SMALLHOLDER FARMERS' PREFERENCES FOR IMPROVED MAIZE SEEDS VARIETIES IN TANZANIA

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ABSTRACT

Improved maize seed varieties are bred with characteristics such as drought and disease tolerance which may not capture farmers' preference. It is therefore, imperative to consider attributes that are preferred by farmers in developing maize seed varieties. This research was conducted to determine attributes that are most preferred by smallholder maize farmers in Tanzania. Specifically, the study aimed to (i) characterize smallholder farmers' preferences for improved maize seed varieties depending on their socio-economic characteristics, (ii) assess the heterogeneity of farmers' preferences for improved maize seed varieties and (iii) determine factors that influence farmers' choice of the most preferred improved maize seed varieties. Descriptive statistics and binary logistic regression were used for data analysis. The study findings revealed that majority (74.7%) of the households were male-headed and (83%) were married. About 90 percent of the farmers had no access to extension services that is supposed to play an important role in agricultural information dissemination. The most preferred improved maize varieties in all zones were PAN6549, SC 627, SC 713, STAHA, KILIMA and DK 8371due to higher production potential. A Logit model showed that agro-ecological zones, farm size, household size and yield positively influenced the likelihood of farmers' choice of improved maize seed varieties. Based on these findings, it is recommended that researchers and suppliers of seed should consider the attributes of farmers' preference in the production of improved maize seeds and put more emphasis on facilitating the delivery of agricultural extension services for more effective uptake of agricultural technologies.

DECLARATION

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

20. 06. 2017

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LIST OF ABBREVIATIONS

AERC	African Economic Research Consortium
ASA	Agricultural Seed Agency
ASARECA	The Association for Strengthening Agricultural Research in Eastern and Central Africa
CBO	Community Based Organisations
CGRFA	Commission on Genetic Resources for Food and Agriculture
CIMMYT	International Maize and Wheat Improvement Centre
FAO	Food and Agriculture Organization
FAOSTAT	Food and Agricultural Organization Statistical databases
GDP	Gross Domestic Product
IMV	Improved maize Varieties
NGOs	Non-Governmental Organization
OLS	Ordinary Least Squares
OPVs	Open Pollinated Varieties
RLDC	Rural and Learning Development Committee
SPSS	Statistical Package for Social Science
SSA	Sub-Saharan African
TOSCI	Tanzania Official Seed Certification Agency
URT	United Republic of Tanzania
USAID	United States Agency for International Development
USDA	United States Department of Agriculture

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background Information

Agriculture is the dominant sector in Tanzania's economy, accounting for 25% of the Gross Domestic Product (GDP) and employing 75% of the labour force (URT, 2014). In Tanzania, 69% of the total population lives in the rural area andmostly represents smallholder farmers (World Bank, 2014). Food crops such as maize, sorghum, millet, cassava, sweet potatoes, bananas, pulses, paddy and wheat are mainly grown in the country, contributing approximately 65% of the agricultural GDP (URT, 2013).

Maize is the most important staple food for over 80% of the population and it accounts for over 20% of agricultural GDP (URT, 2013). Maize covers about 45% of the total cultivated area generating about 50% of rural cash income and employment (USAID, 2010). It is estimated that the crop occupies the most important place among cereals with an annual per-capita consumption of 73 kilograms, contributing about 33% of the total household consumption (URT, 2013).

Improving maize production is therefore one of the most important strategies for food security in Tanzania, especially through the development and improvement of agricultural practices and availability of improved seed varieties (Hepelwa, 2013). However, improved seed varieties developed by the national and international agricultural research centers very often fail to get adopted by smallholder farmers (Morris *et al.*, 1999), partly because farmers have different needs. They require maize seeds of diverse varieties and of multiple traits. This depends on crop variety traits or attributes, which are the performance characteristics of plant varieties that include both the production (agronomic) capacity of the plant and the consumption attributes of the product (Edmeades, 2003). Farmers encounter difficulties in obtaining maize seeds that meet their specific choices.

The evidence shows that the farmers' demand for improved seeds is weak despite efforts by research institutions to develop various maize varieties, which have vigour characteristics for productivity as well as drought and disease tolerance (Tripp, 2000). The adoption rate of improved varieties for the various zones in the country was estimated at 28% for the Central Region, 66% for the Eastern Region, 44% for the Lake Region, 66% for the Northern Region, 24% for the Southern Region, 81% for the Southern Highlands and 36% for the Western Zone (Moshi, 1997). The weak demand for improved seeds has been a major constraint to farm input suppliers as they strive to sell improved seeds. Based on seed sales by Hassan *et al.* (2001), estimated total national maize area planted to improved OPVs and hybrids was about 4%. Related to that, farmers' accessibility to quality seed is limited by seed availability and marketability especially in some parts of Tanzania (Muhammad, 2003). Apparently most farmers lack the knowledge regarding positive traits of improved seeds varieties, hence they stick to traditional varieties, which they seemingly prefer but such seed are not economically efficient. Nonetheless, such traditional varieties have prominent aromatic and palatability characteristics that are preferred by farmers (RLDC, 2009).

Often, smallholder farmers prefer open pollinated varieties (OPVs) because they can be recycled for a longer period and the price is relatively lower compared to hybrids. It is generally accepted that access to improved seeds is an important factor for increasing agricultural productivity among smallholder farmers (URT, 2013). However, such access is constrained by weak seed supply systems, which has been identified as a limiting factor for achieving widespread usage of improved seed varieties in sub-Saharan African (SSA) countries (Tripp, 2000). Minot *et al.* (2007), similarly emphasizes that several factors explain differences among farmers in their decision process of choosing seed varieties and the quantities of seeds to use.

