DETERMINANTS OF DERIVED DEMAND FOR IMPROVED MAIZE SEEDS IN
RURAL MAINLAND TANZANIA

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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.

2017
ABSTRACT

Despite various efforts by international non-governmental, local public and private institutions towards the research and development of improved crop technologies, the use of improved seeds in Tanzania is still low hence low agricultural productivity among smallholder farmers. The general objective for this study was to identify the most preferred improved maize seed varieties and the determinants for the demand for those improved seeds in rural mainland Tanzania so as to suggest measures which could be used to enhance their use in the country. Given that, maize seed industry in Tanzania is one of the major staple crop industries, the present study therefore specifically focused on identifying the most preferred improved maize seed varieties and also the determinants of improved maize seed demand in rural mainland Tanzania. The present study specified and estimated improved maize seed adoption and demand model simultaneously using the national panel survey data for 2012-13-crop season. The survey covered 3,265 households as representative at the national, urban/rural, and major agro-ecological zones but for the case of this study rural mainland households were the main focus. Therefore, 2,124 rural mainland households were the sample size for this study. Results show that KITO, PAN 6195, PAN 6549, SC 621, SC 627, SC 713, SITUKA 2, SITUKA-M1, STAHA, KILIMA, DK 8071 and KATUMANI, SITUKA-M1, TMV2 were the most preferred improved maize varieties across agro-ecological zones. Furthermore, the results suggest that distance to the market, farm size (adoption rate), and credit access and household size significantly influence farmer’s seed purchase decisions. Therefore, joint estimation of technology adoption and seed demand provides holistic methodology to identification of relevant factors that determine seed uptake at the farm level. It’s recommended that, private companies should consider investing more in agricultural extension services given a limited government extension services. Furthermore, it’s recommended that seed
companies should ensure seed availability at locations nearer to the farmers so as to improve adoption rate and subsequent seed demand.
DECLARATION

I, Aloyce Ndakidemi Patrick, 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 for degree award in any other Institution.

Aloyce Ndakidemi Patrick
(MSc Candidate)

The above declaration is confirmed by;

Dr. Damas Phillip
(Supervisor)
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ACKNOWLEDGEMENTS

I thank the Almighty God who facilitated me at every step in my studies. Let His name be honoured forever.

The completion of this study has been possible through contributions made by different individuals and institutions. I hereby therefore wish to acknowledge all the different persons and institutions that have made completions of this dissertation possible and a success.

First and foremost, I wish to express my profound gratitude and sincere appreciation to my supervisor Dr. Damas Philip for his guidance, constructive suggestions and professional comments on both my research proposal and this dissertation.

I heartily thank my parents Prof. Patrick Ndakidemi and Mrs. Esther Ndakidemi for their financial support. Also, I thank the African Economic Research Consortium (AERC) for financial support. Moreover, I thank CIMMYT for organizing a workshop and training on using R software.

It is difficult to mention here all the people who assisted me and their contribution in various ways toward the successful completion of this research. I would like to convey my sincere gratitude to my lovely brother (Goodluck Ndakidemi) and sisters (Theresia, Florah and Florentina). Special thanks go to my friends Tumuhufidze Mvena, Ange Pacifique, Moses Subert and Patience Rutatora.
DEDICATION

This research work is dedicated to my lovely parents Prof. Patrick Ndakidemi and Mrs. Esther Ndakidemi. To my beloved family which is source of my inspiration.
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<thead>
<tr>
<th>Abbreviation</th>
<th>Full Form</th>
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<tbody>
<tr>
<td>ACB</td>
<td>African Centre for Biodiversity</td>
</tr>
<tr>
<td>AERC</td>
<td>African Economic Research Consortium</td>
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<tr>
<td>ASA</td>
<td>Agricultural Seed Agency</td>
</tr>
<tr>
<td>ASARECA</td>
<td>Association for strengthening Agricultural Research in Eastern and Central Africa</td>
</tr>
<tr>
<td>ASDP</td>
<td>Agricultural Sector Development Program</td>
</tr>
<tr>
<td>DRD</td>
<td>Division of Research and Development</td>
</tr>
<tr>
<td>FAO</td>
<td>Food and Agriculture Organization</td>
</tr>
<tr>
<td>KIT</td>
<td>Royal Tropical Institute</td>
</tr>
<tr>
<td>MAFC</td>
<td>Ministry of Agriculture Food Security and Cooperatives</td>
</tr>
<tr>
<td>NAP</td>
<td>National Agricultural Policy</td>
</tr>
<tr>
<td>NBS</td>
<td>National Bureau of Statistics</td>
</tr>
<tr>
<td>NMRP</td>
<td>National Maize Research Program</td>
</tr>
<tr>
<td>OLS</td>
<td>Ordinary Least Squares</td>
</tr>
<tr>
<td>SSA</td>
<td>Sub-Saharan Africa</td>
</tr>
<tr>
<td>TASTA</td>
<td>Tanzania Seed Trade Association</td>
</tr>
<tr>
<td>TOSCI</td>
<td>Tanzania Official Seed Certification Institute</td>
</tr>
<tr>
<td>URT</td>
<td>United Republic of Tanzania</td>
</tr>
<tr>
<td>USDA</td>
<td>United States Department of Agriculture</td>
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</table>
CHAPTER ONE

1.0 INTRODUCTION

1.1 Background Information

Tanzania like other developing countries has over the years embraced the green revolution philosophy as a strategy to combat food insecurity and poverty at large. One of the strategies adopted by the national research and development policy framework to achieve the revolution, is promotion of the adoption of productivity enhancing technologies. Development and use of improved seed varieties is technological force behind the successful green revolution and reduction in rural poverty (Tahirou et al., 2009). As one of the major staple crop industries, maize industry in Tanzania has been target for research and development both by the government and non-governmental organizations (Limbu, 1999). Although maize research in Tanzania started in 1940’s, it was only in 1974 when the National Maize Research Program (NMRP) as a means to coordinate maize research started (ASARECA/KIT, 2014).

The NMRP was vested with the responsibilities of coordinating all phases of maize research from development of maize varieties and on station maize management research to verification in farmers’ fields (Nkonya et al., 1998). The NMRP releases varieties based on technology characteristics such as high yielding, resistant to pest and diseases, tolerant to drought, palatability, seed availability and relatively cheap. Staha, Staha- St, Kilima, Kilima-St, Katumani, TMV-1, ICW and UCA are an example of most preferred open pollinated varieties by smallholders that were released by the NMRP. Other released varieties were Tuxpeño of 1976, hybrids H6302 and H614, which were respectively released in 1977 and 1978, Kito of 1983 and TMV1 and TMV2 of 1987 (Nkonya et al., 1998).
For varietal recommendation, the NMRP divided the country into three agro-ecological zones. The highland zone with elevation above 1500 m above sea level, intermediate or mid-altitudes zone elevated between 900-1500 m above sea level and the lowland zone situated between 0-900 m above sea level (Kaliba et al., 2000). Tuxpeño and TMV1 were recommended for the lowland areas whereas hybrids H6302 and H614 were recommended for the highland zone. Kilima and TMV1 were recommended for the mid-altitude zones while the TMV2 was recommended for the high-altitude zones with high potential maize producing areas (Nkonya et al., 1998).

