ADOPTION OF IMPROVED MAIZE VARIETIES IN NORTHERN AND EASTERN ZONES OF TANZANIA

ATUPOKILE MWAKATWILA

A DISSERTATION SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN AGRICULTURAL AND APPLIED ECONOMICS OF SOKOINE UNIVERSITY OF AGRICULTURE. MOROGORO, TANZANIA.

2016

ABSTRACT

This study analyzed the factors that influence the adoption of improved maize varieties and the extent of adoption in northern and eastern zones of Tanzania. Data were collected from a sample of 548 households in northern and eastern zones by adoption pathway project in 2013 by using household survey questionnaire. Descriptive statistics were employed to determine the improved maize varieties adopted in the two regions and Heckman two stage sample selection model was used to determine factors influencing the adoption and extent of adoption of improved maize varieties. Results from stage one of the Heckman model indicate that respondents who had 7 years and more in school and those who had communication and transportation assets were more likely to adopt improved maize varieties and was significant at ($p \leq 0.05$), and respondent's income and savings also significantly influence the adoption of improved maize varieties at p (≤ 0.1). The results of the second stage of the Heckman model indicate that respondent's income and the difference in the two zones are significantly influencing the extent of adopting improved maize varieties. It is therefore concluded that farmers' education, income, savings, zones and access to transportation and communication assets are the major factors influencing extent and adoption of improved maize varieties. And it is recommended that government and other development organization should create a favorable environment like subsidization of the farming technologies, improvement of rural infrastructures and strengthening farmers' knowledge on modern agriculture production as the way of improving farmer's adaptation to agricultural intensification practices.

DECLARATION

I, Atupokile Mwakatwila, do hereby declare to the Senate of Sokoine University of Agriculture that this dissertation is my own original work done within the period of registration and that it has neither been submitted nor being concurrently submitted in any other institution.

_____ _____

Atupokile Mwakatwila Date

(MSc. Candidate)

The above declaration is confirmed by:

_____ _____

Dr. F. J. Mishili Date

(Supervisor)

COPYRIGHT

ACKNOWLEDGEMENT

I thank God the almighty for providing me with the courage, guidance, patience, strength, and passion throughout my study period, for I understand without him I would have given up.

I am sincerely grateful to my supervisor Dr. F. J. Mishili for his priceless guidance and support during the coursework and research period. I would also like to thank Prof. G. Mlay for his moral support and positive inputs in this work which made it successful.

Furthermore, my great appreciation to the African Economic Research Consortium for scholarship to pursue part of my coursework at university of Pretoria, South Africa and the great role played by Adoption Pathway Project lead by CIMMYT to allow me to use their Tanzania database.

I wish to acknowledge the entire staff of the Department of Agricultural Economics and Agribusiness of Sokoine University of Agriculture for the great support they offered during my study period. Moreover, special thanks to my family for the boundless support and all those who contributed in one way or another to the success of this work. God bless you all.

DEDICATION

This work is dedicated to my beloved parents: Ulindalusya Mwakatwila and Sarah Mwasikili for their sacrifices and enormous support which made me who I am today.

TABLE OF CONTENT

LIST OF TABLE

FIGURE

LIST OF ABBREVIATIONS AND SYMBOLS

CIMMYT	*Centro Internacional de Mejoramiento de Maiz y Trigo*
DIT	Diffusion of Innovation Theory
EARO	Ethiopian Agricultural Research Organization
FAO	Food and Agriculture Organization
GDP	Gross Domestic Product
IDA	International Development Association
JETRO	Japan External Traders Organization
ML	Maximum Likelihood
OLS	Ordinary Least Square
SACCOS	Saving and Credit Cooperative Societies
SFIW	State of Food Insecurity in the World
SIMLESA	Sustainable Intensification of Maize –Legume Cropping System for Food Security in Eastern and Southern Africa
SPSS	Statistical Package for Social Sciences
SWOT	Strength Weakness Opportunity and Threats Analysis
URT	United Republic of Tanzania
WEMA	Water Efficient Maize for Africa

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background Information

Agriculture is the foundation of Tanzanian economy whereby most of Tanzanians are living in rural areas and depend on agriculture to for their livelihood. Agriculture accounts for about 30% of economic activity, and in the least-developed countries as a group, it accounts for 27% of GDP (SFIW, 2012). Agriculture is critical to achieving global poverty reduction targets. According to International Development Association. (2009), agriculture is still the single most important productive sector in most low-income countries, often in terms of its share of Gross Domestic Product and almost always in terms of the number of people it employs. In countries where the share of agriculture in overall employment is large, broad-based growth in agricultural incomes is essential to stimulate growth in the overall economy, including the non-farm sectors selling to rural people (IDA, 2009).

In Tanzania agriculture sector is the leading sector as its performance has significant impact on the output and corresponding income of the Tanzanians. According to United Republic of Tanzania (2015), the significance of this sector in terms of economic growth has been recognized by the fact that it plays an important role in food security, employment, and export earnings. The sector accounts for 27% of the GDP and 35% of the foreign currency and employs about 77% of the total population. It is dominated by the smallholder farmers and it provides raw materials for industries (URT, 2015).

Agricultural Statistics is the aggregate of numerical information of different fields of agriculture and its economy but the main food crops grown in the country are maize,

bananas, pulse, paddy and wheat; cash crops grown include coffee, cashew-nuts, tea, cotton, tobacco and sisal. Food production is the dominant sub-sector in the agriculture sector accounting for about 55% of the agricultural GDP (Larsen *et al.,* 2009). The industrial crops mainly produced for export contribute only 9% of the GDP while the livestock sub sector contributes 32% of the agricultural GDP (URT, 2010). With the increasing population the total demand for food and non food commodities in Tanzania is expected to increase many times. Therefore, increased food production is essential to meet the demand of this growing population.

Maize is a staple food for more than 300 million people in Sub-Saharan Africa and it is grown predominantly by smallholder farmers under rain-fed conditions (WEMA, 2010). On the other hand, high population growth rate demands for an increase in maize productivity. According to Rates (2003), maize is the major and one among the preferred staple food and cash crop in Tanzania. The popularity of maize is evidenced by the fact that it is grown in all the agro-ecological zones in the country. Over two million hectares of maize are planted per year with average yields of between 1.2–1.6 tons per hectare and accounts for 31% of the total food production and constitutes more than 75% of the cereal consumption in the country (WEMA, 2010).

Despite the importance of maize as the main staple crop, average yields in farmers' fields are relatively low averaging 1.2 metric tons per hectare compared to the estimated potential yields of 4–5 metric tons per hectare (WEMA, 2010). According to Kassie *et al.* (2014), developing countries agriculture is characterized by low use of modern technologies and low productivity, therefore adoption of agricultural technology is crucial for agricultural development and productivity in most of the developing countries. An assumption is often made that there are adequate profitable technologieson the shelf in

Tanzania which farmers can use to increase productivity and incomes and hence reduce the level of poverty.

1.2 Statement of the Problem and Justification

1.2.1 Statement of the problem

Farmers in Northern and Eastern zones of Tanzania have a range of alternatives in local and improved maize varieties to be used in production but despite that range the actual maize yield is lower than the estimated potential as it has been reported by WEMA (2010), that maize average yields are relative low which is 1.2Mt/ha compared to the estimated potential4-5Mt/ha. Farmers' adoption of improved maize varieties is a choice between local and improved maize varieties. Farmers' decision to use or not to use is usually based on the profitability and risk associated with the new maize varieties. Before adoption, farmers have to be assured of the expected marginal gains and associated risk. Farmers' concern with marginal gains and risk in turn affects the adoption of the new maize varieties. According to Aloyce *et al*. (2000) most adoption studies under smallholder production systems show that farmers are risk averse and follow a technological ladder in the adoption process. They will first adopt simple components and then move to complex ones and from cheaper to more costly technologies. The process allows farmers to evaluate available alternatives to avoid incurring unnecessary costs.

A number of studies have been conducted on the factors influencing the adoption of improved maize varieties such as Aloyce *et al*. (2000) demonstrated that despite the factors that influence the extent of adopting improved maize seeds and the use of inorganic fertilizer for maize production, farmers preferred those varieties which minimize field loss rather than maximizing returns. Despite the fact that farmers use different strategies to obtain improved maize seeds such as purchasing from agro-dealers,

recycling of their own seeds and formation of Saving and Credit Cooperative Societies (SACCOS), the high costs of improved seed, poor availability and lack of knowledge are some of the reasons why farmers do not use improved seed (Lyimo, 2014). Therefore, improving agricultural productivity and development and thereby improving smallholder farmers' income requires increased efforts in influencing farmer to use yield enhancing technologies like improved maize varieties. It is from this ground the need to determine the factors that influence the adoption decision and extent of adopting improved maize varieties in Northern and Eastern zones of Tanzania seen as a thoughtful gap that must be bridged if the problem of limited improved maize varieties adoption among farmers is to be addressed and agricultural income to be improved.

1.2.2 Justification of the study

This study aimed at understanding the specific factors influencing adoption of improved maize varieties and extent of adopting improved maize varieties in Northern and Eastern zones of Tanzania. The information obtained from this study will generate useful knowledge to development planners, policy makers and practitioners in reducing poverty through increased agricultural productivity and strengthening maize farming and use. This study is also supported by the national vision on KILIMO KWANZA, Activity 1.2 "Modernize and commercialize agriculture for peasant, small, medium and large scale producers under the 1st task of transforming peasant and small farmers to commercial farmers through emphasis on productivity and tradability", as well as to meet Millennium Development Goal 1 which is to eradicate extreme poverty and hunger with its 2 targets of halving between 1990 and 2015, the proportion of people whose income is less than one dollar a day (Target 1), and halve between 1990 and 2015, the proportion of people who suffer from hunger (Target 2).