Farmers' decisions are therefore not only driven by profit maximisation but rather by complex processes that are affected by several socio-economic and psychological variables (Willock *et al.*, 1999). Moreover, farmers grow crops that satisfy their needs. Once there is harmony between needs and variety attributes, the result is varietal preference (Wale and Mburu, 2006). It has been estimated that smallholder farmers generally demand improved seed for three reasons namely; seed replacement, variety change and emergency response (Minot *et al.*, 2007). Seed demand is also influenced by five types of factors including; (i) agro-ecological, natural and man-made disasters, (ii) uneven market development, (iii) farmers' preferences about distribution channels, (iv) timing of seed distributions, and (v) the level of awareness about the traits of the improved seeds (Minot *et al.*, 2007). However, the specific factors accounting for low seed adoption rates in Tanzania are not clearly articulated.

1.2 Problem Statement

In Tanzania, efforts have been made by various institutions towards developing maize seed varieties with higher productivity traits; drought and disease tolerance. Yet, there is still low usage of these improved seed varieties among smallholder farmers (URT, 2013). For example, according to Agricultural Census of 2002/03, only 5.7% of maize farmers in Tanzania use improved varieties together with fertilizer. Such improved maize seed varieties may be high yielding, yet they may not be attractive to farmers unless they possess some crop-specific traits that farmers consider important (Asrat *et al.*, 2009). It has been observed that the majority of smallholder farmers still rely on unimproved, Open Pollinated Varieties (OPVs) for planting, partly because such seeds are easy to multiply, cheaper and readily available (Aquino *et al.*, 2001). Farmers have also tended to stick to preferred traditional varieties and OPVs probably due to their perceived aromatic and palatability characteristics (RLDC, 2009).

Different studies which have been conducted in Tanzania revealed the low use of improved maize seeds (USDA, 2011). About 70% of smallholder farmers continue to use local and recycled maize varieties (Minot *et al.*, 2007). However, seed recycling reduces crop yield. Ayieko *et al.* (2006) showed that continued recycling of seeds was responsible for persistent yield reduction among smallholder farmers. It has also been reported that recycling OPVs seed varieties beyond the recommended duration can lead to yield reduction of up to 5%. Meanwhile, recycled hybrid seed yield reduction can be as high as 32% (Pixley *et al.*, 2002).

In order to enhance the adoption of improved seed, food security and rural welfare, small scale farmers who constitute the majority of producers in Tanzania, should among other things be involved in all processes of maize variety selection and evaluation so that seed that are bred and sold are preferred by farmers. Most breeders of improved maize seed varieties have focused on raising yields, as well as addressing drought and disease tolerance. However, farmers perceive little advantage from such improvement because such seeds are not designed for their need (Reeves *et al.*, 2002). It is, therefore, imperative to develop maize seed varieties which also accommodate attributes that are preferred by farmers.

Improving maize breeding processes cannot be accomplished without the knowledge of attributes that farmers prefer in maize or any other variety. For effective breeding, farmers' preferences for varieties should be clearly identified through researcher-farmers interactions and collaboration (Banziger and Cooper, 2001). This study was guided by the question, which attributes do smallholder farmers consider in choosing improved maize seeds? Such information will enable crop breeders to incorporate such attributes, which will serve as pull factors in the maize seed supply chain.

1.3 Justification of the Study

In Tanzania, the demand for maize has been rising corresponding to the population increase, increased use of maize in animal feed as well increased use for commercial food production like production of corn flakes. In order to feed the increasing population and ensure sustainable food security, high yielding varieties are required. This study informs breeders, seed producers, and extension agents about the key attributes preferred by farmers in order to improve seed quality, consistent with farmers' needs and develop models of distribution channels that supply highly demanded seeds in various parts of the country. The knowledge generated from this study is used to draw inferences regarding improving seed quality by addressing farmer's needs, which enhances demand and use of improved maize seeds in Tanzania. In the next section the study objectives, research questions and study hypotheses are presented.

1.4 Objectives of the Study

1.4.1 Overall objective

The overall objective of the study was to determine attributes of improved maize seed varieties that are most preferred by smallholder farmers in Tanzania.

1.4.2 Specific objectives

Specifically the study pursued three objectives:

(i) To characterize smallholder farmers preferences for improved maize seed varieties based on socio-economic characteristics,

(ii) To assess the heterogeneity of farmers' preferences for improved maize seed varieties, and

(iii) To determine factors that influence farmers' choice of the most preferred improved maize seed variety.

Based on these objectives, research question, and hypotheses are pursued as follow:

1.4.3 Research question

In relation to the first study objective, one question was addressed as follows;

Which characteristics do farmers consider in selecting a maize seed for planting?

The second and third objectives were addressed using research hypothesis as presented below:

1.4.4 Hypotheses

The second objective was addressed by testing research hypothesis which states that there is no significant difference in the farmers' preference of all seed varieties available to them as represented in this study;

Mathematically the null hypothesis for the first hypothesis can present as follows;

$$H_0 : \chi_i^2 = 0$$

Where χ_i^2 is the chi-square for the preference of the i^{th} farmers for six seed varieties that were most preferred from among 34 varieties in the study.

The third objective was addressed by testing the second null hypothesis, which states that socio-economic and other factors do not influencethe farmers' choice of maize seed from among the six most preferred variety;

Mathematically the null hypothesis for the second hypothesis presented as follows;

$$\text{Ho}: \beta_{i1} = \beta_{i2} = \beta_{i3} = \cdots . \beta_{ij} = 0$$

Where β_{ij} is coefficient of the i^{th} farmers for the j^{th} variable

For i = 1, 2, ... n, where "n" is the number of respondents and j= 1,2....10 is number of variables.

