farmer linkage. Therefore, if maize producers are able to get access to credit, extension services that will increase awareness and educate farmers on best farm practices by improving other areas of ineffectiveness: Organization of demonstration by village extension worker, organization of field days, organization of extension-farmer linkage workshops, and farmer training programmes, all of which are gender-friendly, it may help to reduce the inefficiencies in maize production, and consequentially provide a fertile ground for increased adoption of Obatanpa in Zabzugu/Tatale.

5.4 Recommendations

Two main empirical findings emerged from the results of the adoption model in this study: one independent variable that inversely related to adoption of Obatanpa and eight independent variables directly related with adoption of Obatanpa in the study area; and each or collection of them have systemic influence among themselves and on adoption. So a policy recommendation for one in favour of adoption may overlap other significant variables.

Provision of credit facilities will help households with small sizes to hire labour and buy certified seeds and other inputs for maize production. Membership of farmer-based organizations increases one's access to extension services and credit: it is cheaper teaching farmer groups best farming practices than individual farmers; and most financial institutions, too, direct their credit advancement to farmer-groups where debt recovery is relatively easier. Therefore, the government of Ghana through the Ministry of Food and Agriculture needs to mandate formation of FBOs through agricultural zonal supervisors so that extension service expenditure could be minimized and access to credit could be eased.

MoFA, in collaboration with development partners, needs to establish and maintain an efficient seed distribution system in the study area to ensure timely availability of certified seeds at a subsidized price. This will increase farmers' access to certified Obatanpa.

The results of the study of the effectiveness of extension delivery methods also indicated that applications of some of the extension methods are perceived by farmers to be effective in the study area. The results show regular farm visit is crucial for dissemination of extension massages and should be encouraged. However, visits should be meaningful and have a purpose in order to have a positive impact. For agricultural extension to impact on the livelihood of farmers and farming community at large, there is a need for a strong functioning agricultural extension system that will involve a collaborative and vibrant stakeholders planning and working together.

There is already high level (93.8%) of awareness of Obatanpa propagated either through farmer-to-farmer extension or MoFA extension agents; yet maize farmers perceived ineffectiveness in certain methods of extension delivery: organization of field days, organization of demonstration by village extension worker, organization of extension-farmer linkage workshops, and farmer training programmes. visiting farmers, organizing field meetings with farmers, and embarking on supervisions by extension agents in the field were methods considered effective. It will be imperative to ensure that methods regarded to be effective are mainly used to deliver extension messages, since such methods are judged by the farmers themselves as being effective tools of extension delivery.

There is a high level of awareness of the existence of extension agents from analysis of farmers' perception; the descriptive statistics also shows that there was high access to extension service and high level of awareness of Obatanpa; however, farmers' access to credit and FBO membership (14.2% and 26.3% respectively) remain low. This gives an indication that MoFA has paid less attention to facilitating formation of FBOs and farmers' access to credit. This, therefore, is necessary. The department of agricultural extension should encourage the formation of FBOs and, in conjunction with other stakeholders in rural development, link farmers with credit organizations that will provide credit facilities to the farmers to finance the production cost.

5.5. Recommendations for Further Studies

Research effort needs to also gear towards farmers willingness to pay for certified maize varieties.

Further research needs to be conducted into the intensity of adoption of Obatanpa, finding out whether farmers follow the recommended agronomic practices accompanying cultivation of Obatanpa and the way forward.

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APPENDICE

DETERMINANTS OF ADOPTION OF IMPROVE MAIZE VARIETIES – A CASE OF OBATANPA IN ZABZUGU AND TATALE DISTRICTS

NORTHERN REGION OF GHANA

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Household Questionnaire for Maize Producers in Zabzugu/Tatale Districts

NOTE: This questionnaire is designed for adoption study, seeking to identify the determinants of adoption of improve maize variety (Obatanpa) in Zabzugu and Tatale Districts in that policy recommendations would be suggested to Ghana government and other stakeholders in agricultural sector to improve maize productivity. Any responses provided by respondents would be strictly treated as confidential as possible.

Respondent I D #.......................