As in most African countries, maize variety development in Tanzania was initiated by the public sector, which dominated the first decades (Lymo et al., 2014). However, since trade liberalization, there has been a large increase in maize varieties released, and the emphasis has shifted from the public to the private sector. Therefore, the birth and expansion of private sector was vitally important. This is in line with assertion by Kalinda et al. (2014) that private sector roles in seed systems have increasingly been important in the recent years. In Tanzania for example, a number of private companies have since invested in seed breeding, production and marketing. These include Seed Co., Pannar, Suba Agro, Kibo Seed Co. ltd, Pioneer, and Monsanto. According to Minot (2008) both public and private sector have role in developing seed sector in Sub Saharan Africa. In Tanzania therefore seed industry is a public and private partnership sector. The government however remains in full control of seed certification and phytosanitary issues through Tanzania Official Seed Certification Institute (TOSCI).

Seed is a key determinant of agricultural productivity as it determines both the quantity and quality of the output (Kaguongo et al., 2014). Minten and Barret (2008) as cited by Bedasa (2013) argue that adopting a new agricultural technology such as improved seed is
central to agricultural growth and poverty reduction through their effect of increasing agricultural productivity hence food self-sufficiency. However, improving agricultural productivity and production in African smallholder agriculture is widely recognized as a critical outcome in the pathway to growth and poverty alleviation. Moreover, rising agricultural productivity improves competitive position both in rural and urban markets (Kalinda et al., 2014).

Most Eastern and Central African countries that remain food insecure are characterized by low agricultural productivity despite the availability of new and improved technologies (Kaguongo et al., 2014). A key ingredient to increased agricultural productivity and production is farmers’ access to inputs particularly quality seed of superior varieties (ASARECA/KIT, 2014). The importance of enhancing smallholder farmers’ access to quality seed and the role this can play in raising productivity of Tanzania agriculture is highlighted in the country’s various policy and strategy documents such as the National Agricultural Policy (NAP), the Agricultural Sector Development Programme (ASDP) and the Kilimo Kwanza national declaration of 2009.

However, ACB (2015) highlighted that low adoption rate of improved or certified seed in SSA particularly Tanzania is one of the major reasons for low rates of agricultural productivity. The low productivity has among other things led to low incomes among smallholder farmers in the country.

1.2 Problem Statement and Justification

Seed is among the most critical inputs in agricultural production (Wekundah, 2012). According to Tahirou et al. (2009) seeds are first and foremost the sources of most food and therefore have the greatest socioeconomic benefit to human welfare.
The use of good quality seeds of adapted and improved varieties is the most cost-effective way to achieving advances in crop production and productivity. Tripp (1998) presumes that seeds represent a key technology component for the improvement of agricultural productivity. Moreover Wekundah (2012) highlights that good quality seed has significant potential of increasing on-farm productivity and food security.

Success of any crop improvement program depends on availability and effective use of improved and quality seeds. Hence, a functioning seed system can boost productivity through increased adoption of improved seeds. Despite efforts by international non-governmental, local public and private institutions towards the research and development of improved crop technologies, many farmers are still not using improved seeds hence experiencing low productivity (Munyua et al., 2010). This might be a result of poor understanding of factors influencing seed demand in the seed system. Ogola et al. (2012) asserts that an understanding of the seed demand system leads to proper targeting of production, marketing and an increase in output. Therefore, one of the prerequisites for developing a robust seed system is a clear understanding of the factors influencing demand of improved seeds by smallholder farmers.

Lutaladio et al. (2009) however stated that many developing countries lack efficient systems for regular multiplication and distribution of quality seeds and deployment of new improved varieties. As a result, studies by Crissman et al. (1993); Louwaars et al. (2012) and Wekundah, (2012) estimated that, about 80% of seed needs by smallholder farmers in Africa is supplied by the informal seed system where seed exchange and use of seed saved from previous season are the common practices. Moreover, Kaguongo et al. (2014) identified widespread and timely availability of improved varieties and quality seed as a key challenge in seed system and he therefore suggests improvement of the seed system
by providing a better atmosphere for the small and medium-sized as well as large commercial seed entrepreneurs to attract more investment and thrive.

In Tanzania, improved seeds production and distribution systems remain poorly developed, with limited investments in the sub-sector. For example, Munyua et al. (2010) argues that farmer’s unmet need of improved seed is met by recycling grain as seed. Massive efforts in the past have been devoted to getting an understanding of what determines the adoption of improved seed but fundamentally little attention has been paid to the determinants of seed demand. Langtuyo et al. (2006) argues that, if improved seed technology is to make a mark on the poverty of farm households in developing countries, then researchers must not only concentrate on identifying determinants of adoption but also factors limiting seed demand at the farm level. While there is a noticeable growth of improved maize sector, little attention has been paid on the understanding of farm-level seed demand in Tanzania.

Although both price and non-price factors are important in demand analysis, the present study focused on the non-price factors due to their policy relevance and parity of information on their effect on improved seed adoption in the country. This is clearly indicated by the fact that interventions which target price as a key determinant of improved seed adoption for example input subsidies have not enabled the country to increase significantly the number of farmers using improved seed. Therefore, it was deemed reasonable to explore non-price determinants of improved seed demand in order to inform policy makers on the most appropriate measures to improve the use of improved seed in the country. Therefore, information from estimated farm level seed demand and its determinants will allow investors in agro-input and maize seed production companies to
forecast demand, market the seeds in appropriate markets, and timely distribute desired seeds varieties at the farm level.

1.3 Objectives of the Study

1.3.1 Overall Objective
To identify the most preferred improved maize seed varieties and the determinants for the demand for those improved seeds in rural mainland Tanzania so as to suggest measures which could be used to enhance their use in the country.

1.3.2 Specific Objectives
i. To identify the improved maize seed varieties that are mostly preferred by small holder farmers.

ii. To identify the factors determining farm level improved maize seed demand.

1.4 Research Hypothesis
i. Access to extension services, literacy level of head of household, gender, age and credit access do not influence significantly the smallholder farmers’ demand for improved maize seeds.

1.5 Research Question
i. What are the most preferred improved maize seeds among smallholder farmers with different socioeconomic conditions residing in different agro-ecological zones?

1.6 Organisation of the Dissertation
This dissertation is organized into five chapters. The first chapter provides the background
to the study, the problem statement and its justification, research objectives and tested hypothesis and a research question. The second chapter reviews the theoretical and empirical literature. The third chapter provides the methodology used to analyse data. The fourth chapter provides results and discussion while the last chapter provides conclusion and recommendations drawn from the study findings.
2.0 LITERATURE REVIEW

2.1 Derived Demand

According to Beattie et al. (2009), input demand is a derived demand as it depends upon the product price and is thus derived indirectly from the demand for the product. For the grain production and technology, the improved seed is the derived input. Inputs demand function is always referred to as derived demand because it is determined to a large extent by the final demand of the product being produced.

Debertin (2012) asserts that demand for input to the agricultural production is a derived demand. It implies that, an input demand function is derived from the demand by the consumers of the output from the farm. Moreover, input demand is basically dependent on (1) the price of the output being produced, (2) the input price, (3) the prices of other inputs that substitute for or complement the input, and (4) the parameters of the production function that describes the technical transformation of the input into output (ibid.).

2.2 Factors Affecting Demand for a Good

There are both price and non-price factors that affect demand for a good. When price changes, there is a movement along the demand curve whereas changes in non-price factors such as income, taste and preferences, weather causes a shift in the demand curve. Price and non-price factors are important in demand analysis, the present study however, has focused on the non-price factors due to their policy relevance and parity of information on their effect on improved seed adoption in the country. This is clearly indicated by the fact that interventions which target price as a key determinant of improved seed adoption for example input subsidies have not enabled the country to
increase significantly the number of farmers using improved seed. Therefore, it was deemed reasonable to explore non-price determinants of improved seed demand in order to inform policy makers on the most appropriate measures to improve the use of improved seed in the country.