1.5 Organization of the Dissertation

This dissertation is organized in five chapters. The first chapter present the study background covering the. statement of the problem, justification, overall and specific objectives of the study. The second chapter reviews the literature on topics that are relevant to the study. The theoretical framework, empirical studies and the conceptual framework in relation to preference of improved maize seed varieties are also presented. The third chapter presents the research methodology, data collection methods and analysis. The fourth chapter presents the results and discussion. The final chapter presents the conclusions and recommendations based on the study findings.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Status of Seed Industry in Tanzania

According to Cho (2013), seed has a unique feature among all agricultural inputs, whether commercial or subsistence, because seed is a means for delivering technology to farmers. Regardless of the scale of agriculture, seed quality, particularly its genetic attributes, determine the level of crop productivity in the presence of other crop production inputs (Seshatta, 2013). More importantly, quality seeds of any preferred variety are a basis for improved agricultural productivity since they respond to farmers' needs for both their increasing productivity and crop uses (Pelmer, 2005).

In spite of the importance of agriculture to Tanzania, the sector faces a number of constraints, some among them being the high prices of agricultural inputs (seeds and fertilizers) and untimely availability of inputs to farmers (CGRFA, 2011). Prior to the 1970s, Tanzania did not have a seed sector. The formal seed sub-sector was established during the 1970s as a seed project under the assistance of the American government through the United States Agency for International Development (USAID). A number of sub-sectors were established in 1973 under that support, including; (i) Research for developing new varieties, (ii) Seed farms, and (iii) the National Seed Company - TANSEED (Mtoni, 2002). During the same year, the Seed Act No. 29 of 1973 was enacted and the Tanzania Official Seed Certification Agency (TOSCA) was launched, with three laboratories to regulate seed quality (FAO, 2013). However, TANSEED had a bad reputation due to delivery of poor quality seeds, inadequate marketing promotion and inadequate managerial skills.

Following economic liberalization in 1986, the Government launched the National Seed Industry Development Programme, which was in line with the World Economic Reform agenda that emphasized moving from a state controlled economy to a free market economy. The Seed Act was amended in the year 2003 allowing private seed companies to operate in the country. Since then there has been a significant increase in the number of maize varieties released (URT, 2010). In 2003, a body corporate – Tanzania Official Seed Certification Institute (TOSCI) was established as a quality control organ replacing the Tanzania Official Seed Certification Agency (TOSCA) that was established in 1973 (FAO, 2013).

Despite all these efforts, the seed industry for most crops faces a series of challenges and Tanzania is still facing food insecurity due to low productivity, which is attributed to low use of improved inputs. Other factors contributing to low productivity include; climate change, often manifested as drought, farmers' low purchasing power such that they cannot buy improved inputs including seeds, inefficient distribution network of inputs due to an inadequate number of Agro-dealers in rural areas, inability of rural agro dealers to purchase inputs in required quantities, low entrepreneurship skills by the Agro-dealers, lack of or limited rural credit facilities, and poor infrastructure, especially roads and storage. A combination of these factors has resulted into low production and productivity (Hepelwa(2013); URT (2013)).

2.2 Importance of Maize Seed Industry in the Country

Maize is the most important food crop in Tanzania, covering 45% of the cultivated area (USAID, 2010). On average about two million hectares are cultivated annually (FAOSTAT, 2013). The crop is grown in every region of Tanzania mainland, occupying more than 80% of the land planted to cereals. Maize is grown as food by over 80% of the farming community (Matata *et al.*, 2011). Major maize producing regions are; Iringa, Mbeya, Rukwa, Arusha, Kilimanjaro, Morogoro, Kigoma, Mwanza and Tabora (Lyimo *et al.*, 2014). Maize provides up to 60% of dietary calories and more than 50% of utilizable protein to the Tanzanian population. Maize is not only a staple crop, in surplus regions it is also a cash crop (Ramadhani *et al.*, 2002). Recognizing the importance of the maize crop to the lives of Tanzanians, the government has committed human and financial resources to develop the industry (FAOSTAT, 2013). Maize breeding and agronomy trials have been conducted in Tanzania for more than 20 years. For instance, from the 1950s to 2011, about 100 maize varieties have been released in Tanzania. However, farmers plant only 6-12% of the improved varieties (Mafuru *et al.*, 1999). Majority of farmers still grow landraces and OPVs with low production potential (Mafuru *et al.*, 1999). The reasons for such low usage of improved maize varieties are difficulties in accessing improved seed, limited or unavailability of seed and high cost of key inputs like fertilizer (Mbwaga and Masawe, 2002).

Table 1: Maize production trends and consumption required in Tanzania from 2002-2012

Year	Area harvested(ha)	Production(Mt)	Demand(Mt)	Deficit/Excess (Mt)	Import(Mt)
2002	845 950	2 500	2450	-11	11
2003	1 718 200	2 700	2 735	-35	35
2004	3 462 540	2 320	2 396	-76	76
2005	3 173 070	3 230	3 271	-41	41
2006	3 109 590	3 300	3 463	-163	163
2007	2 570 150	3 373	3 344	29	0
2008	2 600 340	3 660	3610	50	0
2009	2 578 000	3 634	3674	-40	40
2010	2 570 000	3 326	3326	0	0
2011	2 765 000	3 600	3580	20	0
2012	2 765 000	3 600	3550	-5	5

Source: USDA (2011).

Table 1 shows trends for maize production in Tanzania for ten years from 2002 to 2012 and the required demand. Out of eleven years there was a deficit in eight (13%) and a marginal net surplus during three years (2002, 2007 and 2011). The deficit during most years was covered through maize importation and use of substitute crops such as other cereals and root crops. Table 1 also shows the amount of maize imported to cover the deficit in each year.

2.3 Attributes for Seed Demanded

The Tanzanian seed sector has a wide variety of public, private sector and civil society actors. The public sector is strongly involved in primary value chain functions such as genetic resource management (National Plant Genetic Resources Institute), variety development, which is done by the Ministry of Agriculture. Food Security and Cooperation, Division of Research Development and Universities, production and distribution of basic seed and certified seed by the Agricultural Seed Agency, and quality control by TOSCI. The private sector comprising of seed companies, is organized under the TanzaniaSeed TradeAssociation. Members of this association produce and market certified seed as well as some basic seed. Certified seed is the progeny of basic seed and is produced on contract by selected seed growers under the supervision of the seed enterprise, public or private. This certified seed can be used by breeders to produce further generations of certified seed or by farmers for grain production. Basic seed is the progeny of breeder or pre-basic seed and is usually produced under the supervision of a breeder or his/her designated agency under the control of a seed quality control agency (FAO, 1993).