Date: …………/..…..…/2016

District…ZABZUGU DISTRICT [ ] TATALE-SANGULI [ ]

Community/ Village……………………….

A. PERSONAL & HOUSEHOLD CHARACTERISTICS

1. Sex 1=Male [ ] 0=Female [ ]

2. Marital status 1=Married [ ] 2=Single [ ]
3. What is the size of your household? Number of males [ ] Number of females [ ]

(Household size in this study is the number of people who eat from the same cooking pot)

4. Are you educated? Yes [ ] No [ ]
5. If yes, what is your level of education? A. Primary [ ] B. Junior High [ ] C. Senior High [ ] D. Tertiary (Diploma, Degree, Masters) [ ]

B. MEMBERSHIP OF FARMER-BASED ORGANIZATION

6. (i) Do you belong to any farmer based organisation? 1=Yes [ ] 0=No [ ]
   (ii) What position do you hold in the farmer based organization? .... No [ ]

   (iii) If yes, do you receive any of the following assistance from the farmer based organisation? Tick the appropriate box.

   - Technical assistance/training 1=Yes [ ] 0=No [ ]
   - Access to inputs (agrochemicals) 1=Yes [ ] 0=No [ ]
   - Machinery services 1=Yes [ ] 0=No [ ]
   - Equipment 1=Yes [ ] 0=No [ ]
   - Credit in kind 1=Yes [ ] 0=No [ ]
   - Credit in cash 1=Yes [ ] 0=No [ ]
   - Storage 1=Yes [ ] 0=No [ ]
   - Marketing services 1=Yes [ ] 0=No [ ]
   - Transportation of inputs and/ products 1=Yes [ ] 0=No [ ]

(iv) If no to 9(i), do you also receive any of the following assistance from a farmer based organization? Tick the appropriate box.

- Technical assistance/training 1=Yes [ ] 0=No [ ]
- Access to inputs (agrochemicals, improve seeds) 1=Yes [ ] 0=No [ ]
- Machinery services 1=Yes [ ] 0=No [ ]
- Equipment 1=Yes [ ] 0=No [ ]

- Credit in kind 1=Yes [ ] 0=No [ ]
- Credit in cash 1=Yes [ ] 0=No [ ]
- Storage 1=Yes [ ] 0=No [ ]
- Marketing services 1=Yes [ ] 0=No [ ]
- Transportation of farm inputs/produce 1=Yes [ ] 0=No [ ]

C. FARM CHARACTERISTICS AND LEVEL OF ADOPTION OF OBAATANPA

7. Do you own land? 1 = Yes [ ] 0 = No [ ]
8. If no, on what basis do you use this current land? 1 = free but to be returned to the owner 0 = Rent
9. What was the total size of your maize farm?..............................acres
10. How long have you been a Maize Farmer?...................................... years
11. Did you use improved maize varieties in the last three years? 1=Yes [ ]0=No [ ]

If yes, which of the following improved maize varieties did you crop and in what number of acres as in the table below? Obatanpa b. Okomasa c.dobidi d. Fafita 2 e. Golden Crystal (yellow maize) f. Other

Year	**Variety cropped**	**Number acres**
2013		
2014		
2015		

12. (i) If you used Obatanpa, why did you use it? a) It is available[ ] b) it has higher yield [ ] c) it is nutritious [ ] c) it is preferred by maize buyers [ ] d) it yields earlier [ ] e) it is accessible[ ] f)other...

(ii) How long have you used Obatanpa? ....years.

(iii) If you did not use Obatanpa, why didn't you use it? Choose answer from

below.

a) Not aware of Obatanpa [ ] b) Not available[ ] c) the yield is low [ ] c) seeds are too costly to buy [ ] d) I am satisfied with the variety I use now [ ] e) not accessible f)other...

13. How did you acquire your seeds? 0 = Purchase[ ] 1= Supplied by a research unit[ ] 2 = Gift from friends[ ]4 = Stored from past produce 5 = others specify…………………….

14. If stored from past produce, how many times have you recycled the seed after you last bought it from certified dealers? ………………………………….