Figure 1: Change in quantity demanded due to price change

Source: http://www.economicshelp.org/microessays/equilibrium/demand/
Smallholder farmers are able to save and use seed from a previous harvest. When there is a necessity or an incentive to acquire fresh seeds is when the possibility for a formal seed provision system emerge (Tripp, 2006). Minot et al. (2007) presume that, Sub Saharan Africa (SSA) farmers derive their seed demand generally from off-farm sources for only three reasons: seed replacement, variety change, and emergency response. Moreover, agro-climatic conditions, natural and man-made disasters, degree of market development, farmers’ preferences about channels and timing of seed distributions, and farmers’ level of awareness about improved seeds are the factors determining seed demand in Sub Saharan Africa (ibid.).

Takeshima et al. (2010) argue that since farmers derive their seed demand from different reasons then one can generally explain the differences among farmers in their decisions as to when they demand seed, which varieties they prefer, and in what quantities. However,
Setimela et al. (2004) identified two factors that determine farmer’s demand for seed of modern varieties. Firstly, is the farmers’ interest in the new variety and the second factor is whether the seed system is appropriate for the crop and varieties and practical for the farmers.

2.4 Types of Seed Demand

Seed demand can be categorized into three types which are; emergency seed, poverty and seed quality (Tripp, 2006).

<table>
<thead>
<tr>
<th>Origin of demand</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Emergence</strong></td>
<td>Seed shortage because of drought, flood or civil disorder</td>
</tr>
<tr>
<td><strong>Poverty</strong></td>
<td>Seed shortage because of poor harvest and/or necessity to sell or consume</td>
</tr>
<tr>
<td><strong>Seed quality</strong></td>
<td>hybrid seed use; convenience seed provision and quality of formal-sector</td>
</tr>
<tr>
<td></td>
<td>seed; crops are not usually stored or harvested for sell; market standards for</td>
</tr>
<tr>
<td></td>
<td>grain require quality seed</td>
</tr>
<tr>
<td><strong>Variety change</strong></td>
<td>seed as source of new variety</td>
</tr>
</tbody>
</table>

**Table 1: Types of seed demand**

Source: Tripp (2006)
2.5 Quality of Seed

Seed quality can be defined as a “standard of excellence in certain characters or attributes that will determine the performance of the seed when sown or stored” (Hampton, 2002). Seed quality is therefore concerned to the behaviour of seed as an end-product of plant growth, as a biological entity in itself, and as a determinant of future plant growth (Amarjit, 1995).

Seed is one of the most important sources of innovation. According to Hampton (2002) good quality seed is distinguished based on genetic and/or physical purity, health, and high germination rate. The size and weight of seeds are important for plant vigour and yield upon planting. The germination rate is another important attribute of seed quality. However, for field practice, the seed emergence rate is more important (Alm et al., 1993). Pieper (1952), as cited by Kaoru Ehara (1971), showed that minor deterioration in the seed germination rate can affect the germination vigour and the rate of emergence. The responses of all other inputs depend to a large extent upon the quality of seeds used (Jaffee et al., 1992). Some of the direct benefits of quality seeds to farmers include enhanced productivity, higher harvest index. This is the weight of a harvested product as a percentage of the total plant weight of a crop. Quality seed also reduced risks from pests and other biotic factors; it also provides higher profits (Funakoshi, 2008).

2.6 Seed Availability and Affordability

Improved seed production for farmers involves producing basic seed. This is the progeny of breeder’s seed, usually produced under the supervision of a breeder or his/her designated agency, and under the control of a seed quality control agency. From basic seeds comes certified seed, which the progeny of basic seed, produced on contract by selected seed growers under the supervision of the seed enterprise, public or private.
Certified seed can be used to produce further generations of certified seeds or it can be planted by farmers for grain production.

Improved seeds are open pollinated or hybrid. Open pollinated seeds are produced from natural random pollination. In most cases smallholder farmers save the best of these seeds for use from year to year. Hybrid seeds result from cross-breeding two parent plants that have desirable traits, and the resulting plants realize their potential in the first season, but lose its effectiveness in subsequent generations a situation that forces farmers to buy new seeds each year. Low availability of improved maize seeds has been a major constraint that limits smallholder farmers’ maize production (Bett et al., 2006). Low availability of improved seeds to farmers may be occasioned by local impediments such as poorly developed and inefficient distribution networks. Long distances between distribution outlets, end users, and poor transportation facilities. All these make it costly for farmers to obtain the desired seeds.

Limited availability of good quality seed is a key constraint repeatedly identified by farmers in rural areas in many countries (ASFG, 2011). A number of initiatives that have addressed this problem through sustainable local seed production have resulted in improved access of appropriate, affordable and timely seeds (ibid.). Farmers everywhere need easy access to high-quality seed of well-adapted, productive crops to allow them to produce good quality crops. Ongoing efforts to encourage the private sector to play a role in ensuring efficient production and distribution of seed in developing countries has led to increased yield (FAO, 2009).

2.7 Seed Systems in Sub Saharan Africa

Seed system is totality of the physical, organizational and institutional components that determine seed supply and use in quantitative and qualitative terms (Van Amstel et al.,...
1996). An efficient seed system involves a complex combination of public sector support and private sector commercial activities. The public sector plays a bigger role in plant breeding and some aspects of regulations; the private sector makes contributions in the area of seed multiplication, processing, and distribution (Minot, 2008). However, Seed systems can vary by type of targeted farmer (small-scale or commercial), crop production systems (self-pollinating, cross-pollinating, or vegetative propagated crops), and geographic location (ACB, 2015).

There are two distinctive and interacting types of seed delivery systems namely formal and informal. However, Wekundah (2012) argues that there are only three groups of seed supply systems found in Africa namely informal seed supply system, integrated seed supply system and the formal seed supply system. Furthermore ACB (2015) presumes that, seed systems in SSA are generally classified as being formal, semi-formal and informal. This is in line with the proposition by Fransis (2014) that, seed systems are generally categorized into formal, informal and semi-formal and they co-exist in Eastern and Central Africa. However, despite differences in these seed systems, the degree of integration between them in SSA is significant (Sperling et al., 2013).

2.7.1 Maize seed system in Tanzania

Maize seed system in Tanzania is categorized into formal and informal systems. Formal system consists of the maize seed production and field multiplication, processing and distribution. The government through Tanzania Official Seed Certification Institute (TOSCI) supervises formal seed system. Under informal system, farmers select the best healthy grains after harvest; store the grains ready for next season. Informal seed system supplies about 80% of seed needs of smallholder farmers in most African countries.
including Tanzania hence proving to be the key seed source for their staple crops (Crissman et al., 1993; Louwaars and De Boef, 2012; Wekundah, 2012).

2.7.1 Formal seed system

Formal seed system generally consists of public sector research institutions, public and private sector agencies producing and marketing seed and organizations responsible for seed certification and quality control (Setimela et al., 2004). The formal seed system can be characterized as being deliberately constructed with formal regulation to maintain varietal identity and purity, and physical, physiological and sanitary quality (ACB, 2015). Furthermore, Setimela et al. (2004) argues that, there are two models of seed systems that operate within the formal seed system. These models include state or parastatal model and private sector model.

Under state model, researchers provide breeder seed to a parastatal or state agency to multiply on state farms or contract seed growers. Hence all activities that include seed cleaning, processing and marketing are performed by state agencies. Under private model, researchers provide breeder seed to be multiplied into foundation and commercial seed.

Therefore, private companies and farmer cooperatives do seed processing and marketing. Formal seed sector therefore, provides about 10-20% of seed requirements by most of African governments (Wekundah, 2012).