1.3 Objectives of the Study

1.3.1 General objective

The main objective of this study was determination of factors influencing the adoption decision and extent of adopting improved maize varieties in Northern and Eastern zones of Tanzania.

1.3.2 Specific objectives

To achieve the general objective, this study was sought to:

i. Identify the factors affecting the farmers' decision to adopt improved maize varieties.
ii. Determine the factors that influence the extent of adopting improved maize varieties.

1.4 Hypotheses

i) Decision of adopting improved maize varieties was not significantly influenced by socioeconomic factors.
ii) Socioeconomic factors do not significantly influence the extent of adopting improved maize varieties by the smallholder farmers in the study area.

1.5 Theoretical and Conceptual Framework

1.5.1 Theoretical framework

Diffusion of innovation theory (DIT) by Rogers (2003) is the theory guiding this study. According to Medlin, (2010) DIT is the most appropriate for investigating the adoption of technology in higher education and educational environments. In fact Rogers (2003) used the word innovation and technology as synonyms. He defined technology as a design for instrumental action that reduces the uncertainty in the cause-effect relationships involved

in achieving a desired outcome. And adoption as the decision of full use of an innovation as the best course of action available where as rejection is a decision not to adopt an innovation and diffusion is the process in which an innovation is communicated through certain channels over time among the members of a social system. As expressed in the definition of diffusion, innovation, communication channels, time, and social system are the four key components of the diffusion of innovations. The main objective of this theory is to understand the adoption of innovation in terms of four elements, including innovation, communication channels, time and social systems and five stages, including knowledge stage, persuasion stage, decision stage, implementation stage and confirmation stage.

Innovation: Rogers defines innovation as an idea, practice, or project that is perceived as new by an individual or other unit of adoption.It may have been invented a long time ago, but if individuals perceive it as new, then it may still be an innovation for them. The newness characteristic of an innovation is more related to the three steps, namely knowledge, persuasion, and decision of the innovation-decision process. According to Rogers (2003) uncertainty is an important obstacle to the adoption of innovations. An innovation's consequences may create uncertainty, whereas consequences are the changes that occur in an individual or a social system as a result of the adoption or rejection of an innovation. To reduce the uncertainty of adopting the innovation, individuals should be informed about its advantages and disadvantages to make them aware of all its consequences.

Communication channels: The second element of the diffusion of the innovation process is communication channels. For Rogers (2003) communication is a process in which participants create and share information with one another in order to reach a

mutual understanding. This communication occurs through channels between sources. Besides Rogers defines source is an individual or an institution that originates a message and the channel is the means by which a message gets from the source to the receiver. In addition Rogers states that diffusion is a specific kind of communication and includes these communication elements: an innovation, two individuals or other units of adoption, and a communication channel. Mass media and interpersonal communication are two communication channels. While mass media channels include a mass medium such as TV, radio, and newspaper, interpersonal channels consists of a two-way communication between two or more individuals. On the other hand, diffusion is a very social process that involves interpersonal communication relationships. Thus, interpersonal channels are more powerful to create or change strong attitudes held by an individual. Ininterpersonal channels, the communication may have a characteristic of homophiles, that is, the degree to which two or more individuals who interact are similar in certain attributes, such as beliefs, education, socioeconomic status, and the like, but the diffusion of innovation requires at least some degree of heterophony, which is the degree to which two or more individuals who interact are different in certain attributes.In fact, one of the most distinctive problems in the diffusion of innovations is that the participants are usually quite heterophilous.

Time: According to Rogers (2003) the time aspect is ignored in most behavioral research. He argues that including the time dimension in diffusion research illustrates one of its strengths. The innovation-diffusion process, adopter categorization, and rate of adoptions all include a time dimension.

Social System: The social system is the last element in the diffusion process. Rogers (2003) defined the social system as a set of interrelated units engaged in joint problem

solving to accomplish a common goal. Since diffusion of innovations takes place in the social system, it is influenced by the social structure of the social system. For Rogers (2003) structure is the patterned arrangements of the units in a system. He further claimed that the nature of the social system affects individuals' innovativeness, which is the main criterion for categorizing adopters.

Furthermore, technology adoption-decision process involves information-seeking and information-processing activity, where an individual is motivated to reduce uncertainty about the advantages and disadvantages of that technology. As demonstrated by Rogers (2003) the technology adoption-decision process involves five steps, namely knowledge, persuasion, decision, implementation and confirmation. These stages typically follow each other in a time-ordered manner as described below.

The knowledge stage: The technology adoption-decision process starts with the knowledge stage. Where an individual learns about the existence of new technology and seeks information about it. "What?" "how?," and "why?" are the critical questions in the knowledge phase. In this phase, the individual attempts to determine "what the new technology is and how and why it works". According to Rogers (2003) the questions from three types of knowledge namely awareness-knowledge, how-to-knowledge and principles-knowledge. Awareness-knowledge represents the knowledge of the technology's existence and it can motivate the individual to learn more about the technology and then to adopt it. With the type of how-to-knowledge contains information about how to use the technology at the expected level correctly. According to Rogers (2003) how-to-knowledge is an essential variable in the technology adoption-decision process. To increase the adoption chance of the technology, an individual should have a sufficient level of how-to-knowledge prior to the trial of this technology. On the other

side, principles-knowledge is the knowledge that includes functioning principles describing how and why the technology works. The technology can be adopted without this knowledge, but the misuse of the technology may cause its discontinuance. For Seemann (2003) to create new knowledge, technology education and practice should provide not only a how-to experience but also a know-why experience. In fact, an individual may have all the necessary knowledge, but this does not mean that the individual will adopt the technology because the individual's attitudes also shape the adoption or rejection of the technology.

The Persuasion stage: This stage occurs when an individual has a positive or negative attitude toward the new technology, but the formation of a positive or negative attitude toward the technology does not always lead directly or indirectly to an adoption or rejection The individual shapes his or her attitude after he or she knows about the technology, so the persuasion stage follows the knowledge stage in the technology adoption-decision process. Furthermore, Rogers (2003) states that while the knowledge stage is more cognitive- centered, the persuasion stage is more effective-centered. Thus, the individual is involved more sensitively with the innovation at the persuasion stage.

The decision stage: In the technology adoption-decision process, the decision stage is where an individual chooses to adopt or reject the new technology. If the technology has a partial assessment basis, it is usually adopted more quickly, since most individuals first want to try the technology in their own situation and then come to an adoption decision. The vicarious assessment can speed up the technology adoption-decision process. However, rejection is possible in every stage of the technology adoption-decision process.

The implementation stage: In this stage, the technology is put into practice. However, the technology brings the newness in which some degree of uncertainty is involved in diffusion. Uncertainty about the outcomes of the technology still can be a problem at this stage. Thus, the implementer may need technical assistance from change agents and others to reduce the degree of uncertainty about the consequences.

The confirmation stage: The technology adoption-decision already has been made, but at the confirmation stage the individual looks for support for his or her decision. According to Rogers (2003), this decision can be reversed if the individual is exposed to conflicting messages about the innovation. However, the individual tends to stay away from these messages and seeks supportive messages that confirm his or her decision. Thus, attitudes become more crucial at the confirmation stage. Depending on the support for adoption of the technology and the attitude of the individual, later adoption or discontinuance happens during confirmation stage.

1.5.2 Conceptual framework

Agricultural technology adoption patterns often vary from one smallholder farmer to another and this variation is due to the disparity in institutional and socioeconomic factors. As it was demonstrated by CIMMTY (1993) farmers' decision to adopt or not to adopt new technologies can be influenced by the factors related to their objectives and constraints, these factors include farmers' endowments which can be measured by farm size and assets ownership, size of the family labors, age, formal education and institutional support system available for inputs.Therefore in a situation where smallholder farmers adopt new technologies, the efficiency of the technology is converted into economically valuable output increases and productivity rises. Productivity rise in agriculture can have a positive impact on the income of the smallholder farmers since the

increase in yield will lead to an increase in farmers' revenue hence increase in farmers' profit. From Figure 1, presents conceptual framework and the arrows indicate the expected relationship between the variables,which is agriculture development projects and other stakeholders come up with the different technology packages such as improved maize varieties and other farming practices while the decision to adopt or not to adopt the technology is made by an individual farmer and can be influenced by the different factors such as socioeconomic and institutional factors, and when the farmer make the decision to adopt then the farm productivity is expected to be increased and and also that changes will have impact on the economic status of the particular farmer.