Agro dealers are involved in the retail trade of certified seed produced by various seed companies, working together with farmer's organizations including Community-based Organizations (CBOs), MVIWATA members and the Tanganyika Farmers' Association as platforms to link with end users of the seed chain. The farmer's organization can also be involved in certified and quality declared seed under formal and informal production arrangement with TOSCI (ASARECA, 2014).

Seed value chain supporting services are provided by the public sector including extension services for husbandry and other on farm and postharvest advice. Tanzania Official Seed Certification Institute (TOSCI) provides quality inspection and certification services. These are complemented by private sector extension services and seed use promotion services by agro dealers and seed companies. Non-Governmental Organization (NGOs) and farmer organizations are also involved in providing seed related extension services, largely as facilitators for the informal sector and QDS seed production (Barnett *et al.*, 2011). Despite considerable efforts by several programme and organizations, the adoption of improved agriculture technologies is still low in Tanzania (URT, 2013).

Table 2 shows the rate of using improved maize seed varieties for three seasons from 2007 to 2010. Only about 26% of the total area was planted with improved maize seed varieties by the year 2010 (MAFSC, 2011). This is despite the knowledge that using traditional seed varietie leads to low production. In order to increase production of maize and meet the prevailing demand for the crop, there is a need to sensitize farmers on the importance of using improved maize varieties along with other inputs like fertilizer Such efforts should however go along with providing assurance to farmers about the market availability for their produce.

Table 2: Percentage of the area planted with improved maize seed varieties.

Year	Area (Ha)	Production (Tones)	Area with improved maize variety	% of area with improved maize variety
2007/08	2 570 000	3 373 000	523 850	20.4
2008/09	3 168 000	5 446 000	826 250	26.1
2009/10	3 700 000	4 475 410	985 125	26.6

Source: Ministry of agriculture, Food Security and Cooperative (2011)

2.4 Maize Varieties Grown by Farmers in Tanzania

Farmers in Tanzania grow a wide range of maize varieties. The choice of maize variety is determined by the farmer's objectives, the length of growing season, the elevation, and the amount of rainfall at a given locality (Kaliba *et al.*, 1998). According to Kaliba *et al.* (1998) the recommended varieties for intermediate altitude areas (900-1500 m above sea level with low rainfall (<1000 mm) in the Western Zone includes Kilima, Katumani, TMV1, CG4142, UCA, H622, and H632. Kaliba *et al.* (1998) further reported that in the Eastern zone of Tanzania, four varieties that are grown in both lowland and intermediate altitude. These include; Staha, TMV1, Katumani, and Tuxpeño. Other varieties that farmers grow include CG4141 and ICW in the lowlands and Kito, ICW, CG4141, and Kilima in the intermediate altitude. Staha was mostly planted in the lowlands by 44.7% of farmers interviewed followed by local variety in both the Western and Eastern zone.

A study conducted by African Centre for Biodiversity (2016) in Morogoro and Mvomero districts revealed that there is a widely held view among farmers that improved varieties contribute to diversity of crops. Consequently, these varieties are in demand by farmers because of their specific traits, such as high yield potential, the demand for which increases with the increasing monetization of local economies. However, local varieties are still in high demand from consumers who prefer the taste, aroma and an assortment of other use-related characteristics embedded in these varieties. The study by the African Centre for Biodiversity (2016) further pointed out that farmers in Morogoro and Mvomero districts grow local maize varieties like Kitweeko, Mhingo, Manjano, and Kimekele; But, they also grow improved varieties including OPVs - Staha, Ilonga, Katumani, TMV1, NATA, MMCLU, Situka, TAN 254, TAN H600, TAN 236 and hybrids - Pannar, SeedCo, and Kifaru.

2.5 Improved Maize Varieties Preferred by Farmers in Tanzania

Open Pollinated Varieties remain the most preferred among the improved maize varieties. Westengen *et al.* (2014) reported that two open pollinated varieties (OPVs), Staha and TMV1, are cultivated on two-thirds of the maize fields among the surveyed households in Mangae village within the semi-arid agro-ecological zone in Tanzania. Kaliba *et al.* (1998) similary found that Staha and TMV1 were the most preferred improved maize varieties in both lowland and intermediate zones of Eastern Tanzania. About 55% of lowland farmers and 38% of intermediate zone farmers preferred Staha. In the lowlands, Staha and TMV1 were preferred for their high yield and tolerance to drought stress. Tuxpeño was valued for its tolerance to drought stress. In the intermediate zone, Staha and TMV1 were preferred for the same characteristics. It is not surprising that tolerance to drought stress was emphasized in both zones. However, hybrid maize varieties are preferred for high yield and disease resistance, but in most cases farmers argue that hybrids are too expensive to grow since the seed cannot be recycled and they require inorganic fertilizers to grow well (Kaliba *et al.*, 1998). The practice of recycling improved varieties and seed selection were also reported by Westengen *et al.* (2014) and Kaliba *et al.* (1998) to be common on-farm seed management practices.

2.6 Farmers' Preference for Maize Variety Traits

Smallholder farmers have been growing various crops based on certain traits. However, there is variation in preference from one crop to another. Trait preference tacitly indicates the objectives and priorities of farming household. The preferences are also dictated by the opportunities and constraints farmers face in selecting their farming enterprise and its management (Kassie *et al.*, 2012).