2.7.1.2 Formal seed system environment in Tanzania

The formal seed system in Tanzania is monitored and supervised by the government through National seed committee that is responsible for the formulation of the National Seed Policy and coordination of the Seed industry. On the other hand, the Tanzania
Official Seed Certification Institute (TOSCI) also plays major roles in monitoring and supervising the seed industry. TOSCI’s main function is to control seed certification and all phytosanitary issues in the country. However, in 2006 the government launched Agricultural Seed Agency (ASA) whose task is to produce, process and market both basic and certified seeds.

Since trade liberalization in Tanzania private sector has also been engaging in the formal seed system. Hence a growing number of private companies such as Seed Co., Pannar, Suba Agro, Kibo Seed Co. ltd, Pioneer, and Monsanto have ventured into the seed industry in Tanzania.

2.7.1.3 Main actors of formal seed sector in Tanzania

The Tanzania formal seed sector has a variety of public and private sector actors. The public sector is strongly involved in primary chain functions such as genetic resource management (NPGRI), variety development through Ministry of Agriculture, Food Security and Cooperatives (MAFC) under Division of Research and Development (DRD), basic and certified seed production and distribution (ASA) and quality control (TOSCI). The private sector comprised of seed companies that are organised by Tanzania Seed Trade Association (TASTA), produces and markets certified and some basic seeds.

Agro dealers are involved in the retail of certified seeds from various seed companies. Moreover, the other actor includes the National seed committee that is responsible for the formulation of the National Seed Policy and coordination of the Seed industry.
Informal seed system

Informal seed system is unstructured and unregulated hence activities conducted are neither monitored nor supervised by any public or private institution (Etwire et al., 2013). Under this seed system the seeds are more easily accessible and cheaper but are of inconsistent quality. Informal seed system supplies about 80% of seed needs of smallholder farmers in most African countries hence proving to be the key seed source for their staple crops.

It constitutes channels such as saved seeds, seed exchanges among farmers and/or local grain/seed market (Crissman et al., 1993; Louwaars and De Boef, 2012; Wekundah, 2012).
### Table 2: Actors in formal and informal seed systems

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<tr>
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<th>Public</th>
<th>Private</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Formal</strong></td>
<td>Universities, seed parastatal, National Agricultural Research Institutes (NARIs), regulatory bodies</td>
<td>Small to Medium Enterprises (SMEs), seed companies, multinational &amp; national seed companies, agro-input companies, agro dealers, financial input providers, credit and insurance providers, seed trade associations.</td>
</tr>
<tr>
<td><strong>Informal</strong></td>
<td>Farmers, traders, processors, producer organizations, local credit providers, NGOs, community based seed groups.</td>
<td></td>
</tr>
</tbody>
</table>

**Source:** Sperling *et al.* (2014)

#### 2.8 Empirical Review on Derived Demand

Arnade *et al.* (2008) estimated the derived demand for cattle feeding input using the generalized McFadden dual cost function. Their study focused on estimating derived demand relationships among four weight categories of feeder cattle entering the Texas feedlots.

The study results demonstrated positive cross-price elasticities among the three weight categories whereby the estimated elasticities were consistent with input substitution among weight categories.

Marsh (1991) estimated the derived demand elasticity for beef choice by using the marketing margins methods and econometric inverse demand model approach. Between the two approaches used, the marketing margins study approach was found to be more
restrictive than the other approach despite the fact that both approaches tend to overestimate the beef price flexibility and revenue changes.

Conway et al. (1987) estimated the demand for real cash balances in agricultural production. Trans log cost function was used to estimate the demand for real cash balance with its respective demand elasticities. The results showed that real cash balance is an important agricultural input and its demand is relatively inelastic with respect to changes in user cost of money and that the real cash balances are a substitute for machinery and capital.

Kavoi et al. (2009) estimated the derived demand for factor inputs in smallholder dairying in Kenya using duality theory and the restricted Translog cost function to estimate the demand with its respective elasticities. Results proved the presence of substitution between the six inputs that were examined based on their estimated elasticities.

With cross sectional data Binswanger (1974) estimated the elasticities of derived demand and elasticity of substitution in US agricultural sector using Translog cost function. Moreover, restricted generalized least squares were used to estimate the elasticities.

Langyintuo et al. (2006) estimated the farm level improved seed demand in Mozambique using the Tobit model and system of simultaneous equations. Demand model estimated suggested that adoption rate, household wealth, distance to market, and input support programs (or free seed distribution) significantly influence farmers’ seed purchase decisions.
2.9 Conceptual Framework

Based on consumer behaviour theory, the use of good technology by farmers is influenced by various factors including technology attributes, socio-economic factors, policy and institution factors. Farmer’s decision on using improved maize seeds is influenced by socio-economic factors such as age, education, sex, family size, farm size and crop yield. On the other hand, these factors also influence breeders and research centres in producing good seed that suits farmer’s demand. Furthermore, policy and institutional factors such as access to extension services, input support programs, research and development influence farmers to use improved maize seed and other technologies that improve farm productivity.

Figure 4: Conceptual framework

Source: Own conceptualization
CHAPTER THREE

3.0 RESEARCH METHODOLOGY

3.1 Description of the Study Area

This study focused on the mainland part of Tanzania that basically has seven different agro-ecological zones namely; Lake, Northern, Eastern, Western, Southern, Southern highlands and Central zones. The focus of this study is rural mainland Tanzania because majority of maize smallholder farmers in the country are located in the rural area especially the mainland part of the country.

Figure 5: Map of Tanzania showing agro-ecological zones

Source: USDA, 2003
3.2 Theoretical Framework

The model for this study borrows from literature considering the role of input attributes in production function (Ladd and Martin, 1976) and goods attribute in utility function (Lancaster, 1966; Ladd and Suvannunt, 1976) in placing the variety attribute choice within the decision-making framework of the agricultural household. Basically, this study is underpinned by the theory of non-separable agricultural household model. The theory suggests that farmer’s production and consumption decisions are inseparable. Therefore, static risk free agricultural household model (Strauss et al., 1986) that incorporates variety attributes and accounts for market imperfections in rural environment is used to derive reduced form variety demand equation (Edmeades, 2003). Production and consumption of improved maize seeds by rural semi-subsistence farmers in Tanzania are described in the model.

Let the household utility function $U$ be defined as:

$$U[X^C(G, a^c), V^o, W | \Omega_{hh}, \Omega_{lm}]$$ ................................................................. (1)

Where $X^C$ is $N$- dimensional vector of consumption attributes, $G$ is a $J$- dimensional vector of food products of each plant variety consumed, $a^c$ is a $J \times N$ matrix of input output coefficients where $a_{in}^c$ maps consumption of a unit variety $i$ to a unit of attribute $j$, $V^o$ is the consumption level of other goods, $W$ is the household leisure, $\Omega_{hh}$ is the household characteristics and $\Omega_{lm}$ is the local market characteristics. While the household can vary the type and amount of maize varieties, the input-output coefficients associated with different maize varieties are assumed to be exogenous to the decision process. That is variety specific intrinsic consumption attributes are fixed from the perspective of an individual household.
The agricultural household also engages in production. The variable inputs in production of food crops includes amount of land pre-allocated for maize production, labour, seeds and other inputs such as fertilizer. The variety mix (local versus improved) is dependent on farmer’s perceptions of the intrinsic attributes or characteristics of the varieties.