D. EFFECTIVENESS OF EXTENSION SERVICES DELIVERY

15. Where did you learn how to plant Obatanpa?

a. From another farmer [ ] 2.Attending a field day organized by farmer organization [ ]

b. Attending a field day of extension service [ ] 4. Visit from extension agent [ ]

c. Reading extension bulletin [ ]6. Own experiments[ ] 7. Other [ ]

16. Did an extension agent visit your maize farm in the 2015 season?1 = Yes[ ] 0 = No[ ]

17. If yes, how many times did they visit?..................... times

18. In which of the following activities did you receive education/training from extension agents in your maize farm? 1. Land preparation and sowing[ ] 2) Weeding[ ] 3) fertilizer application [ ] 4) weedicide application[ ] 5) pesticide application[ ] 6) harvesting and post harvest practices [ ]

19. Did you attend a workshop related to Maize production in 2015 season? 1=Yes [ ] 0=Otherwise [ ]

20. If yes, which of the following types of organizations organized the training? 1 = Public Extension Organization[ ] 0 = Private Extension Organization[ ]

21. Do you use a radio& and or TV? 1= Yes [ ] 0 = No [ ]

22. If yes, do you receive farming information through the radio or TV?

    1 = Yes 0 = No

23. Do extension agents visit you to ask of your farming problem?

    1 = Yes [ ] 2 = No [ ]

24. Do you visit extension agents to give complaints about problems of your farm? 1 = Yes [ ] 0 = No [ ]

25. If yes, are you satisfied with the attention they give you? 1 = Satisfied [ ] 0 = Not satisfied[ ]

E. FARMERS' PERCEPTION OF THE LEVEL OF EFFECTIVENESS OF EXTENSION DELIVERY

Thick (√) where you think is best described your perception of the corresponding extension activities in the table below:

No.	Indicator	Numerical scores of level of effectiveness		
		Not effective (1)	Effective (2)	Very effective (3)
1	Awareness			
2	Visit			
3	Field meeting			
4	Regularity			
5	Field days			
6	Demonstrations			
7	Supervision			
8	Extension-Farmer Linkage Workshop			
9	Farmer Training			
10	Effectiveness			

F. SOCIO-ECONOMIC FACTORS

ACCESS TO CREDIT

26. (i) Do you have access to credit for maize production? 1=Yes [ ] 0=No [ ]

(ii) If yes, provide the information below.

Type		Source	Interest Rate	Repayment period (months)	Availability	Other cost
Cash						
Kind	Labour					
	Seeds					
	Ploughing					
	Weedicide					
	Pesticide					
	Fertilizer					
	Other					

Source of credit: 1= Formal Bank, 2= Money Lenders, 3= Friends, 4= family/Relatives 5= Others Specify

Availability: 1=Readily Available 2= Available 3= Scarce

27. What is your major occupation? 1=Farming [ ]2=Trading [ ] 3=Salary worker [ ]

5=Others (Specify)………………………

28. (i) Did you engage in an off-farm employment activity? 1=Yes [ ] 0=No [ ]

(ii) If yes, which of the following were you engaged in? a. Casual labour [ ] b. salary employment [ ] c. Masonry [ ] d. Carpentry[ ] e. Fitting [ ] f. Petty trading [ ]

a) other …………………..