From years immemorial farmers noticed that not all plants were the same. Some plants may have grown larger than others, or some kernels tasted better or were easier to grind. The farmers saved kernels from plants with desirable characteristics and planted them for the next season's harvest. The literature shows that traits like yield potential, colour, maturity, and drought resistance are most desired by farmers. A study conducted by Dao *et al.* (2015) in Burkina Faso, revealed that maize farmers preferred varieties that carry traits like high yield potential, and early maturity. Tolerance to drought was also preferred by farmers (Dao *et al.*, 2015; Mahadevan and Asafu-Adjaye, 2014).

Sibiya *et al.* (2013) in acase study from KwaZulu-Natal Province, South Africa presented results that indicatedlimited selection of maize varieties grown by farmers in the area compared to other communities in Africa. This is probably because 97% of the farmers in the study grew a local landrace called *Natal-8-row* or *IsiZulu*. Hybrids and improved open pollinated varieties were planted by less than 40% of the farmers. The local landrace was preferred for its taste, recycled seed, tolerance to abiotic stresses and yield stability.

It is evident based on these findings that the preferred characteristics of maize varieties were high yield, disease resistance, early maturity, white grain colour, as well as drying and shelling qualities. In another study, Sinafikeh *et al.* (2010) found that environmental adaptability and yield stability were the important attributes for farmers' choice of crop varieties in Ghana. According to Kassie *et al.* (2012) farmers in Zimbabwe, Zambia, Malawi and Angola mentioned the yield potential of varieties more than any other trait of an ideal maize germplasm. Other traits frequently mentioned include; the number and quality of cobs, early maturity, performance under poor soil fertility, drought resistance, and pest and disease resistance. However, government policies and institutional practices also play a role in influencing farmers' choice of maize seed varieties (Longyintuo, 2005). In general, the smallholder farmer's decision to use or not to use a certain technology is usually based on the profitability and risks associated with the new technology. In the next section, specific aspects of the seeds are elaborated in relation to farmers' choice, focusing on those which policy makers and breeders can improve upon.

2.6.1 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 and Hill, 2002). Seed quality is therefore concerned to the behavior 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 and Hill (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). It's 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.*, 1994). 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 (Cromwell, 1996).

2.6.2 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 (ASFG, 2011). 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)

2.6.3 Farmers' attitude and knowledge

Despite the provision of extension services to train farmers on the importance of using certified improved maize seeds, the level of use among smallholder farmers is still low (Hepelwa, 2013). There are different explanations for the very low adoption rate, synonymous to an apparent rejection of improved maize seed by farmers, including; negative attitudes toward improved seed, inadequate knowledge on how to use the seed, lack of information on availability, high price of improved seeds, farmers' age, and availability of family labour (Suhane *et al.*, 2008).

Farmers' perceptions play an important role in the decision to adopt improved maize seed varieties. It is expected that when farmers understand and appreciate the innovation of the improved maize seed varieties they would accept it, as it has been described by Ayuya *et al.* (2011) that farmers adopt the improved seed when they view the innovation is beneficial to them.

Markets and transportation are also important factors that influence the adoption of improved maize seed. Improved infrastructure and a good transport system ensure timely delivery but it also reduced the cost of seed making it more affordable to smallholder farmers. Millar and Tolley (1989) found that market interventions such as price supports can speed up the adoption of new technologies. Moreover, government subsidies can also be used to enhance adoption of improved technologies such as improved maize seed varieties.

2.7 Analytical issues on Preference of Improved Maize Seed Varieties

The farmers' preference of specific improved maize seed varieties is affected by several factors including socio-economic and institutional factors. A study conducted by Westengen *et al.* (2014) showed that farmers' practice of seed selection and recycling improved seed varieties are common on-farm seed management practices. Drought tolerance and high yield are the most important characteristics reported as reasons for growing current varieties as well as the most important criteria for farmers' seed selection (Westengen *et al.*, 2014). Moreover, Westengen *et al.* (2014) emphasized that seed varieties must be available; farmers must be able to access the seeds; and the seed should be of satisfactory quality in order to ensure and adoption.

It has been argued that improved cereal varieties are still poorly accessed by smallholder farmers in Tanzania (URT, 2009). Nevertheless, liberalization of the seed sub-sector has enabled the emergence of private seed companies, which are already taking up production and sale of improved cereal seeds and marketed by the Agricultural Seed Agency (ASA) (URT, 2009). Previously in the 1970s modern maize seed varieties represented less than 5% of the maize area, however by the year 2010 the maize area under improved varieties has increased to around 30% (URT, 2011).

Nyamai (2010) reported that smallholder farmers in arid and semi-arid parts of Kenya increase their maize yields by growing improved varieties that are available through formal seed markets. It was found however that smallholder farmers' access to improved germplasm, was limited.

While analysing the quantitative factors influencing farmers' choice of improved maize seeds, the study findings also showed that extension contacts, access to credit, membership to farmer groups and experience on using improved maize varieties positively influenced the likelihood of a farmer's choice to use improved maize seeds. The cost of seeds, distance to output markets and access to extension service, unavailability of improved high yielding maize varieties at the farm level, and transaction costs negatively influenced the choice of improved maize seeds. Policy makers can intervene to improve the adoption enhancing factors while addressing the negative factors studies on seed adoption have used various analytical models but the logistic model is most often used.

Chuma (2009) in Tanzania used a Logistic regression model in the investigation of the factors affecting the adoption of selected agricultural technologies on maize production in Mvomero District and found that, 74% of the farmers apply improved maize seed, and recommended that suitable maize varieties must be developed to suit farmers' taste and preference.

In Kenya, Mureithi *et al.* (2002) used a Logit analysis model to analyze factors affecting adoption of maize production technologies in Embu District, and the results indicated that, adoption of maize production technologies is significantly influenced by gender, extension services, hired labour and access to credit facilities. However, their study did not consider technology-specific attributes as a factor influencing adoption decision. The present study

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2.8 The Conceptual Framework

Based on consumer behaviour theory, the use of good technology by farmers is influenced by various factors including the type of technology, socio-economic factors, policy, research and institution factors.