Let the production function be defined as:

\[ V[C, E^b(A, H^k), L, F|\Omega_t\Omega_n] = 0 \] \hspace{1cm} (2)

Where \( V \) is \( K \)-dimensional vector of crop products from each variety, \( E^b \) is an \( I \)-dimensional function defining the relationship between the \( K \)-dimensional vector \( A \) of production scales for each crop variety grown and the relative \( Q \) production attributes they yield, \( H^k \) is a \( K \times I \) matrix with fixed elements \( H_{ij} \) defining this mapping. \( L \) and \( N \) are household labour and fertilizer inputs. \( \Omega_t \) denotes exogenous farm characteristics and \( \Omega_n \) captures market-related characteristics that influence production decisions.

Household market participation is conditional on the market imperfections such as high transaction costs. The imperfect and asymmetric information, transport costs include the transaction costs that influence market participation rather than exogenous market prices (de Janvry et al., 1991; Sadoulet and de Janvry, 1995).

The household maximizes utility from consumption attributes, other goods and leisure by choosing the level of crop products consumed from each available variety, spending on other goods, and labour hours spent in maize production subject to income, time, land, production technology, seed, fertilizer, and non-negativity constraints:

\[
\max_{G,V,W,L} U[X^c(G, a^c), V^o, W| \Omega_{rt}\Omega_{lm}] \] \hspace{1cm} (3)

Subject to:
$V[C, E^b (A, H^k), L, F |\Omega_i \Omega_n] \leq 0 \ .................. \ .................. \ .................. \ .................. \ .................. \ (4)$

$(C - G)' P^m - P^o V^o + I \leq 0 \ .................. \ .................. \ .................. \ .................. \ .................. \ (5)$

$T - L - W = 0 \ .................. \ .................. \ .................. \ .................. \ .................. \ (6)$

$Q_i = 0 \ \forall \ i \in \tilde{Q} \ .................. \ .................. \ .................. \ .................. \ .................. \ (7)$

$\tilde{Q} \leq \sum_{i=1}^{n} Q_i \ .................. \ .................. \ .................. \ .................. \ .................. \ (8)$

$X_i \leq 0, C_i \leq 0, Q_i \leq 0 \ \forall \ i \in \tilde{Q} \ .................. \ .................. \ .................. \ .................. \ (9)$

Where $I$ is exogenous income, $T$ is the total household time available, $P^m$ is the vector of maize output prices; $P^o$ is the price of other goods, $\tilde{Q}$ is the set of crop varieties for which seed is available at the village level, $Q$ denotes total scale of maize production. Production technology in equation (4) establishes the maize production margins while the full income constraint in equation (5) represents budget limitations to the household. The total time available to production and home activities is captured by time constraint in equation (6). Constraint (7) captures the effect of the magnitude of available seed (local versus improved) in terms of crop varieties at the village level. The physical limitations of available land to household for crop production are captured by land constraint represent in equation (8).

Acknowledging the possibility of corner solutions, the following form reduced derived demand relationship for maize varieties arises from the Kuhn-Tucker formulation of the optimization problem:

$Q_i(\alpha^c, H^k, P^m, P^o, I, T, \tilde{Q}, \Omega |\Omega_{hh}, \Omega_{tm}, \Omega_i) \ \forall \ Q_i \geq 0 \ .................. \ .................. \ .................. \ ................. \ (10)$
Derived variety demand is defined as quantity of seed from a given variety grown by household. The non-separable agricultural household model implies that seed demand is functionally dependent on all exogenous variables in the problem including variety-specific consumption and production attributes, household characteristics, exogenous prices and income, production technology and market related variables.

3.3 Research Design

3.3.1 Source and type of data

Secondary data (panel data) from third round National Panel Survey for 2012-13 by National Bureau of Statistics (NBS) was used. The survey consisted of four questionnaires; a household questionnaire, agriculture questionnaire, livestock/fishery questionnaire, and a community questionnaire. Responses from the household questionnaire that comprised of thematic sections, the agriculture questionnaire that collected information at both the plot and crop level on inputs, production, and sales, and community level questionnaire that collected data on contextual variables especially information on physical and economic infrastructure and events in surveyed communities.

3.3.2 Sampling procedure and sample size

The survey covered 3 265 sample households as representative at the national level, urban or rural level, and major agro-ecological zones. Basically, the purposive sampling (non-probabilistic sampling) was employed in data collection.

The sample size is clustered in 409 numeration areas (2 124 households in rural areas and 1,141 urban areas) across Tanzania and Zanzibar. According to the NBS the sample allows analysis at four primary domains of inference, namely: Dar es Salaam, other urban areas on mainland Tanzania, rural mainland Tanzania, and Zanzibar.
3.4 Data Analysis

The data was analysed using R-software, Stata and Excel. In order to address each objective, the following analytical framework summarizes each objective with its corresponding hypothesis and model.

3.5 Analytical Framework

Table 3: Analytical framework

<table>
<thead>
<tr>
<th>Objective</th>
<th>Hypothesis/ Research question</th>
<th>Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>i. To identify the most preferred improved maize seed varieties in different agro ecological zones</td>
<td>What are the most preferred improved maize seed varieties among smallholder farms from different agro ecological zone?</td>
<td>Descriptive statistics</td>
</tr>
<tr>
<td>ii. To assess the factors determining farm level improved maize seed demand</td>
<td>Access to extension services, head of household education, gender, age and credit access do not influence the smallholder farmers’ derived demand for improved maize seed.</td>
<td>Sample selection model</td>
</tr>
</tbody>
</table>

3.6 Empirical Analysis

3.6.1 Objective one

Descriptive statistics especially the mean, frequencies and the percentages and cross tabulations was used to identify improved maize seed varieties that are mostly preferred by the smallholder farmers.

3.6.2 Objective two

Adoption studies indicate that farmers maximize utility by choosing different adoption intensities for each available crop variety given socio-economic circumstances and other resource and market constraints. Under perfect market condition, a farmer will therefore
adopt maize seed in a two-step process; decide to adopt or not to adopt; and then, decide on the quantity of seeds to plant or acreage of land to allocate to improved seeds.

Therefore, quantity of improved seeds and acreage under improved maize seeds can proxy each other. Under a joint decision assumption, the empirical model to estimate is the Tobit model (Staub, 2014) in which the dependent variable is proportion of land allocated to improved maize seeds for adopters and zero otherwise or quantity of improved seeds planted. For non-adopters, the value of quantity of improved seeds is zero.

However, for a two-stage decision process, an appropriate empirical model to estimate is a sample selection model, especially the heckit model (Heckman, 1979), also known as Tobit type II model in the terminology of Amemiya (1985). The key advantage of using sample selection model is that it controls for sample selection biases that could otherwise arise from existence of unobservable variables that determine both discrete and continuous choices pertaining improved seeds use (Vance and Buchheim, 2005).

In this case, the first stage is the selection equation which is the Probit Model (Bliss, 1934) and the second stage is the outcome equation involving OLS estimation for modelling the selected subset of observations where under this case is the demand equation represented by either the quantity of seeds planted or proportion of land allocated to improved seeds.