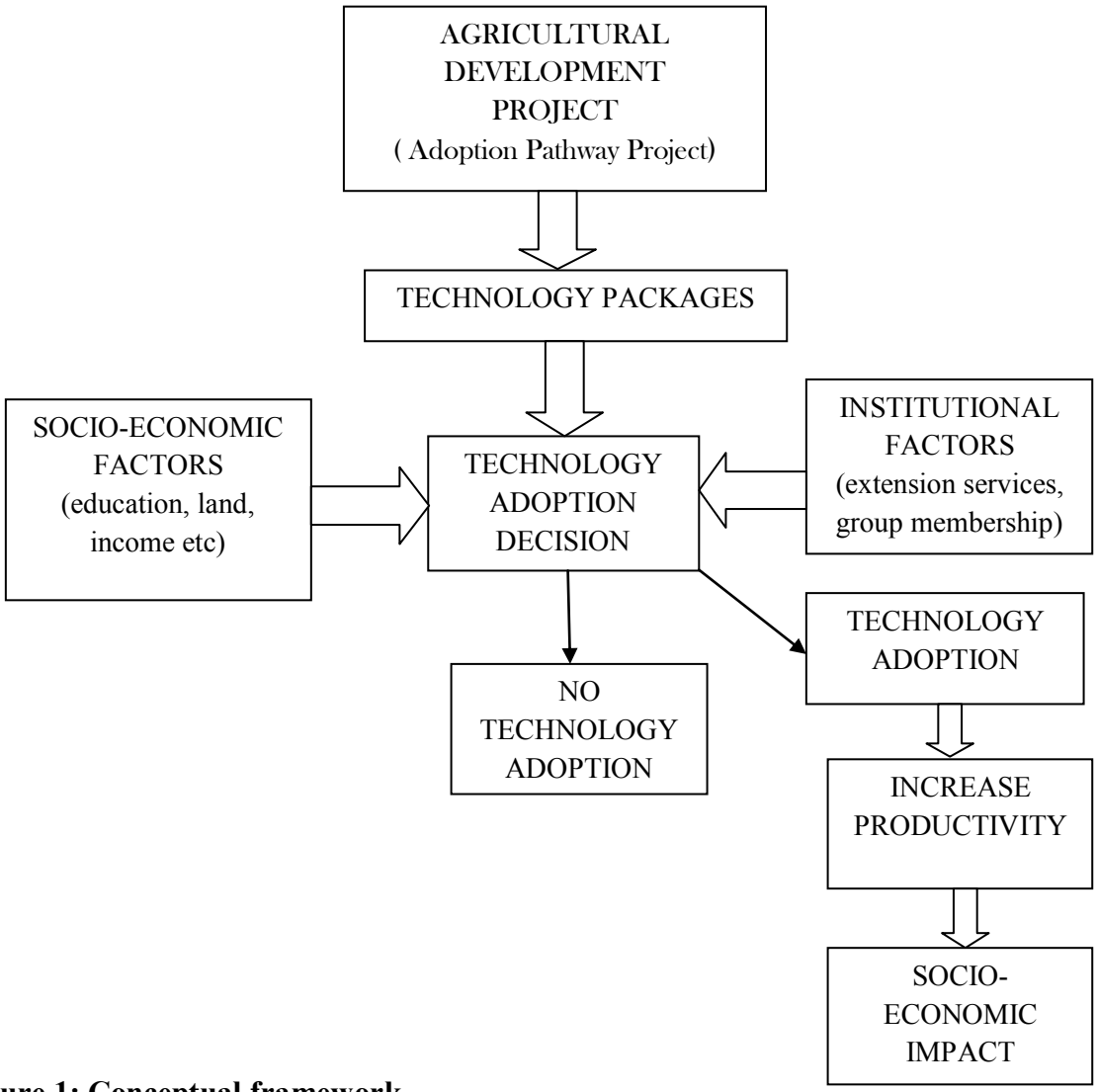

Figure 1: Conceptual framework

Source: Adopted (with modified) from Nassoro, (2006).

1.6 Organization of the Dissertation

This study is organized in five chapters. Chapter one gives background information of the study, problem statement, objectives of the study and hypotheses while chapter two presents a critical review of the literature relevant to the study and chapter three presents a description of the study area, the source of the data and the methodology employed, in chapter four the results and discussion are presented while chapter five presents conclusions and recommendations drawn from the study findings.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Definitions of Terms and Concepts

2.1.1 An overview on the concept of technology

Technology has been defined as a process intended to achieve a given action as reducing the improbability in the cause-effect relationship involved in achieving a desired outcome (Moore, 2002). Technology transfer is the process by which innovations are exchanged between the individuals or organizations involved in research and development on the one hand, and those putting technological innovations into use on the other. However, it is not simply a one-way process as there are responsive linkages from current and potential users about their needs and about the usefulness of existing processes (Moore, 2002). Farmers will only decide to adopt a new technology if they are convinced of its benefits and if technology does not require undesirable efforts on their part. Therefore, there is a need for involving farmers as active participants in the conceptualization, generation and evaluation of recommended technological innovations.

2.1.2 Adoption concept

The Adoption process is the change that takes place within individuals with regard to an innovation from the moment that they first become aware of the innovation to the final decision to either use it or not. Also, as it is emphasized by Ray (2001) adoption does not necessarily follow the suggested stages from awareness to adoption; trial may not always be practiced by farmers to adopt new technology, they may adopt the new technology by passing the trial stage. The adoption pattern for a technological change in agriculture is a multifaceted process. A large number of personal, situational and social characteristics of farmers have been found to be related to their adoption rate. According to Ray (2001)

adopters have a high rate of literacy and higher level of formal education, operate large sized holdings, own the land they operate, have a relatively high income and economic status, are commercial in farming operation, have relatively high levels of extension contact, and belong to upper socioeconomic status categories. Unlike non-adopters who have a low rate of literacy and level of formal education, operate smallholdings, are mostly small and marginal farmers, belong to low income group, have a low level of socioeconomic status categories.

According to Ajayi*et al*. (2003) and Gemeda*et al*. (2001) in developing countries, improving the livelihoods of rural farm households via agricultural productivity would remain a meager wish if agricultural technology adoption rate is low. Therefore, there is a need to adopt the improved agricultural technologies so as to improve production as well as productivity and thereby the living condition of the rural poor. Furthermore, for developing countries, the best way to catch developed countries is through agricultural technology diffusion and adoption (Foster and Rosenzweig, 2010). Additionally, in Mozambique, Uaiene*et al*. (2009) reported that if attention is not given to the use and adoption of agricultural technologies, then agriculture production and productivity will slow down and rural poverty will prevail more. In their finding, Ibrahim *et al*. (2012) purport about the direct effect of technology adoption on the farmer's income resulting from higher yields and prices.

2.2 Theoretical Review and Empirical Studies

2.2.1 Improved maize varieties adoption and diffusion in Africa

Mugisha and Diiro (2010) provide an overview of maize production in Uganda as a staple food across all regions and the targeted support in its production from both government and non-government organizations. They argued that the overall trend of production, area

and yield showed that yield stagnated and the growth in maize production had primarily been due to area expansion.

They also analyze adoption of improved maize varieties and its effects on farm yields and rural poverty in central Uganda. Results showed very high levels of adoption about 80% and a low level of adoption intensity. Furthermore, they found that the mean yields from improved maize varieties of 2941.5kg/ha per season is significantly higher than the yields from local varieties of 1694 Kg/ha per season and extension advisory services are strongly associated with the adoption of improved varieties. Intensity of adoption of improved maize varieties increased farm yields. However, maize yields increase with increasing adoption rate and they concluded that adoption of improved maize varieties leads to increased maize yield. This more technical assistance in the form of training and extension is justified in the country on efficiency and welfare grounds.

Diiro (2013) conducted a study on the impact of off-farm income on agricultural technology adoption intensity and productivity; in his study, he analyzed the impact of off-farm earnings on the intensity of adoption of improved maize varieties and the productivity of the maize farming in Uganda in the years 2005/06 and 2009/10. The results show significantly higher adoption intensity and expenditure on the purchased inputs among households with off-income relative to their counterpart without off-farm income. The results of the random effect Tobit model show positive and significant association between off-farm income and the proportion of the land planted with improved maize varieties.

Katengeza *et al.* (2012) carried out a study in Malawi on drivers of improved maize variety adoption in drought prone areas. Takane (2008) as was quoted by Katengeza *et al.* (2012) reported that maize has been providing on average over 65% of the daily calories consumed by Malawians and it makes up a higher share of the national diet in Malawi

than in any other comparable African country. For most Malawians, eating maize is seen as essential to having a good life and self-sufficiency in maize is a widely and highly held value (Levy, 2005).

In identifying the determinants of adoption and adoption-intensity of improved maize varieties in Malawi, Katengeza *et al*. (2012) found that labor 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. Households where the head had membership of a social group were also found to be less likely to adopt. The intensity of adoption was found to be negatively related to livestock wealth and fertilizer use. Equally, the age of the household head, the labor 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 researchers 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. Agricultural extension enhances provision of timely and quality agricultural information which is vital to smallholder farmers' production and marketing decisions and hence, key to decisions to adopt new and improved technologies such as improved maize varieties.

Tura *et al*. (2010) analyzed the factors that explain adoption as well as continued use of improved maize seeds in one of the high potential maize growing areas in central Ethiopia. Using a bivariate probit with sample selection model approach, the study provides insights into the key factors associated with adoption of improved maize seed and its continued use. The result showed that human capital such as adult workers, off-farm work and experience in hiring labor, asset endowment like size of land owned,

institutional and policy variables like access to credit, membership in cooperatives all strongly influence farmers' decisions to adopt improved maize varieties, while continuous use of the seed is influenced by the proportion of farmland allocated to maize, literacy of the household head, involvement in off-farm work, visits by extension agents, farmers' experience, household land size and fertilizer usage. Again Tura *et al*. (2010) emphasized that policies and interventions that informed about such factors were required to accelerate the adoption and continued use of improved maize seeds in order to increase farm yields and remedy shortage of food and fight poverty and insecurity more effectively and more sustainably.