Assuming that 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, then these farmers factor also influence breeders and research centres in producing good seed that suits farmers demand. Furthermore, the policy and institutional factors such as access to extension services, input support programs, irrigation systems and research and development encourage farmers to use improved maize seed and other technologies that improved the productivity such as fertilizer, tractors - mechanization, and agronomic practices.

In this study, thirty four (34) maize seeds varieties were grown in all seven agro-ecological zones in Tanzania. Depending on the ability of maize seed variety to adapt to different zones coupled with disease and drought resistance, potential yield and day to maturity, it was noted that only six improved maize seed varieties are the most preferred in all seven agro-ecological zones. These are PAN6549, SC 627, SC 713, STAHA, KILIMA and DK 8371. It is presumed that if farmers use the certified improved maize seed varieties with the above traits, they can increase maize production and productivity. This in turn increases food security and improves farmers' living standard. This is conceptualized in Fig. 1.

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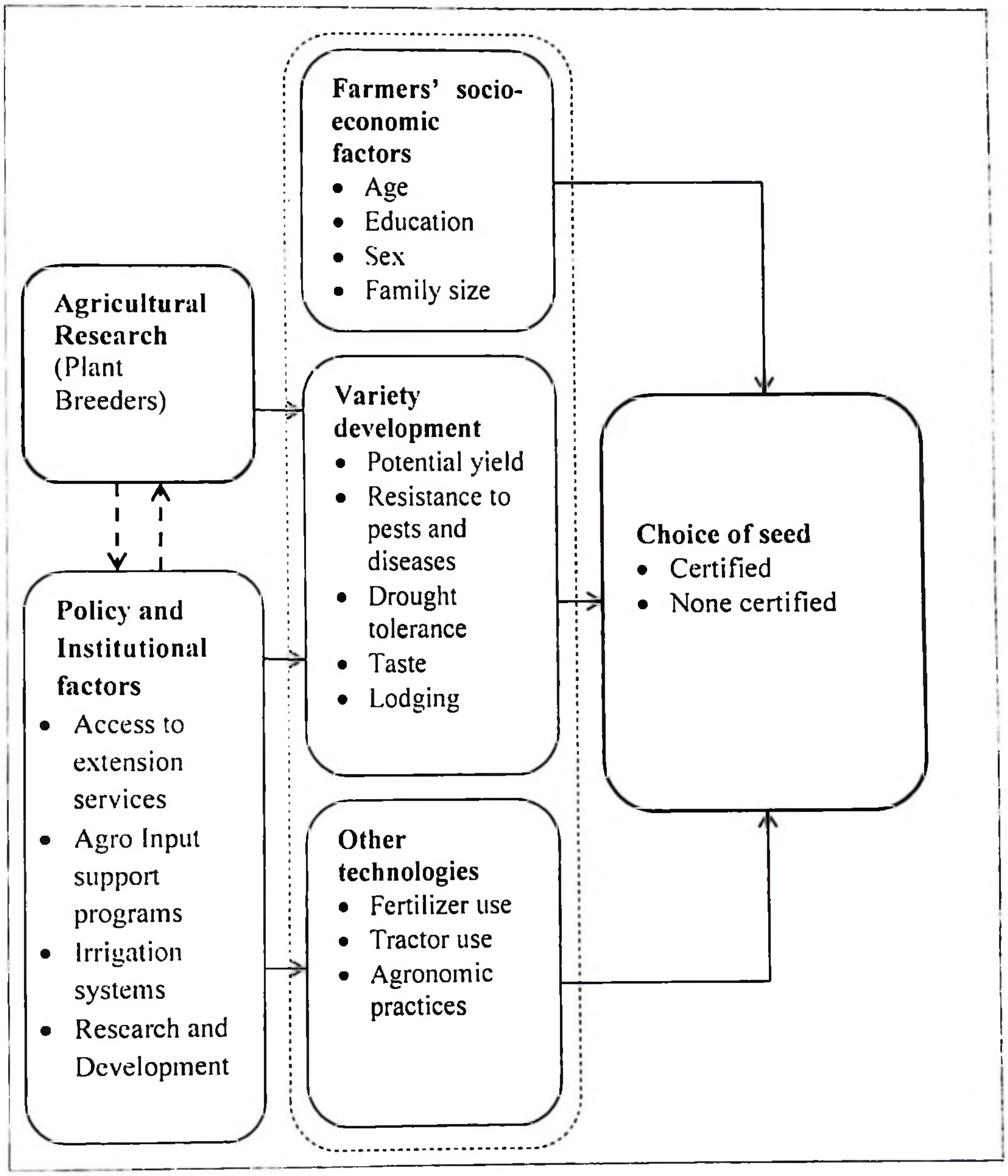

Figure 1: Research conceptualization

CHAPTER THREE

3.0 METHODOLOGY

3.1 Area of the Study

The study was conducted in twenty regions of Tanzania mainland, where farmers who grow maize from all seven agro-ecological zones were selected to participate in a survey. Most farmers in these agro-ecological zones including the Lake zone, Northern zone, Eastern zone, Southern Highland zone, Southern zone, Western zone, and Central zone depended on rain availability. Farms size ranges from 0.5 to 75 ha which were located at altitude ranging from 0 – 1500 m above sea level with varied climatic condition.

Figure 2: Map of Tanzania showing agro-ecological zones

Classifying agro-ecological zones depends on various factors such as altitude or rainfall. However, with the on-going climate change effects it is therefore proposed to classify the zones according to location, where crops are grown (Kaliba *et al.*, 1998). Although maize production is more favourable in high rainfall areas such as the southern highlands, lake zone, and northern zone, maize is also produced in the central zone, which often suffers from drought. Nonetheless, about half of all the maize produced in Tanzania comes from the Southern Highlands (Temu *et al.*, 2011; Wilson and Lewis, 2015).