First stage – selection equation

\[ Y_i^* = \beta X_i + \epsilon_i ; \epsilon_i \approx N (0, \sigma^2) \]  

Where;

\( Y_i^* \) = A latent variable whose true value is unobservable

\( X_i \) = A vector of explanatory variables
\( \beta = \) Parameter to be estimated

\( \varepsilon_i = \) A normally distributed error term

What is observed in practice is a smallholder farmer either adopted the technology \( (Y_i = 1) \) or did not adopt the technology \( (Y_i = 0) \).

\[
Y_i = \begin{cases} 
1 & \text{if } Y_i^* > 0 \\
0 & \text{if } Y_i^* \leq 0
\end{cases}
\]  

(12)

The conditional probability that smallholder farmer I adopt the technology is given by;

\[
P(Y_i = 1 \mid X_i) = P(Y_i^* > 0 \mid X_i) = P(\beta X_i + \varepsilon_i > 0 \mid X_i)
\]

\[
P(Y_i = 1 \mid X_i) = P(\varepsilon_i > -\beta X_i \mid X_i) = P(\varepsilon_i \leq \beta X_i \mid X_i)
\]

\[
P(Y_i = 1 \mid X_i) = \int_{-\infty}^{\beta X_i} \phi(\varepsilon_i) \, d\varepsilon_i
\]

\[
P(Y_i = 1 \mid X_i) = \Phi(\beta X_i)
\]  

(13)

Under the assumption of standard normal distribution of the error term, equation (13) represents the probit model whose parameters were estimated by maximum likelihood (ML) method. Literature highlights that farmers located in a close proximity tend to have a similar choice behaviour therefore it is important to account for interdependence in farmer’s decisions. The inverse mill ratio therefore is estimated and included in the second stage so as to correct for selectivity bias (Anselin and Bera, 1998).

**Second stage – outcome equation**

This stage involves estimation of an Ordinary Least Square regression (OLS) for a sub sample of the farmers who use improved maize varieties.

\[
L_i = \beta_i X_i + \beta_j \lambda + \varepsilon_i \quad \text{If } Y_i^* > 0 
\]  

(14)
Where;

\[ L_i = \text{Proportion of land allocated to improved seeds or quantity of improved seeds purchased by a farmer} \]

\[ X_i = \text{Vector of explanatory variables} \]

\[ \beta_i = \text{Vector of estimated coefficients of explanatory variables} \]

\[ \lambda = \text{Inverse Mills Ratio} \]

\[ \beta_j = \text{Coefficient of Inverse Mills Ratio} \]

\[ \varepsilon_i = \text{Error term} \]

Table 4: Description of variables in the selection equation

<table>
<thead>
<tr>
<th>Variable</th>
<th>Unit</th>
<th>Sign</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>Dummy</td>
<td>+</td>
<td>Male HHHs are expected to be better adopter than female HHHs.</td>
</tr>
<tr>
<td>Marital status</td>
<td>Dummy</td>
<td>+</td>
<td>Married HHHs are expected to adopt.</td>
</tr>
<tr>
<td>Age</td>
<td>Years</td>
<td>+/-</td>
<td>Age of HHH either positively or negatively influences improved variety adoption.</td>
</tr>
<tr>
<td>Household size</td>
<td>Number</td>
<td>+</td>
<td>A large household provides more labour hence expected to positively influence adoption.</td>
</tr>
<tr>
<td>Education</td>
<td>Years</td>
<td>+</td>
<td>Educated HHHs are expected to adopt.</td>
</tr>
<tr>
<td>Potential yield</td>
<td>+</td>
<td></td>
<td>Variety with more potential yield is likely to be adopted</td>
</tr>
<tr>
<td>Farm size</td>
<td>Acre</td>
<td>+</td>
<td>A larger land holding is expected to positively influence adoption.</td>
</tr>
<tr>
<td>Extension</td>
<td>Dummy</td>
<td>+</td>
<td>The access to extension services is expected to positively influence farmers’ adoption</td>
</tr>
<tr>
<td>Credit access</td>
<td>Dummy</td>
<td>+</td>
<td>Accessing credit services is expected to positively influence farmers’ adoption.</td>
</tr>
<tr>
<td>Distance to market</td>
<td>Km</td>
<td>+</td>
<td>It is expected that the closer the seed market is the higher the chance of adoption.</td>
</tr>
</tbody>
</table>
Table 5: Description of variables in the outcome equation

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
<th>Unit</th>
<th>Expected sign</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quantity of improved maize seeds</td>
<td>Dependent Variable</td>
<td>Acre</td>
<td></td>
</tr>
<tr>
<td>Proportion of land allocated to improved seeds</td>
<td>Independent variable</td>
<td></td>
<td>+</td>
</tr>
<tr>
<td>Age</td>
<td>Independent variable</td>
<td>Years</td>
<td>+/-</td>
</tr>
<tr>
<td>Cooperative membership</td>
<td>Independent variable</td>
<td>Dummy</td>
<td>+</td>
</tr>
<tr>
<td>Credit access</td>
<td>Independent variable</td>
<td>Dummy</td>
<td>+</td>
</tr>
<tr>
<td>Distance to the market</td>
<td>Independent variable</td>
<td>Km</td>
<td>-</td>
</tr>
<tr>
<td>Education</td>
<td>Independent variable</td>
<td>Years</td>
<td>+</td>
</tr>
<tr>
<td>Extension services</td>
<td>Independent variable</td>
<td>Dummy</td>
<td>+</td>
</tr>
<tr>
<td>Farm size</td>
<td>Independent variable</td>
<td>Acre</td>
<td>+</td>
</tr>
<tr>
<td>Household size</td>
<td>Independent variable</td>
<td>Number</td>
<td>+</td>
</tr>
<tr>
<td>Zone</td>
<td>Independent variable</td>
<td>Dummy</td>
<td>+/-</td>
</tr>
<tr>
<td>Maize price</td>
<td>Independent variable</td>
<td>Tsh</td>
<td>-</td>
</tr>
</tbody>
</table>
CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Descriptive Statistics of Survey Household

From Table 6, up to 70% of household heads are male headed showing the predominance of male household heads. Most of the families in Tanzania and Africa generally are male headed and males are the main decision makers of different farming activities. Being the decision makers, they tend to be more difficult in trying out new agricultural innovations unless when economic constrains restrains their efforts.

Furthermore, the results presented in table 6 show that the mean age of household heads was 46. The role of age in explaining technology adoption is somewhat controversial. In adoption studies, there is an underlying assumption that older people have more farming experience that helps them to adopt new technologies. However due to risk averting nature, older aged farmers are more conservative than the youngest one to adopt new technology. The average household size was 5 household members per family. Farming in rural areas depends mostly on human labour and largely family labour. Therefore, the larger the family, the more the labor force is available for production purpose. The mean farm size owned by the household is 8.7 acres. Farmers with more farm size are likely to adopt new technology by allocating some portions of their farms to the new technology.

Table 6, shows about 43.79% of farmers adopted improved maize seed technology and the mean proportion of land that was allocated to improved seeds was 0.7 acres. Credit access is a crucial factor for farmers to access improved technology especially improved seeds in this case, however only 34.18% of farmers could access credit.
Infrastructure plays an important role in input access and flow of information on new technologies. The distance that a farmer covers from home to the market influences market access, the observed mean distance to the market was 12.7 km. The mean years of schooling is 11 years, which basically is a secondary level education. This indicates that farmers do not have enough capacity to grasp information of improved maize technologies.