Schroeder *et al*. (2013) conducted a study on the potentials of hybrid maize varieties for smallholder farmers in Kenya. They demonstrated that maize is the primary staple crop and plays an important role in the livelihood of the people of Kenya. Its availability and abundance determines the level of welfare and food security in the country. The researchers continued emphasizing that the future increases in maize production in Kenya needed to meet domestic demand will have to rely on improvements in yield rather than on the expansion of the maize production area and enhanced maize productivity can be achieved by increased use of modern production techniques such as the adoption of hybrid maize varieties, the use of chemicals and fertilizer application. Their study tried to review the reasons for the low rate of adoption of hybrid maize varieties among small-scale farmers.

Schroeder *et al*. (2013) also found that lack of awareness of existing or newly released hybrid varieties, lack of hybrid varieties adapted to marginal areas, lack of confidence in the quality of some hybrid maize seeds, poor access to stockists, low profitability due to high seed cost, inadequate access to credit, the need for fertilizer application and low

literacy level have been found to be important factors explaining the low adoption rates by smallholder maize producers in marginal areas. Concluded that, these constraints might also explain the widespread practice of recycling hybrid grain among small-scale farmers once they have adopted hybrid maize varieties. Therefore, it is hoped that by overcoming these constraints, the adoption of hybrid maize varieties among smallholder farmers could be greatly enhanced, which in turn could lead to a significant positive impact on the country's food security situation.

In Zambia maize production is a very important source of food and farm income for smallholders, accounting for about 80% of their total value of crop production (Jayne *et al*., 2007). Kalinda *et al.* (2014) in their study reported that maize is also a staple food for much of southern Africa. For many of these countries, its supply is essential to food security and domestic stability. Their study used data collected from a survey of a random sample of farm households in southern Zambia to develop a Tobit regression model. The results indicate that expectations about output price and yield are important determinants of adoption. Other factors directly correlated with the probability of adoption include the status of being male-headed, farm size and membership to farmer organizations. Kalinda *et al.* (2014) reported that households with more wealth and educated heads were also significantly more likely to adopt improved varieties and suggested the policy implications such as intervention strategies should be designed and implemented to encourage poor households and those with low levels of formal education to participate in local farmer organizations. With respect to the positive interaction between membership to organizations and the adoption of technologies they suggested that group based extension approaches should be encouraged not only for their role in collective action but also for their positive impact on information diffusion and technology adoption.

2.2.2 Improved maize varieties adoption and diffusion in Tanzania

The study conducted by Lyimo *et al*. (2014) on the use of improved maize varieties in Tanzania reports maize as the important food crop in Tanzania, covering 45% of the cultivated area. The study found that drought, low prices of the produce, pests and diseases, and high input prices were the most important constraints for maize production and also high costs and poor availability of improved seeds and lack of knowledge were some of the reasons why farmers did not use improved seed. Lyimo *et al*. (2014) suggested research and development efforts to be directed to solve the farmers' major production constraints such as drought, lack of markets and low produce prices, and pests and diseases. Knowledge of how to obtain and grow improved varieties, including good husbandry practices, is critical in adopting improved varieties.

Amare *et al*. (2011) examined the driving forces behind farmers' decisions to adopt improved pigeon pea and maize and estimated the causal impact of technology adoption on household welfare using data obtained from a random cross-section sample of 613 small-scale farmers in Tanzania. Overall the analysis of the determinants of adoption identified inadequate local supply of seed, access to information, human capital, and access to private productive asset as key constraints for maize/pigeon pea technology adoption. The causal impact estimation from both the propensity score matching and switching regression suggests that maize/pigeon pea adoption has a positive and significant impact on income and consumption expenditure among sample households.

Mwangi *et al*. (2012) did a research on gender differentials in the adoption of improved maize production technologies in Mbeya Region of Tanzania. The results indicated that the adoption of improved maize seed and fertilizer is biased by gender, where female-headed households adopt the technologies less. The number of cattle, availability of extension services and years of education had a positive influence on the adoption of improved maize seed for male-headed households, while the use of organic fertilizer, household size, and radio ownership had a positive influence on the adoption of inorganic

fertilizer female-headed households. The number of cattle, years of education, available extension services, and area under maize did not affect the adoption of improved maize seed or fertilizer for female-headed households, mainly due to significantly less access of female heads to these resources or services. Mwangi *et al*. (2012) suggested that policy strategies should address, gender disparities in access to extension services, formal education and cattle ownership that exist because of socio-cultural and institutional factors limiting the adoption of technologies by female-headed households.

2.2.3 Participation of farmers in improved agricultural technologies

According to Liberio (2009) most of the times in developing countries poor farmers are not involved in the early stages of an agricultural innovation programmes development like seed production, sowing, spacing, application of fertilizer and pesticides. They are usually mobilized to implement agricultural innovation programmes that are decided at district, regional or national level. The need for involving people in agricultural innovation programmes is essential because; participation is the key to learning process in agricultural production programme, it also empowers farmers and supports the progress and sustainability of agricultural production programme, as well as promoting a sense of agricultural production programme ownership to the farmers and lastly participation promotes self-reliance to the farmers in agricultural production programme.

2.2.4 Empirical studies on farmers' adoption behavior

A number of empirical studies have been conducted by different people and institutions on the adoption of agricultural technologies around the world to see what are the determinants of agricultural technology adoption. Sex of the household head found to have influences on the adoption of improved agricultural technologies. Some adoption studies discovered that male headed households are more likely to adopt improved agricultural technologies than their counterparts' female headed households. For example,

a study by Fitsum (2003) reported the negative and significant relation between fertilizer use intensity and female-headed households.

There is an association between adoption decision and years of education of the farmers because it is believed that education increases the farmers' ability to obtain, and analyze information that helps him/her to make appropriate decisions. A study carried out by Teferi (2003) in Ethiopia indicated that education, affected the adoption of fertilizer use positively. However, a study conducted by Asnake *et al.* (2005) in Ethiopia showed that education had no significant effect on the adoption of improved chickpea varieties. On the side of income, most of the studies reviewed shows the effect of farm income on the household's adoption decision is significant. Some of them are like the study conducted by, Degnet *et al.* (2001) and Getahun (2004) reported a positive influence of household's farm income on adoption of improved technologies.

Also the amount of land held by farmers' has influence on farmers' adoption decision. For instance Asnake *et al.* (2005) conducted a study on the adoption of improved chickpea varieties and found that farm size was positively related to the adoption of improved chickpea varieties. Also Tesfaye and Alemu (2001) reported that farm size contributed positively to in farmers' adoption of improved wheat varieties. Similarly, Mulugeta (2000) and Taha (2007) reported a positive relationship of farm size and adoption of improved agricultural technology. In addition to farm experience is also another important variable that is related to the adoption decision as supported by Kidane (2001) and Melaku (2005) who observed that farming experience have positive and significant relation with farmers' adoption decision. However, Ebrahim (2006) found that the farming experience has a negative relationship with overall dairy adoption.

According to Tesfaye *et al*. (2001) there is a significant relationship between the variable access to extension services and farmers' adoption decision. In the same study it is reported that there is a significant relationship between the variable access to credit and adoption of improved agricultural technology. A study conducted by Gockowski and Ndoumbe (2004) on the adoption of intensive mono-crop horticulture in Cameroon indicated that cash requirements for intensive horticulture production combined with the failure of formal rural credit institutions significantly affected adoption especially by resource poor households. Also Kiptot *et al.* (2006) in their study of sharing seeds and knowledge farmer to farmer dissemination of agro forestry technologies in Kenya, confirm that informal social networks such as relatives, friends and groups are important avenues for spreading new technologies.

2.3Empirical Models

Wodjao (2007) argued that time use data have peculiar characteristics that require special consideration when using them in regression analysis. These characteristics may arise from the respondents' behavioral responses or the design of the time use survey, these unique characteristics may result in too many zeros reported for the various activities included in the time use surveys (Schwierz, 2003). The traditional approach to deal with data that have too many zeros, yielding a censored dependent variable, has been to use the standard Tobit model, originally formulated by Tobin in 1958. According to Espineira, (2006) Tobit model permits the incorporation of all observations, including those censored at zero without considering the source of the zeros. As this ignores the zero observations due to respondents' non-participation decisions, applying the Tobit model imposes the assumption that all the zeros arise from other factors alone such as economic and institutional factors of the smallholder farmers.

Heckman (1979) proposes a model that addresses the problem associated with the zero observations generated by non-participation decisions, arguing that an estimation on a selected sub sample result in sample selection bias. The model overcomes this problem by undertaking a two-step estimation procedure known as heckit. In this estimation, a full sample Probit estimation is followed by a censored estimation carried out on the selected sub sample. While the first estimates the probability of observing a positive outcome known as the selection equation, the second estimate the extent of participation conditional on observing positive values known as the conditional outcome equation. The model assumes that different sets of variables could be used in the two-step estimations. The heckman model differs from the Tobit model in two ways. First, the heckman recognizes the process to be a two-stage decision, and second it permits the use of different sets of explanatory variables in both stages of estimations. Consequently, the heckman can be viewed as a generalized version of the Tobit model (Wodjao, 2015).