3.2 Research Design

The research design for this study is cross sectional. This is a kind of research design in which the data are collected at a single point in time from a sample to represent a large population. The design is suitable in descriptive study and for determination of the relationship between and among variables. It is also economical in terms of time and financial resources (Babbie, 1993). Moreover the design was considered to be sufficient in addressing study objective.

3.3 Theoretical Framework

Studies on seed adoption have been guided by the consumer behaviour theory to determine attributes of improved maize seed varieties that are most preferred by smallholder farmers. The analytical methods for studying individual preferences were based on the consumer behaviour theory (Ben-Akiva *et al.*, 1985), which purports that individuals choose from among alternative bundles of goods and services with the objective of maximizing their utility. Lancaster (1966) extended the consumer theory with an assertion that the direct source of utility for consumers is the intrinsic attributes that a good possesses rather than the good itself. Consumers will then strive to attain a product with attributes they most desire under their budget constraint.

One way to measure consumer preference for attributes of the improved maize seeds is the farmers' willingness to use the improved maize seed varieties based on seed' attributes. Smallholder farmers are assumed to be consumers of agricultural technology inputs and hence categorised as users and non-users of improved maize seed varieties depending on whether they adopt or not. As illustrated by Vishwanath (2003) adoption is a mental process. An individual passes through stages first from hearing about an innovation up to the final utilization. The decision to use a technology is a behavioural response arising from a set of alternatives and constraints facing the decision maker.

The choice of improved maize seeds is discrete in nature, which involves 'either-or' choices. Models of qualitative choice are therefore relevant for analysis (Pindyck *et al.*, 1991). Since the dependent variable in these models is not continuous, the Ordinary Least Square (OLS) regression model is inappropriate (Pindyck and Rubinfield, 1991). Furthermore, due to the problem of heteroscedasticity, OLS estimates of β will not be efficient. If statistical inference is based on the parameters estimated, it may lead to the wrong conclusion. The Logit and probit models are more appropriate because of the discrete nature of the dependent variable.

3.4 Analytical Framework

(i) Objective One

In order to address the first specific objective, which intended to characterize farmers' preferences for improved maize seed varieties, descriptive statistics were used. These include percentages and frequencies for socio-economic characteristics of the smallholder farmers' such as age, sex, education level, family size and farm size, which are analysed in relation to the farmers' preference for improved maize seed varieties.

(ii) Objective two

The second objective intended to assess the heterogeneity of farmers' preference of improved maize seed varieties. Cross-tabulation was used to check for the existence of any correlation between agro-ecological zones and maize attributes preferred by farmers. Farmers' preference of improved maize seed variety attributes were measured based on a three level scale, namely; (i) as not favoured, (ii) no option or (iii) favoured, depending on a number of maize seed attributes, which include; potential yield, number of days to maturity, drought resistance, lodging, pests and diseases resistance.

Table 3: Respondents in each agro-ecological zone by maize seed varieties (n = 930)

Varieties	Zone							Total	(%)
	Lake N=300	Northern N=128	Eastern N=91	Southern Highland N=92	Southern N=115	Western N=150	Central N=54	N=930	N=100
PAN 6549	38	9	7	8	17	32	13	124	13.3
SC 627	75	32	8	28	22	43	7	215	23.1
SC 713	85	17	8	15	9	21	5	160	17.2
STAHA	3	0	42	1	19	2	12	79	8.5
KILIMA	24	3	3	6	4	14	7	61	6.6
DK 8371	3	29	0	1	10	3	5	51	5.5
OTHERS	72	38	23	33	34	35	5	240	25.8

These maize seed attributes were correlated with farmers' preference in all agro-ecological zones. The chi-square test was used to test for the relationship between agro-ecological zones and improved maize seed. It was found that thirty four improved maize seed varieties were used by farmers varying from one location to another (Appendix1), however, only six which are most preferred as presented in Table 3.

(iii) Objective three

In order to determine factors that influence farmers' choice of the most preferred improved maize seed variety as addressed by the third objective, a binary logistic regression model through maximum likelihood estimation procedures was used. The dependent variable used was farmers' choice of improved maize seed variety. The probability of farmers choosing certified maize seed was given the value of '1' while that of non-certified seeds was given the value of '0'. The model relates the probability of the explanatory variable asseccing which farmers chossing to adopt improved seed variety to the independent variables, such that the probability lies between 0 and 1. The logistic cumulative probability function of the farmers who choose to use improved maize seed varieties is represented by equation (1) which is simplified as follows;

$$P_i = E[y = 1|x_i] = \frac{1}{1 + e^{-Z_i}} \quad \ldots (1)$$

$$P_i = \frac{1}{1 - e^{-z_i}} \quad \ldots (2)$$

$$P_i = \frac{1}{\frac{e^{z_i} + 1}{e^{z_i}}} = 1 \div \frac{e^{z_i} + 1}{e^{z_i}} \quad \ldots (3)$$

$$P_i = 1 \times \frac{e^{z_i}}{e^{z_i} + 1} \quad \ldots (4)$$

$$P_i = \frac{1}{1+e^{-Z}} = \frac{e^Z}{1+e^Z} \quad \ldots (5)$$

Where:

P_i = The probability of the i^{th} farmer choosing to use the certified seed varieties; P_i is nonlinearly related to the linear combination of multiple explanatory variables.

e =represents the base of natural logarithms.