Table 6: Descriptive statistics social economic variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
<th>Median</th>
<th>Std. deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seed quantity used (kg)</td>
<td>0.25</td>
<td>150</td>
<td>17.77</td>
<td>10</td>
<td>38.20</td>
</tr>
<tr>
<td>Land proportion allocated to improved seeds</td>
<td>0.05</td>
<td>1</td>
<td>0.7</td>
<td>1</td>
<td>0.4</td>
</tr>
<tr>
<td>Age of household head</td>
<td>21</td>
<td>93</td>
<td>46</td>
<td>45</td>
<td>17.1</td>
</tr>
<tr>
<td>Gender of household head (1 = male, 0 = female)</td>
<td>0</td>
<td>1</td>
<td>0.7</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Farm size</td>
<td>0.03</td>
<td>50</td>
<td>8.7</td>
<td>4.4</td>
<td>23.4</td>
</tr>
<tr>
<td>Distance to Market (km)</td>
<td>0</td>
<td>135</td>
<td>12.7</td>
<td>8</td>
<td>15.3</td>
</tr>
<tr>
<td>Household size</td>
<td>1</td>
<td>30</td>
<td>5.7</td>
<td>5</td>
<td>3.4</td>
</tr>
<tr>
<td>Household head marital status (1= married, 0= otherwise)</td>
<td>0</td>
<td>1</td>
<td>0.8</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Credit access (1= access, 0 = no access)</td>
<td>0</td>
<td>1</td>
<td>0.4</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Household head years of education</td>
<td>1</td>
<td>22</td>
<td>6</td>
<td>4</td>
<td>3.5</td>
</tr>
<tr>
<td>Extension service measured in frequency of extension visits</td>
<td>0</td>
<td>7</td>
<td>0.33</td>
<td>0</td>
<td>1.04</td>
</tr>
</tbody>
</table>

Note: n = 2 124
4.2 Most Preferred Improved Maize Seed Varieties

The first objective aimed at identifying the most preferred improved maize seed varieties among smallholder farmers from different agro ecological zones. Households surveyed were categorized according to seven different agro ecological zones namely Lake, Northern, Eastern, Southern Highland, Southern, Western and Central. The use of improved seeds among small holders from different agro ecological zones was about 45.1% in Lake zone, 16.5% in Western zone, 14.5% in Southern highland zone, 9.4% in Northern zone, 8.8% in Eastern zone, 3.1% in Central zone and 2.6% in the Southern zone.

Out of 37 improved maize seed varieties reported by farmers, fourteen most preferred varieties were KITO, PAN 6195, PAN 6549, SC 621, SC 627, SC 713, SITUKA 2, SITUKA-M1, STAHA, KILIMA, DK 8071 and KATUMANI, SITUKA-M1, TMV2. This might be due to dependence on the adaptability of the maize seed variety to acclimatise to different zones coupled with disease and drought resistance, potential yield and day to maturity.

The difference of choice of variety could be attributed to difference in weather and soil conditions in the zones together with the delivery of necessary services for the use of the improved maize seed varieties. This has an important implication for targeting areas for further expansion of new maize seed varieties where adoption is low and scaling up where adoption is in good level.
Table 7: Most preferred maize varieties in various agro-ecological zones

<table>
<thead>
<tr>
<th>Variety name</th>
<th>Zones</th>
<th>Lake</th>
<th>Northern</th>
<th>Eastern</th>
<th>Southern Highland</th>
<th>Southern</th>
<th>Western</th>
<th>Central</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dk 8071</td>
<td></td>
<td>52</td>
<td>40</td>
<td>5</td>
<td>3</td>
<td>0</td>
<td>2</td>
<td>6</td>
<td>108</td>
</tr>
<tr>
<td>Katumani</td>
<td></td>
<td>49</td>
<td>11</td>
<td>14</td>
<td>7</td>
<td>30</td>
<td>5</td>
<td>2</td>
<td>118</td>
</tr>
<tr>
<td>Kilima</td>
<td></td>
<td>54</td>
<td>4</td>
<td>4</td>
<td>12</td>
<td>1</td>
<td>30</td>
<td>3</td>
<td>108</td>
</tr>
<tr>
<td>Kito</td>
<td></td>
<td>0</td>
<td>2</td>
<td>13</td>
<td>0</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>19</td>
</tr>
<tr>
<td>Pan 6195</td>
<td></td>
<td>14</td>
<td>8</td>
<td>1</td>
<td>3</td>
<td>2</td>
<td>13</td>
<td>0</td>
<td>41</td>
</tr>
<tr>
<td>Pan 6549</td>
<td></td>
<td>91</td>
<td>11</td>
<td>14</td>
<td>14</td>
<td>2</td>
<td>54</td>
<td>15</td>
<td>201</td>
</tr>
<tr>
<td>Sc 621</td>
<td></td>
<td>0</td>
<td>13</td>
<td>6</td>
<td>13</td>
<td>0</td>
<td>27</td>
<td>1</td>
<td>60</td>
</tr>
<tr>
<td>Sc 627</td>
<td></td>
<td>165</td>
<td>36</td>
<td>13</td>
<td>68</td>
<td>4</td>
<td>73</td>
<td>9</td>
<td>368</td>
</tr>
<tr>
<td>Sc 713</td>
<td></td>
<td>222</td>
<td>23</td>
<td>11</td>
<td>15</td>
<td>1</td>
<td>57</td>
<td>6</td>
<td>335</td>
</tr>
<tr>
<td>Situka 2</td>
<td></td>
<td>68</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>0</td>
<td>74</td>
</tr>
<tr>
<td>Situka-m1</td>
<td></td>
<td>71</td>
<td>13</td>
<td>19</td>
<td>0</td>
<td>0</td>
<td>18</td>
<td>0</td>
<td>121</td>
</tr>
<tr>
<td>Staha</td>
<td></td>
<td>4</td>
<td>2</td>
<td>54</td>
<td>2</td>
<td>2</td>
<td>6</td>
<td>12</td>
<td>82</td>
</tr>
<tr>
<td>Tmv2</td>
<td></td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>118</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>118</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>790</td>
<td>165</td>
<td>154</td>
<td>255</td>
<td>46</td>
<td>289</td>
<td>54</td>
<td>1753</td>
</tr>
</tbody>
</table>

Table 8: Most preferred varieties among smallholder farmers

<table>
<thead>
<tr>
<th>Variety name</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sc 627</td>
<td>368</td>
<td>20.99</td>
</tr>
<tr>
<td>Sc 713</td>
<td>335</td>
<td>19.11</td>
</tr>
<tr>
<td>Pan 6549</td>
<td>201</td>
<td>11.47</td>
</tr>
<tr>
<td>Situka-m1</td>
<td>121</td>
<td>6.90</td>
</tr>
<tr>
<td>Katumani</td>
<td>118</td>
<td>6.73</td>
</tr>
<tr>
<td>Tmv2</td>
<td>118</td>
<td>6.73</td>
</tr>
<tr>
<td>Dk 8071</td>
<td>108</td>
<td>6.16</td>
</tr>
<tr>
<td>Kilima</td>
<td>108</td>
<td>6.16</td>
</tr>
<tr>
<td>Staha</td>
<td>82</td>
<td>4.68</td>
</tr>
<tr>
<td>Situka 2</td>
<td>74</td>
<td>4.22</td>
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<tr>
<td>Sc 621</td>
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<td>3.42</td>
</tr>
<tr>
<td>Pan 6195</td>
<td>41</td>
<td>2.34</td>
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<tr>
<td>Kito</td>
<td>19</td>
<td>1.08</td>
</tr>
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</table>


4.3 Determinants of Improved Maize Seed Demand

The second objective aimed at looking on the factors that determine farm level improved maize seeds demand among smallholder farmers. Heckman two-step approach was employed. The following discussion is based on the results as per second objective.

Access to credit positively and significantly influence the likelihood of accessing improved maize seeds. Access to credit improves farmer’s purchasing power for agricultural inputs (Argwings Kodhek et al., 1999).

Credit access was found to be significant at 1% in probit model and 10% in demand model. Those having access to credit have a 15% more probability of accessing improved maize seeds than those without access to credit.