Cragg (1971) modifies the Tobit model to overcome the restrictive assumption inherent in it, namely, he suggests the "double-hurdle" model to tackle the problem of too many zeros in the survey data by giving special treatment to the participation decision. The model assumes two hurdles to be overcome to observe positive values. Stated in terms of acquisition of durable goods, first, one has to desire a positive amount, and second, there have to be favorable circumstances to realize this positive expenditure. In general, the first-hurdle refers to the participation or ownership decision and the second to the extent of use. According to Wodge (2007) the Heckman and the double-hurdle models are similar in identifying the rules governing the discrete outcomes in that models recognize that these outcomes are determined by the selection and the level of use decisions. They also permit the possibility of estimating the first- and second-stage equations using different sets of explanatory variables. However, the heckman, as opposed to the double-

hurdle, assumes that there will be no zero observations in the second stage once the first-stage selection is passed. In contrast, the double-hurdle considers the possibility of zero realizations (outcomes) in the second-hurdle arising from the individuals' deliberate choices or random circumstances. It is from these differences that this study confidently employed heckman two-stage selection model for analyzing the factors that influence the adoption decision of improved maize varieties and factors that influence the extent (amount of land allocated to improved maize varieties) of adopting improved maize varieties in Eastern and Northern zone of Tanzania.

CHAPTER THREE

3.0 METHODOLOGY

3.1 Description of the Study

This study employed cross sectional data collected by Adoption Pathways Project, which was the follow up study of SIMLESA study and traced the same households that were targeted by with SIMLESA project. Sustainable Intensification of Maize and Legume System for Food Security in Eastern and Southern Africa (SIMLESA) it is a project developed by African and Australian stakeholders and managed by CIMMYT, It aims at increasing farm-level food security and productivity whereby in Tanzania the project was based in Northern and Eastern zones where data was collected in 2010 and intervention was made after that exercise in which farmers were trained on different ways of agricultural intensification practices including the use of improved maize varieties and intercropping maize and legumes, is after that intervention then the Adoption Pathway project followed up and collected the data on the same households by using household and individual survey questionnaire, gender, zone differences, age, land owned by a farmer, level of education, communication and transportation assets, savings and farmer's income are variables which were part of the Adoption Pathway questionnaire and were also used in this study.

3.2 Descriptive Statistics

The qualitative and quantitative data collected were analyzed using the Statistical Package for Social Science (SPSS) software. Data were analyzed by computing the mean, median and standard deviation for the quantitative variables and the cross tabulation for the qualitative variables to show the characteristics of adopters and non-adopters, lower and

higher adopters. For the objective one which was to identify the improved maize varieties grown in the study area frequencies and percentage were computed.

3.3 Empirical Models

3.3.1 Heckman model

The choice to be selected to participate in any program may not necessarily be random as a result selectivity bias may exist. In this scenario because the sample that was included in the study was based on the selection of the participants, there could be selection bias. Thus Heckman two stage model was used to control the possibility of selection bias problem. There were three underlying assumptions; Smallholder farmers were faced with only two choices and any choice an individual takes depends on his or her characteristics. Different sets of explanatory variables were used in the two-step estimation and there were no zero observation on the second stage of estimation once the first stage is passed. The adoption decision was formulated in two interrelated choices. First choice is related to the choice to use or not to use the improved maize varieties and if the choice is positive, then the second choice is how many acres out of the total will be allocated to improved maize varieties. The second choice came only when the first choice was positive. In the analysis, probit equation was specified for whether or not the farmer was using improved maize varieties (stage one: selection equation) and an ordinary least square (OLS) equation for determining the extent in terms of acreage allocation (stage two: outcome equation) as shown below.

3.3.1.1 Stage one-selection equation

Index Model

The decision to adopt a technology is associated with an assessment by the farmers of the costs and benefits associated with it. This can be presented by an Index model as an equation

$$Y_i^* = \beta X_i + \varepsilon_i \; ; \; \varepsilon_i \approx N(0, \delta^2) \quad \ldots\ldots (1)$$

Where Y is a latent variable reflecting the net benefits (not observable) from the technology. These are influenced by the explanatory variables represented by the column vector X, β_i is a vector of the estimated parameters and ε_i is a vector of the error term.

What is observed in practice is a smallholder farmer either adopted the technology (Yi=1) or did not adopt the technology (Yi=0). The relationship between the index model and observed decision is presented in the equation (2).

$$Y_i = \begin{pmatrix} 1 & \text{if } Y_i^* > 0 \\ 0 & \text{if } Y_i^* \leq 0 \end{pmatrix} \quad \ldots\ldots (2)$$

The conditional probability that smallholder farmer I adopt the technology is given in equation (3)

$$P(Y_i = 1|X_i) = P(Y_i^* > 0|X_i) = P(\beta X_i + \varepsilon_i > 0|X_i)$$

$$P(Y_i = 1|X_i) = P(\varepsilon_i > -\beta X_i|X_i) = P(\varepsilon_i \leq \beta X_i|X_i)$$

$$P(Y_i = 1|X_i) = \int_{-\infty}^{\beta X_i} \phi(\beta X_i) \partial X_i$$

$$P(Y_i = 1|X_i) = \Phi(\beta X_i) \quad \ldots\ldots (3)$$

Under the assumption of standard normal distribution of the error term equation (3) represents the Probit model whose parameters was estimated by maximum likelihood (ML) method.

Where

Y_i - Dependent variable equals 1 if the farmer adopted improved maize varieties and 0 otherwise.

ϕ - Standard normal density function.

Φ- Standard normal cumulative distribution function.

β - Vector of the estimated parameters.

X_i - Is the vector of explanatory variables which are

X_1- Gender variable (dummy), 1=male; 0=female

X_2- Zones (dummy), 1= Northern; 2= Eastern

X_3- Dummy variable for age (36-60 years)

X_4- Dummy variable for age (above 60 years)

X_5- Land owned by the farmer (acres)

X_6- Dummy variable for education (7-8 years)

X_7- Dummy variable for education (above 8 years)

X_8- Dummy variable for the farmer who had access to communication assets

X_9- Dummy variable for the farmer who had access to transportation assets

X_{10}-Dummy variable for the farmer who had access to savings

X_{11}- Farmers' income (Tanzanian shillings)

3.3.1.2 Stage two – outcome equation

Involves the estimation of an ordinary least square regression (OLS) of a sub sample of the farmers that actually use the improved maize varieties such as:

$$L_i = \beta_i X_i + \beta_\lambda \lambda + \mu_i \text{ If } Y_i^* > 0 \quad \text{.....(4)}$$

Where

L_i - Land (acreage) allocated for improved maize varieties

X_i - Vector of the explanatory variables (These are the same with selection equation)

β_i - Vector of the estimated coefficients

λ - Inverse Mills Ratio

β_λ - Coefficient of Inverse Mills Ratio

μ_i - Error term

3.4 Model specification

3.4.1 Selection equation

$$Y_i = \beta_0 + \alpha_1 X_1 + \alpha_2 X_2 + \alpha_3 X_3 + \alpha_4 X_4 + \beta_1 X_5 + \alpha_5 X_6 + \alpha_6 X_7 + \alpha_7 X_8 + \alpha_8 X_9 + \alpha_9 X_{10} + \beta_2 X_{11} + \varepsilon_i$$

3.4.2 Outcome equation

$$L_i = \beta_0 + \alpha_2 X_2 + \beta_1 X_5 + \alpha_5 X_6 + \alpha_6 X_7 + \alpha_8 X_9 + \beta_2 X_{11} + \beta_\lambda \lambda_i + \mu_i$$

Table 1: Expected signs for the coefficients

Variable	Coefficient	Expected sign
Gender	α_1	-ve/+ve
Zones	α_2	-ve/+ve
Dummy1 age	α_3	-ve/+ve
Dummy2 age	α_4	-ve/+ve
Land owned	β_1	+ve
Dummy1 education	α_5	+ve
Dummy2 education	α_6	+ve
Dummy communication assets	α_7	+ve
Dummy transportation assets	α_8	+ve
Dummy savings	α_9	+ve
Farmers' income	β_2	+ve

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Improved Maize Varieties Adopted by Smallholder Farmers

The study shows that the improved maize varieties which were adopted by smallholder farmers in Northern and Eastern zone were Situka M-1 (13.1%), Staha (15.1%), Kito-ST (0.2%), TMV-1 (6.4%), Kilima (2.4%), Lishe-K1(0.5%), PAN 67 (1.5%), Sc 627 (12%), DK 8031 (12%), H 513 (1.5%), H 515 (0.2%), Seedco (0.7%), SC 403 (0.7%), SC 513 (0.2%), DK 8053 (0.2%), Sc 512 (0.2%), ZAM (0.7%) and Improved variety (0.2%), which make a total of 67.8% of smallholder farmers who used improved maize varieties (Table 2) and 32.2% of smallholder farmers who used local maize varieties.

Table 2: Improved maize varieties adopted by smallholder farmers

Maize Varieties	Frequency	Percentage
Situka M-1	72	13.1
Staha	83	15.1
Kito-ST	1	0.2
TMV-1	35	6.4
Kilima	13	2.4
Lishe K1	3	0.5
PAN 67	8	1.5
SC 627	66	12
DK 8031	66	12
H 513	8	1.5
H 515	1	0.2
Seedco	4	0.7
Sc 403	4	0.7
Sc 513	1	0.2
DK 8053	1	0.2
Sc 512	1	0.2
ZAM	4	0.7
Improved	1	0.2
Total	**372**	**67.8**

4.2 Economic Characteristics of Adopters and Non-Adopters

Table 3 of descriptive statistics presents the difference in mean, median and standard deviation between adopters and non-adopters for the quantitative variables. Results show

that there is a difference in mean between the two groups which indicate that land owned by the smallholder farmer and their income was among the characteristics differentiating adopters from non-adopters, although statistically there is no difference between the two groups of adopters and non-adopters with or without land and with lower or higher income.