No.	Off-farm income generating activity	Work Income (GH¢) per month/year
1.		
2.		
3.		

```
. sum adoptnotadopt sex marstus age experience hhsz edu fbo frmsz aware_obatampa access_credi
> t acmob access_ext acc_tv_radio

    Variable |       Obs        Mean    Std. Dev.       Min        Max
-------------+--------------------------------------------------------
adoptnotad~t |       240       .5875     .493313          0          1
         sex |       240    .9166667     .276963          0          1
     marstus |       240    .8541667    .3536766          0          1
         age |       240    31.96667    14.33341         18         72
  experience |       240     10.0475    6.598839          3         36
-------------+--------------------------------------------------------
        hhsz |       240    12.44583    6.597608          2         35
         edu |       240    2.141667     4.93607          0         21
         fbo |       240    .2541667    .4363017          0          1
       frmsz |       240     11.0375     8.40618          1         55
aware_obat~a |       240       .9375    .2425673          0          1
-------------+--------------------------------------------------------
access_cre~t |       240       .1375    .3450941          0          1
       acmob |       240    .4791667    .5006098          0          1
  access_ext |       240    .4916667    .5009753          0          1
acc_tv_radio |       240    .1708333    .3771498          0          1
```

```
. logit adoptnotadopt sex marstus age experience hhsz edu fbo frmsz aware_obatampa access_credit acmob a
> ccess_ext acc_tv_radio

Iteration 0:   log likelihood = -162.66133
Iteration 1:   log likelihood = -42.104071
Iteration 2:   log likelihood = -36.997784
Iteration 3:   log likelihood = -28.519248
Iteration 4:   log likelihood = -25.455542
Iteration 5:   log likelihood = -25.148674
Iteration 6:   log likelihood =  -25.14171
Iteration 7:   log likelihood = -25.141701
Iteration 8:   log likelihood = -25.141701

Logistic regression                               Number of obs   =        240
                                                  LR chi2(13)     =     275.04
                                                  Prob > chi2     =     0.0000
Log likelihood = -25.141701                       Pseudo R2       =     0.8454

------------------------------------------------------------------------------
adoptnotad~t |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         sex |    3.85528   2.138567     1.80   0.071    -.3362355    8.046795
     marstus |   1.633634   1.589919     1.03   0.304    -1.482551    4.749819
         age |  -.2135601   .0635482    -3.36   0.001    -.3381123   -.089008
  experience |   .0907833   .1184577     0.77   0.443    -.1413895    .3229561
        hhsz |   .4035332   .1366143     2.95   0.003      .135774    .6712924
         edu |   .0626178   .1055302     0.59   0.553    -.1442177    .2694532
         fbo |   2.030445   1.380094     1.47   0.141    -.6744885    4.735379
       frmsz |   .6298254   .2056137     3.06   0.002     .2268299    1.032821
aware_obat~a |   5.504044   2.070766     2.66   0.008     1.445417    9.562671
access_cre~t |   6.884746   2.299369     2.99   0.003     2.378066    11.39143
       acmob |   1.843098   1.028365     1.79   0.073    -.1724596    3.858657
  access_ext |   3.199467   1.252766     2.55   0.011     .7440898    5.654844
acc_tv_radio |   1.404514   .9759315     1.44   0.150    -.5082763    3.317305
       _cons |  -18.38377   7.210232    -2.55   0.011    -32.51557    -4.25198
------------------------------------------------------------------------------
Note: 0 failures and 16 successes completely determined.
```

```
. mfx

Marginal effects after logit
      y  = Pr(adoptnotadopt) (predict)
         =  .88675391
```

variable	dy/dx	Std. Err.	z	P>|z|	[95% C.I.	]	X
sex*	.7292014	.28469	2.56	0.010	.171212	1.28719	.916667
marstus*	.2487193	.29546	0.84	0.400	-.330367	.827805	.854167
age	-.021446	.00872	-2.46	0.014	-.038528	-.004364	31.9667
experi~e	.0091166	.01134	0.80	0.422	-.013115	.031348	10.0475
hhsz	.0405234	.01406	2.88	0.004	.012962	.068084	12.4458
edu	.0062882	.01025	0.61	0.540	-.013808	.026385	2.14167
fbo*	.1489329	.07834	1.90	0.057	-.004616	.302482	.254167
frmsz	.063248	.02218	2.85	0.004	.019768	.106728	11.0375
aware_~a*	.8739569	.10397	8.41	0.000	.670189	1.07773	.9375
acces~it*	.2472823	.09494	2.60	0.009	.061213	.433352	.1375
acmob*	.1893575	.11706	1.62	0.106	-.040081	.418795	.479167
acces~xt*	.3565909	.14201	2.51	0.012	.078248	.634934	.491667
acc_tv~o*	.1013413	.07493	1.35	0.176	-.045525	.248207	.170833

(*) dy/dx is for discrete change of dummy variable from 0 to 1