Distance to the market was statistically significant at 1% in probit model and 10% in seed demand model. The marginal effect of market distance implies that the more distant the market is the less probability is the farmer considered to adopt a technology. Therefore, it’s estimated that farmers who are far from the market are less likely to access improved seeds from the market by about 14% probability. Langyintuo et al. (2006) argue that the further away farmers are from the market the less they consider profitability as an object of farming. Long distances increase transaction costs thereby reducing the benefits of improved maize seeds (Renkow et al., 2004). Considering the seed demand model the elasticity of market distance implies that if markets are a kilometre closer to farmers then their seed demand is estimated to increase by 5% holding other factors constant.

Marital status was found to be significant at 5%. Married households have a 9% more likely probability to adopt a technology compared to non-married households. On the
other hand, household head’s years of education was found to be significant at 5% level. Level of education differentiates users and non-users of improved technology. Educated farmers are generally more open to innovative ideas and new technologies which is essential for decision making. Furthermore, education facilitates farmers’ understanding of the technical extension services (Weir et al., 2000). The estimated marginal effect was 0.205 implying that households with more years of education have a 21% probability of adopting improved maize seed than those with few years ceteris paribus.

Farm size and adoption rate (proportion of land allocated to improved seeds) was found to positively influence farmer’s seed demand. Both farm size and adoption rate were significant at 1%. Farmers with big farms are 27% more likely to adopt improved seeds than those with small farm size. Furthermore, it is estimated that a percentage increase in farm size leads to about 14% increase in seed demand by farmer ceteris paribus. Farmers with big farm size are 1.5% more likely to adopt more improved varieties than those with small proportion of land allocated land to improved seeds.

Household size has positive and significant influence on the access of improved maize seed variety (Feder et al., 1958). Conteh et al. (2015) argues that farming in most rural areas depend on human labour and largely family labour therefore, large family size is associated with labour availability for timely operation of farm activities that enhance productivity. This implies that bigger households provide the required farm labour associated with the use of new technology. Household size was found significant at 5% from the seed demand model and therefore it’s elasticity implies that a percentage increase in household size leads to about 4% increase in the seed demand holding other factors constant. Furthermore, results suggest that the likelihood of adoption increases with increase in the household size because of increased labour supply for the farm.
Potential yield is an important factor that can influence the adoption of improved maize seeds among smallholder farmers. Results in table 9, show that potential yield positively and significantly influenced the likelihood of farmers to adopt improved maize seeds at 5%. Marginal effect from the results suggests that maize varieties with high potential yield have 49% probability to be adopted by farmers than those with low potential yield.

The results further suggest that smallholder farmers have incentive to purchase certified seeds using the money obtained from sales of maize from the previous harvest as Langyintuo and Mungoma (2008) and Wen-chi et al. (2015) demonstrated earlier that the maize yield is positively correlated with adoption of new technologies. The findings are also similar to those reported by Mbugua (2009) who conducted a study in Makuyu Division, Murang’a South District- Kenya, that technology profitability in terms of high yields was significant in influencing adoption decision for using improved maize seed varieties.

The coefficient of the number of extension visits was positive and statistically significant at 1%. The positive effect of extension shows the role that proactive extension can play in accelerating technological change in smallholder agriculture in Africa. Farmers with more extension visits have a 33% probability of adopting improved maize seeds. The frequency of contact between the extension agent and farmers accelerates the effective dissemination of adequate agricultural information to farmers, which enhance farmer’s decision to choose new technologies.
Table 9: Factors determining the use and demand for improved seeds

| Adoption equation | Coefficient | Standard error | P>|z| | dy/dx | dlnY/dlnX |
|-------------------|-------------|----------------|------|------|-----------|
| Household size    | 0.0074      | 0.0069         | 0.286| -    | -         |
| Credit access     | 0.2134      | 0.0604         | 0.000***| 0.146|           |
| Sex               | 0.0857      | 0.0738         | 0.245| -    | -         |
| Marital status    | 0.2168      | 0.0853         | 0.011**| 0.097|           |
| Household years of education | 0.0086 | 0.0041 | 0.035** | 0.205 |           |
| Extension service | 0.1066      | 0.0255         | 0.000***| 0.328|           |
| Distance to the market | -0.0062 | 0.0019 | 0.001***| -0.135|           |
| Pest resistance   | 0.8527      | 6.175          | 0.371| -    | -         |
| Potential yield   | 13.3175     | 5.281          | 0.041**| 0.489|           |
| Proportion of land allocated to improved seeds | 0.0217 | 0.0048 | 0.000***| 0.015 |           |
| Farm size         | 0.008       | 0.0028         | 0.004***| 0.271|           |
| Constant          | 0.6261      | 0.0913         | 0.000|      |           |

Outcome equation

| Seed demand model | Coefficient | Standard error | P>|z| | dy/x | dlnY/dlnX |
|-------------------|-------------|----------------|------|------|-----------|
| Credit access     | 3.8204      | 1.9821         | 0.054*| 0.041|           |
| Household size    | 0.4960      | 0.2286         | 0.030**| -0.054|           |
| Distance to the market | -0.1086 | 0.0647 | 0.093*| -    | -         |
| Farm size         | 0.7576      | 0.0387         | 0.000***| 0.138|           |
| North zone dummy  | 2.0141      | 0.870          | 0.021**| -    | -         |
| East zone dummy   | 2.4785      | 2.219          | 0.264| -    | -         |
| Central zone dummy| 0.1268      | 2.433          | 0.958| -    | -         |
| West zone dummy   | 0.9889      | 2.755          | 0.72 | -    | -         |
| South zone dummy  | -0.2786     | 2.0249         | 0.891| -    | -         |
| Lake zone dummy   | 0.4725      | 2.5429         | 0.853| -    | -         |
| Extension service | -0.2744     | 1.8542         | 0.882| -    | -         |
| Constant          | 30.7587     | 7.447          | 0.000|      |           |

Mills

| Lambda | -31.2617 | 7.1828 | 0.000 |
| Rho    | -1.0000  |        |       |
| Sigma  | 31.2617  |        |       |

| Number of obs | 2124 |
| Wald chi² (11) | 513.58 |
| Prob > chi²   | 0.0000 |

Note: *** significant at 1%; ** significant at 5%, * significant at 10%
CHAPTER FIVE

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusion

The main objective of this study was to assess farm level improved maize seed demand and its determinants in rural mainland Tanzania. Specifically, the study focused on identifying the improved maize seed varieties that are mostly preferred by smallholder farmers and also assessing the factors determining farm level improved maize seed demand. Descriptive statistics were used to identify improved maize seed varieties that are mostly preferred in different agro ecological zones. On the other hand, sample selection model was employed in estimating farm level seed demand as well as its determinants.

Findings showed that KITO, PAN 6195, PAN 6549, SC 621, SC 627, SC 713, SITUKA 2, SITUKA-M1, STAHA, KILIMA, DK 8071 and KATUMANI, SITUKA-M1, TMV2 were the most preferred varieties across all agro ecological zones. Basically, the preference is backed up by the intrinsic attributes that the varieties possess. Moreover, from the adoption and seed demand models it was revealed that potential yield attribute, farm size, access to extension service, household size, credit access, household years of education and distance to the market were found to be significant determinants of improved maize seed use. However, some variable such as age, sex, zone and pest resistance were not found to be significant as per prior expectation. Therefore, joint estimation of technology adoption and seed demand provides holistic methodology to identification of relevant factors that determine seed uptake at the farm level.
5.2 Recommendations

In view of the above findings and conclusion, the following recommendations can be drawn:

Seed companies ought to consider supplying seed to farmers at locations nearer them directly because distance seems to affect seed demand and improved seed uptake at large. Furthermore, given limited extension service coverage by government, there should be an intervention strategy that encourage seed companies to consider investing more in demonstrations at the village community level that show superiority of improved maize varieties over local ones so as to improve seed uptake.
REFERENCES