Table 3: Economic characteristics of adopters and non-adopters

	Adopters			Non Adopters			
Variables	**Mean**	**Median**	**Std. Deviation**	**Mean**	**Median**	**Std. Deviation**	**p-value**
Land (acres)	5.2418	3.5000	6.3911	7.2032	3.5000	3.053E1	0.508
Income (Tshs.)	1.04E6	3.00E5	2.32E6	4.54E5	1.50E5	7.45E5	0.767

4.3 Socioeconomic Characteristics of Adopters and Non-Adopters

Table 4 presented the socio-economic characteristics of adopters and non-adopters and the analysis shows that 72.7% of smallholder farmers in northern zone involved in the study adopted improved maize varieties and 63.3% of smallholder farmers in eastern zone involved in the study adopted improved maize varieties and there is evidence that the two zones are statistically different in adoption decision (p= 0.019), this implies that the majority of a smallholder farmers in the northern zone of Tanzania were in position of transforming their agriculture practice compared to farmers in the eastern zone. The findings a indicated that there is statistical evidence at (p=0.04) that male headed households adopted more improved maize varieties than female headed households, whereby 69.4% of male headed households used improved maize varieties and only 57.7% of female headed households adopted improved maize varieties. This indicates that most of male headed households in the Northern and Eastern zone of Tanzania were engaged in modern agriculture than female headed households. The findings also indicate that majority of improved maize varieties adopters aged between 36-60 years, although

statistically there is no difference in adoption decision between the age groups (p=0.436). This signifies that improved maize varieties adopters were dominated by middle aged people who actively enough to perform agricultural activities.

On the other hand, in Table 4 the findings indicated statistically (p=0.000) that the (84.8%) of smallholder farmers spend more than 8 years in school adopted improved maize varieties compared to those who spend less than 8 years and this implies that the majority of smallholder farmers were literate enough to use the improved seeds. Regarding asset ownership, the findings indicate that communication, land and transportation assets influence making the adoption decision towards improved maize varieties whereby 73.9 smallholder farmers with communication assets adopted improved maize varieties, 76.3% with transportation assets and land assets 67.9% of them used improved maize varieties and it is statistically significant at (p=0.007).

Table 4: Socioeconomic characteristics of adopters and non-adopters

	Adopters		Non Adopters		Total	Chi^2	
Variables	**Freq**	**%**	**Freq**	**%**	**Freq**	**df**	**p-value**
Zones							
Northern	189	72.7	71	27.3	260	1	0.019
Eastern	183	63.3	106	36.7	289	1	0.019
Sex							
Female	45	57.7	33	42.3	78	1	0.040
Male	327	69.4	144	30.6	471	1	0.040
Age group							
≤ 35 years	69	67.6	33	32.4	102	2	0.436
36-60 years	216	69.7	94	30.3	310	2	0.436
> 60 years	87	63.5	50	36.5	137	2	0.436
Education group							
0-6 years	103	56.3	80	43.7	183	2	0.000
7-8 years	240	72.3	92	27.7	332	2	0.000
> 8 years	28	84.8	5	15.2	33	2	0.000
Assets							
communication	257	73.9	91	26.1	348	1	0.000
Land	361	67.9	171	32.1	532	1	0.784
Transport	119	76.3	37	23.7	156	1	0.007

4.4 Institutional Characteristics of Adopters and Non-Adopters

Institutional characteristics of the smallholder farmers are presented in Table 5. The findings show that savings is among the characteristics that differentiate adopters from non-adopters that is smallholder farmers who have access to savings are more likely to adopt improved maize varieties was statistically evidenced at (p=0.000). Likewise, it is statistically evidenced that group membership in crop marketing groups and farm input supply groups are the factors that distinguished adopters from non-adopters. As well as group membership in crop/seed production, women association and youth association groups distinguished adopters and non-adopters though statistically there is no difference in adoption decision between the farmers belonging to these groups. Also Table 5 showed that access to credit to buy seeds, fertilizer, farm equipment and herbicides and pesticides distinguished the two groups in adoption decision making although statistically there is no difference in adoption decision making between smallholder farmers belongs to these groups.

Table 5: Institutional characteristics of adopters and non-adopters

	Adopters		Non Adopters		Total	Chi^2	
Variables	**Freq**	**%**	**Freq**	**%**	**Freq**	**df**	**p-value**
Savings	207	73.4	75	26.6	282	1	0.000
Institutions							
Crop marketing Group	9	100	0	0	9	1	0.037
Crop/seed production	10	76.9	3	23.1	13	1	0.474
Farm input supply	11	91.7	1	8.3	12	1	0.073
Women association	9	52.9	8	47.1	17	1	0.184
Youth association	2	50	2	50	4	1	0.446
Credit							
Buy seed	9	90	1	10	10	1	0.129
Buy fertilizer	2	100	0	0	2	1	0.328
Buy farm equipment	3	75	1	25	4	1	0.756
Buy herbicides	3	100	0	0	3	1	0.231

4.5 Economic Characteristics of Lower and Higher Adopter

The adoption rate or extent of adopting (area allocated for improved maize varieties) improved maize varieties is different from one smallholder farmer to another. Table 6 presents characteristics that differentiate the low adopters from higher adopters. The analysis shows that there is a difference in mean of adoption rate between lower and higher adopters this implying that between the two groups there is a difference in their rate of adoption. Also the mean differences in land and income variables indicate that land and income could be used to distinguish low adopters from higher adopters.

Table 6: Economic characteristics of lower and higher adopters

	1		2		3	
Variables	**Mean**	**Std. Deviation**	**Mean**	**Std. Deviation**	**Mean**	**Std. Deviation**
Adoption rate	47.3263	6.27604	67.6600	6.22023	95.0833	7.85861
Land	5.1743	6.22474	3.9205	2.70483	6.4015	8.30694
Income	1.1319E6	2.2106E6	1.2351E6	3.2906E6	7.7195E5	1.1901E6

4.6 Socio-Economic Characteristics of Lower and Higher Adopters

Table 7 presents the socioeconomic characteristics of lower and higher adopters. The analysis shows that 44.8% of smallholder farmers from eastern zone who were involved in this study were in the group of higher adopters while 20.1% of farmers from the northern zone who were involved in this study, they were in the group of higher adopters and is statistically evidenced at (p=0.000) that the majority of farmers from eastern zone had higher adoption rates than those from northern zone. With regard to the number of years spent in school by the farmers, the study shows that farmers who spend less than 8 years in school, the majority of them were in the group of lower adopters unlike those who spend more than 8 years in school, 35.75% of them, they are in the group of higher adopters although statistically there is no difference between education groups in adoption rate (p=0.144). Regarding assets ownership findings show that the majority of farmers

who were involved in this study and who had access to communication and transportation assets were belonged to the group of lower adopters and few of them, they were in the group of higher adopters and statistically there is different between the two groups.

Table 7: Socioeconomic characteristics of lower and higher adopters

Variables	1 count	%	2 Count	%	3 count	%	Total	chi^2 p-value
Sex								
female	18	40.0	13	28.9	14	31.1	45	0.948
Male	134	41.0	87	26.6	106	32.4	327	0.948
Zone								
northern	100	52.9	51	27.0	38	20.1	189	0.000
eastern	52	28.4	49	26.8	82	44.8	183	0.000
Age grp								
≤35	31	44.9	22	31.9	18	23.2	69	0.428
36-60	84	38.9	58	26.9	74	34.3	216	0.428
>60	37	42.5	20	23.0	30	34.5	87	0.428
Education								
0-6 years	52	50.5	22	21.4	29	28.2	103	0.144
7-8 years	91	37.9	68	28.3	81	33.8	240	0.144
>8 years	8	28.6	10	35.7	10	35.7	28	0.144
Asset 1								
No	53	46.1	35	30.4	27	23.5	115	0.053
Yes	99	38.5	65	25.3	93	36.2	257	0.053
Asset 2								
No	6	54.5	3	27.3	2	18.2	11	0.544
Yes	146	40.4	97	26.9	118	32.7	361	0.544
Asset 3								
No	92	36.4	78	30.8	83	32.8	253	0.014
Yes	60	50.4	22	18.5	37	31.1	119	0.014

4.7 Institutional Characteristics of Lower and Higher Adopters

A large portion of the respondents who adopted improved maize varieties and have memberships in crops marketing groups they have low adoption rates and statistically there is evidence that there is different between the two groups for the farmers who belongs to crop marketing groups. As depicted in the Table 8 where farmers who have memberships in crops/seeds production and farm input supply groups they are concentrated in high adoption rate group than in low adoption rate group and statistically there is a difference between the two groups of lower and higher adopters for the farmers who have group memberships in the crop/seed production and farm input supply group,

whereby 60.0% and 54.5% of the farmers who have membership in crop/seed production and farm input supply groups respectively are in high adoption rate and only 10% and 9.1% of them are in the low adoption rate group. This implies that the majority of farmers got information about improving maize varieties from their institutional groups.

Table 8: Institutional characteristics of lower and higher adopters

Variables	1 Count	%	2 count	%	3 count	%	Total	Chi^2 p-value
Savings								
No	67	40.6	50	30.3	48	29.1	165	0.330
Yes	85	41.1	50	24.2	72	34.8	207	0.330
Institution1 no								
	146	40.2	100	27.5	117	32.2	363	0.136
Yes	6	66.7	0	0	3	33.3	9	0.136
Institution2								
No	151	41.7	97	26.8	114	31.5	362	0.087
Yes	1	10.0	3	30.0	6	60.0	10	0.087
Institution3								
No	151	41.8	96	26.6	114	31.6	361	0.085
Yes	1	9.1	4	36.4	6	54.5	11	0.085
Institution4								
No	150	41.3	98	27.0	115	31.7	363	0.300
Yes	2	22.2	2	22.2	5	55.6	9	0.300
Institution5								
No	151	40.8	99	26.8	120	32.4	370	0.580
Yes	1	50.0	1	50.0	0	0	2	0.580
Loan-seeds								
No	150	41.3	95	26.2	118	32.5	363	0.143
Yes	2	22.2	5	55.6	2	22.2	9	0.143
Loan-fertilizer								
No								
	151	40.8	99	26.8	120	32.4	370	0.580
Yes	1	50.0	1	50.0	0	0	2	0.580
Loan-farm equipment								
No	151	40.9	98	26.6	120	32.5	369	0.247
Yes	1	33.3	2	66.7	0	0	3	0.247
Loan-herbicides								
No	151	40.9	100	27.1	118	32.0	369	0.347
Yes	1	33.3	0	0	2	66.7	3	0.347

4.8 Heckman Maximum Likelihood Estimates for Factors that Influence the Adoption Decision and Extent of Adoption

The heckman two-step model was applied to analyze the socioeconomic and institutional factors that determine the adoption decision and extent of adopting improved maize varieties and the results indicated that the model was appropriately specified with an overall chi-square of 50.47 that was significant at 1% level of significance (p>chi2=0.0000) Table 9. The inverse mills ratio was also seen to be positive and insignificant implying that the two equations were independent.

Table 9: Heckman sample selection model results of determinants of adoption decision and extent

Variables	Coefficient	P>/Z/
Step 1: Maximum likelihood estimates for factors that influence adoption decision		
Gender (male=1, female=0)	0.0612103	0.288
Zones (northern=1, eastern=2)	-0.0588337	0.470
Dummy2-age (36-60 years)	0.0193612	0.712
Dummy3-age (above 60 years)	0.0618247	0.343
Land (acres)	-0.0009167	0.406
Dummy2 education (7-8 years)	0.1300534	0.011**
Dummy3 education (above 8 years)	0.2400154	0.007***
Access to communication assets (yes=1, no=0)	0.1056936	0.017**
Access to transportation assets (yes=1, no=0)	0.0956449	0.034**
Savings (yes=1, no=0)	0.0647805	0.102*
Income (Tshs.)	2.03e-08	0.081*
Wald chi^2 (15)	50.47	
Prob>chi^2		0.0000
N	548	
Step 2: OLS estimate of factors that influence the extent of adoption		
Dummy2 education (7-8 years)	-0.2710631	0.368
Dummy3 education (above 60 years)	-0.024585	0.965
Zones (northern=1, eastern=2)	1.061866	0.005***
Land (acres)	-0.0005969	0.956
Income (Tshs.)	6.51e-08	0.101*
Access to transportation assets (yes=1, no=0)	0.1273259	0645

*** Significant at 1%, ** at 5% and * at 10%.

Table 9 shows that the decision to adopt improved maize varieties significantly increases with increase in income of the smallholder farmer implying that those with higher incomes are more likely to adopt the improved maize varieties than those with lower incomes and this is due to the fact that money is used in exchange with the seeds and it is evidenced at (p=0.081).

Access to communication and transportation assets was the socio-economic characteristics that were found to be statistically significant and positively influencing adoption decision at (p=0.017) and (p=0.0034) respectively. This implies that the smallholder farmers with communication assets like phones are more likely to adopt improved maize varieties because they have access of getting more information on the pros and cons of the improved maize varieties than others and the same case applies to the smallholder farmers with transportation assets that they are more likely to adopt improved maize varieties than those without the transportation assets because the adoption of the improved technologies comes together with the expectation of increase in agricultural output so it is easier and less costing for the farmer with the transportation assets to take the surplus to the market than the one without the transportation assets.

On the other side smallholder farmer's savings was also influencing the adoption of improved maize varieties at a significance level of (p=0.102), this could also be used to explain the higher probability of smallholder farmers to use the improved maize varieties. Due to the higher savings, farmers can easily access to agricultural inputs, including the improved maize varieties. The influence of education for the farmer who spent between seven to eight years in school at 5% level of significance (p=0.011) and those who spent more than eight years in school at 1% level of significance (p=0.007) on the adoption of the improved maize varieties has been seen positive at and this implying that the farmers'

educational background is potential factor in determining the readiness to accept and properly use of innovation and it has role to play when the technology is more complex.

After analyzing the adoption decision of improved maize varieties, the second step analyses the extent (amount of land allocated to improved maize varieties) of adopting improved maize varieties. The Mills Ratio as it brings consistency in the estimation of the remaining coefficients of the equation, it was estimated from the first equation and it was added to the second equation as an independent variable so as to capture the selection bias effect. The results show that income had a positive effect on the extent of adoption of improved maize varieties at 10% level of significance (p=0.101). This implies that farmers with higher incomes spend more money for purchasing agricultural inputs such as seeds and land than those with lower income. Also the zone variable as a source of variation was statistically significant at the 1% level of significance (p=0.005) influencing the extent of adopting improved maize varieties as shown in Table 9, the percentage of farmers in eastern zone are in the group of higher adopters than a counterpart in northern zone this is due to the difference in the two agro ecological zones.

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATION

5.1 Conclusion

The main objective of this study was to determine the factors influencing the adoption decision and extent of adopting improved maize varieties in Northern and Eastern zone of Tanzania. Specific objectives were the determination of the factors influencing the adoption decision and extent of adopting improved maize varieties and heckman two-step sample selection model was employed. The identification of improved maize varieties adopted in the two zones was done by applying descriptive statistics using SPSS.

From the analysis of descriptive statistics the findings suggested that the improved maize varieties which were grown by the smallholder farmers who were involved in this study that about eighteen varieties were adopted in the study area which were Situka M-1, Staha, Kito-ST, TMV-1, Kilima, Lishe K1, PAN 67, SC 627, Improved varieties, DK 8031, H513, H 515, Seedco, Sc 403, SC 513, DK 8053, SC 512 and ZAM. On the other side, the first objective which was to determine the factors that influence the adoption of improved maize varieties. The results show that for the farmers who were involved in this study in eastern and northern zone of Tanzania the farmers who spend more than seven to eight years in school they had higher probability of adopting improved maize varieties at 5% level of significance ($p=0.011$) and also the farmers who spent more than eight years in school they had higher probability of adopting improved maize varieties at 1% level of significance ($p=0.007$) compared to the illiterate ones.Also the study suggested that farmers' decision to adopt improved maize varieties could be higher if the farmers' income and savings would increase as they have positive influence in adoption decision at 10% level of significance. Furthermore the access to communication and transportation

assets was found to influence the farmers' decision to adopt improved maize varieties at 5% level of significance. Likewise on the second objective which was to determine the factors that influence the extent of adopting improved maize varieties and from the result it was found that farmers' income which was significant at 10% level of significance and zone variable as the source of variation which was significant at 1% level of significance was having positive effect on the amount of land allocated to improved maize varieties.

5.2 Recommendations

Based on the findings of the study the following recommendations are suggested for the improvement of the livelihood of the smallholder maize producers in eastern and northern zone of Tanzania. The study recommends that farming technologies including the agricultural inputs produced should be affordable to farmers based on farmers' scarce resources, so as to enhance technology transferring with the available extension and research supports and are sustainable over the long term. And also government should come up with policies aimed at subsidizing the cost of farm inputs such as improved seeds, fertilizer and pesticides so as to lower the cost of production.

Government should make sure rural transportation and infrastructures are improved to make them passable in all seasons in order to make many producing areas accessible to input and output market and contribute to timely input delivery. Strengthening the farmers' knowledge on the modern agricultural production by proper linking the extension services with farmers especially those smallholder maize producers by involving them in experimentation of innovations such as dissemination of those innovations to their fellow farmers which will motivate them to adopt the new agricultural technologies.

Establishment of rural financial institutions to address farmers' credit needs onloan terms with low interest rate so as to capture farmers with low income to purchase the improved

agricultural inputs. Farmers should be encouraged to form an association of maize producers which will help them to find market for their products at profitable rate. Furthermore, this research did not focus on the assessment of the impact of adoption of improved maize varieties on the income of smallholder farmers therefore; further research on this subject should be done to explore issues that were not captured by this study.

REFERENCES

Ajayi, O. C., Franzel, S., Kuntashula, E. and Kwesiga, F. (2003). Adoption of improved fallow technology for soil fertility Management in Zambia: Empirical studies and emerging issues. *Agro forestry Systems* 59: 317 – 326.

Amare, M., Asfaw, S. and Shiferaw, B. (2012). *Welfare Impacts of Maize-Pigeonpea Intensification in Tanzania.*International Wheat and Improvement Center, Nairobi, Kenya. 53pp.

Armstrong, G. and Kolter, P. (2006). *Principle of Marketing*. Pearson Prentice Hall, New Jersey. 56pp.

CIMMYT (1993). *The Adoption of Agricultural Technologies: A Guide for Survey Design.* International Wheat and Improvement Center, Londres, Mexico. 98pp.

Cragg, J. (1971). Some statistical models for limited dependent variables with application to the demand for durable goods.*Econometrica* 39(5): 829 – 844.

Diiro, G. M. (2013). *Impact of Off-farm Income on Agricultural Technology Adoption Intensity and Productivity.* International Food Policy Research Institute, Uganda. 15pp.

Ebrahim, J. (2006). Adoption dairy innovations: its income and gender implications in Adami Tulu District.Dissertation for Award of MSc Degree at Haramaya University, Haramaya, Ethiopia, 113pp.

Espineira, R. M. (2006). A box-cox double-hurdle model of wildlife valuation: The citizen's perspective. *Ecological Economics* 58(1): 192 – 208.

Foster, A. D. and Rosenzweig, M. R. (2010). *Micro Economics of Technology Adoption.* Discussion Paper No. 984. Economic Growth Center Yale University. 43pp.

Gemeda, A., Aboma, G., Verkuijl, H. and Mwangi, W. (2001).*Farmers' Maize Seed Systems in Western Oromia, Ethiopia*.International Maize and Wheat Improvement Center, Mexico. 32pp.

Getahun, D., Mwangi, M., Verkuijil, H. and Wondimu, A. (2000). *An Assessment of the Adoption of Seed and Fertilizer Packages and the Role of Credit in Smallholder Maize Production in Sidama and North Omo Zones, Ethiopia.* Ethiopian Agricultural Research Organisation, Ethiopia. 24pp.

Heckman, J. (1979). Sample selection bias as a specification error. *Econometrica* 47(1): 153 – 161.

Ibrahim, M., Wojciech, J. F. and Kolavalli, S. (2012). *The Determinants of Farmer Adoption of Improved Peanut Varieties and Their Impact onFarm Income:* International Food Policy Research Institute, Ghana. 16pp.

IDA (2009).*Agriculture an Engine for Growth and Poverty Reduction.* World Bank, Washington DC.172pp.

Jayne, T. S., Chapoto, A. and Govereh, J. (2007). Grain marketing policy at the crossroads: Challenges for Eastern and Southern Africa. *Paper Presented at the Food and Agriculture Organization Workshop on Staple Food Trade and Market Policy Options for Promoting Development in Eastern and Southern Africa.* Rome, Italy. pp. 1 – 63.

Kaliba, A. R. M., Verkuijl, H. and Mwangi, W. (2000).Factors affecting adoption of improved maize seeds and use of inorganic fertilizer for maize production in the intermediate and Lowland Zones of Tanzania.*Journal of Agricultural and Applied Economics* 32(1): 35 – 47.

Kalinda, T., Tembo, G.andKuntashula, E. (2014). Adoption of improved maize seed varieties in Southern Zambia.*Asian Journal of Agricultural Sciences* 6(1): 33 – 39.

Kassie, M., Jaleta, M. and Mattei, A. (2014).Evaluating the Impact of Improved Maize Varieties on Food Security in Rural Tanzania: Evidence from Continuous Treatment Approach.International Maize and Wheat Improvement Center, Nairobi, Kenya. 4pp.

Katengeza, S. P., Mangisoni, J. H., Girma, T., Kassie, G. H., Sutcliffe, C., Langyintuo, A., Rovere, R. and Mwangi, W. (2012). Drivers of improved maize variety adoption in drought prone areas of Malawi. *Journal of Development and Agricultural Economics* 4(14): 393 – 403.

Kathange, J., Qaim, M., Kassie, M. and Shiferaw, B. (2013).*Big Constrains or Small Returns? Explaining Non-adoption of Hybrid Maize in Tanzania.* Georg-August-University of Göttingen, Germany. 28pp.

Kidane, G. (2001). Factors influencing the adoption of new wheat and maize varieties in tigray, Ethiopia: The Case of HawzienWoreda. Dissertation for Award of MSc Degree at Alemaya University, Ethiopia, 140pp.

Kiptot, E., Hebinck, P., Franzel, S. and P. Richards. (2006). Adopters, testers or pseudo adopters? Dynamics of the use of improved tree fallows by farmers in Western Kenya. *Agricultural Systems* 94: 509 –519.

Larsen, K., Kim, R. and Theus, F. (2009).*Agribusiness and Innovation Systems in Africa.Agriculture and Rural Development*.World Bank, Washington DC. 242pp.

Levy, S. (2005). *Starter Packs: A Strategy to Fight Hunger in Developing Countries*? Commonwealth Agriculture Bureau International, Wallingford, UK. 320pp.

Liberio, J. (2009). Improving Sunflower Crop Production.Sokoine University of Agriculture, Morogoro, Tanzania. Dissertation for Award of MSc Degree at Sokoine University of Agriculture, Morogoro, Tanzania, 91pp.

Lyimo, S., Mduruma, Z. and Groote, H. (2014).The use of improved maize varieties in Tanzania.*African journal of Agricultural Research* 9(7): 643 – 657.

Medlin, B. D. (2001). The Factors that may Influence a Faculty Member's Decision to Adopt Electronic Technologies in Instruction.Thesis for Award of PhD Degree at Virginia Polytechnic Institute and State University, 186pp.

Melaku, G. (2005). Adoption and profitability of Kenyan top bar hive beekeeping technology: A study in Ambasel Woreda of Ethiopia. Dissertation for Award of MSc Degree at Alemaya University, Ethiopia, 124pp.

Mugisha, J. and Diiro, G. (2010). Explaining the adoption of improved maize varieties and its effects on yields among smallholder maize farmers in Eastern and Central Uganda.*Middle-East Journal of Scientific Research* 5(1): 6 – 13.

Mulugeta, E., Belay K. and Legesse, D. (2001). Determinants of Adoption of Soil Conservation Measures in Central Highlands of Ethiopia. *Journal of Agriculture and Rural Development in the Tropics and Subtropics* 105(1): 49 – 62.

Mwangi, W., Verkuijl, H. and Bisanda, S. (2012). *Gender Differentials in Adoption of Improved Maize Production Technologies in Mbeya Region of Southern Highlands of Tanzania*. International Maize and Wheat Improvement Center, Ethiopia. 13pp.

Nassoro, H. N. (2006). Adoption and impact of treadle pump on farm productivity: A case of Mbarali District, Mbeya. Dissertation for Award of MSc Degree at SokoineUniverisy of Agriculture, Morogoro, Tanzania, 121pp.

RATES (2003). *Maize Market Assessment and Baseline Study for Tanzania.*Regional Agricultural Trade Expansion Support Program, Nairobi, Kenya. 2pp.

Ray, G. L. (2001). *Extension Communication and Management*. Naya Prokash Publisher, Calcutta. 162pp.

Rogers, E. M. (2003). Diffusion of innovations. *Journal of Educational Technology* 5(2): 14 – 23.

Schroeder, C., K'Oloo, O., Ranabhat, N. B., Jick, N. A., Parzies, H. K. and Gemenet, D. C. (2013). Potentials of hybrid maize varieties for smallholder famers in Kenya: A Review Based on SWOT Analysis. *African Journal of Food, Agriculture, Nutrition and Development* 13(2): 7562 – 7586.

Schwierz, C. (2003). The effects of taxes and socioeconomic variables on market work and home production in Norway in the years 1970 to 2000. Dissetation for Award of MSc Degree at University of Oslo, Norway, 33pp.

Seemann, K. (2003). Basic principles in holistic technology education.*Journal of Technology Education*14(2): 28 – 39.

SFIW (2012). *The Role of Agricultural Growth in Economic Growth, and Poverty and Hunger Reduction, Contribution of Agricultural Growth to of Poverty, Hunger and Malnutrition.*The State of Food Insecurity in the World, Washington DC. 8pp.

Takane, T. (2008). *African Rural Livelihoods under Stress: Economic Liberalization and Smallholder Farmers in Malawi.*Institute of Developing Economics, Japan.76pp.

Tesfaye, Z. and Shiferew, T. (2001).*Determinants of Adoption of Maize Technologies and Inorganic Fertilizer in Southern Ethiopia.* Research Report No. 39. Ethiopia Agricultural Research Organization. Ethiopia. 54pp.

Tobin, J. (1958). Estimation of relationships for limited dependent variables. *Econometrica* 46(1): 24 – 36.

Tura, M., Aredo, D., Tsegaye, W., Rovere, R., Tesfahun, G., Mwangi, W. and Mwabu, G. (2010). Adoption and continued use of improved maize seeds: Case study of Central Ethiopia. *African Journal of Agricultural Research* 5(17): 2350 – 2358.

Uaeieni, R. N., Arndt, C. and Masters, W. A. (2009). *Determinants of Agricultural Technology Adoption in Mozambique*. International Food Policy Institute, Maputo. Mozambique. 27pp.

URT (2010). *The Economic Survey 2009.* Ministry of Finance and Economic Affairs, Dar es Salaam, Tanzania. 222pp.

URT) (2015). *Compendium of Agricultural Statistics Classifications for Tanzania Mainland.* National Bureau of Statistics, Dar es Salaam Tanzania. 84pp.

WEMA (2010).*Mitigating the Impact of Drought in Tanzania:* WEMA Intervention, Dar es Salaam, Tanzania. 4pp.

Wodjao, T. B. (2007). *A Double-Hurdle Model of Computer and Internet Use in American Households*. Department of Economics, Western Michigan University. 14pp.