If P_i is the probability that the i^{th} farmer choosing to use the improved seed varieties then, (1-P) represent the probability of farmers who do not choose to use improved maize seed varieties as given in equation (5)

$$P_i = \frac{e^{z_i}}{e^{z_i} + 1} \quad \ldots (6)$$

$$1-P_i = 1-\frac{e^{z_i}}{e^{z_i}+1} \text{..(7)}$$

$$1-P_i = \frac{(e^{z_i}+1)-e^{z_i}}{e^{z_i}+1} = \frac{1}{e^{z_i}+1} \text{..(8)}$$

$$1-P_i = \frac{1}{1+e^{Z_i}} \text{..(9)}$$

Dividing equation (5) by equation (9), the odds ratio in favour of farmers who choose to use improved maize seed variety is given as follows:

$$\frac{P_i}{1-P_i} = \frac{\frac{e^{z_i}}{1+e^{z_i}}}{1-\frac{e^{z_i}}{1+e^{z_i}}} = \frac{\frac{e^{z_i}}{1+e^{z_i}}}{\frac{1+e^{z_i}-e^{z_i}}{1+e^{z_i}}} \text{..(10)}$$

$$\frac{P_i}{1-P_i} = \frac{e^{z_i}}{1+e^{z_i}} \div \frac{1}{1+e^{z_i}} \text{..(11)}$$

$$\frac{P_i}{1-P_i} = \frac{e^{z_i}}{1+e^{z_i}} \times \frac{1+e^{z_i}}{1} = e^{z_i} \text{..(12)}$$

$$\frac{P_i}{1-P_i}\text{(odds ratio)} = \frac{1-e^{Z_i}}{1-e^{-Z_i}} = e^{Z_i} \text{ ....(13)}$$

In order to estimate the Logit model, the dependent variable was transformed by taking the natural logarithm of equation 13 to obtain;

$$L_i = \ln\left(\frac{P_i}{1-P_i}\right) = \ln e^{Z_i} = Z_i = \beta_0 + \beta_1 X_1 \ldots + \beta_{11} X_{11} + \mathcal{E} \text{ ....(14)}$$

Where;

L_i = Log of odds ratio, X_n= explanatory variables of the model, **β_0 is the constant, β_1 for $i = 1$ up to 15 are coefficients to be estimated** and $\mathcal{E}$ = an error term.

The model which was used for empirical estimation is given in equation 15

$$Y_i = \beta_0 + \beta_1 S + \beta_2 MAR + \beta_3 AGE + \beta_4 EDU + \beta_5 EXT + \beta_6 HHS$$
$$+ \beta_7 FS + \beta_8 DIST + \beta_9 YLD + \beta_{10} D2 + \beta_{11} D3 + \beta_{12} D4 +$$
$$\beta_{13} D5 + \beta_{14} D6 + \beta_{15} D7 + \varepsilon_i \text{..(15)}$$

Where;

$Y_i = L_i$ = Log of odds ratio $\left(\frac{P_i}{1-P_i}\right)$ in relation to the use of improved maize seed varieties where 1 represent a farmer who used certified seed and zero for farmer who did not use certified seed

β_0 = Constant

β_i = Coefficients of explanatory variables estimated for i=1 up to i=15

ε = An error term

S=Sex

MAR=Marital status

AGE=Age of the household head (years)

EXT=Access to extension services

HHS=Household size

FS= Farm size

DIST=Distance to the market in km

YLD=Yield in kg/ha

D= Zones

3.5 Description of Variables

(i) Age

The age of the household head positively influences the farmer's decision to choose certified improved maize seeds varieties. Age is a human capital variable that reflects the ability of the respondent as a manager of the farm. Older household heads are expected to be more experienced in farming and therefore make better farming decisions, including the use of good quality seed. However, younger household heads may be more innovative and less risk averse which can make them to be more likely to use certified improved seeds. So the expected sign on the coefficient for this variable is positive.

(ii) Education

Education which is measured by the number of years in school was expected to have a positive effect on using certified improved maize seed varieties the sense that the more time (in years) the farmer spent in school the more knowledgeable they become.

Moreover, education also has an implication on the ability of decision making within the household. Education was therefore expected to increase the probability of using improved maize seed varieties.

(iii) Sex of the household head

Male-headed households are hypothesized to be more inclined to use certified improved maize seed varieties compared to female headed ones, because they have more resource, better access to information and therefore able access seeds through the formal sources than female-headed households. The coefficient for the male sex is therefore expected to have a positive sign.

(iv) Distance to the market

Distance is expected to have a negative influence because the longer the distance to the market the higher the cost of transports which effectively reduces the returns to maize production. Thus, farmers who stay far from markets are less likely to choose improved maize seeds. The distance to the market was measured in kilometers by considering distance from the farm to the market. It is therefore expected that this variable will negatively affect the choice of improved maize seeds, hence a negative sign on the coefficient.

(v) Farm size

The economic status of farmers positively influences access to improved maize seed. Land size could be viewed as important in enhancing access to credit, capacity to bear risks and access to scarce inputs such as certified seeds. Land size measured in acres is therefore hypothesized to positively influence the farmers to use of improved maize seeds.

(vi) Access to extension services

Extension service is a major source of agricultural information that is required by farmers to make decisions regarding the choice of maize seed. More contacts with extension service providers for information delivery on maize seed use are likely to result in better farming decisions by households including use of improved maize seeds. This study hypothesizes that contact with extension agents will have a positive influence on the choice of improved maize seeds.

(vii) Expected Maize Yield

The farmers' expectation of yield from a particular variety is used to capture farmer's incentives for choosing to use improved maize seeds. Farmers who use improved maize varieties are expected to obtain higher maize yields under normal conditions and favourable farm management practices, and therefore have an incentive to buy improved seed. These farmers are more likely to buy and plant improved maize varieties than those who plant maize varieties with lower yields. It is therefore hypothesized that high expected maize yield positively influence the choice of variety improved maize variety seeds. Expected maize yield was quantified in kilograms by the considering quantity harvested per unit area.

(viii) Zone

It is hypothesed that the use of improved maize seed variety is highly influenced by agro-ecological zone. In fact the zones have different characteristics in terms of weather, soils hence they are likely to support different types of seed varieties which is reflected in the farmers' uptake of the innovation within each zone. Furthermore, the zones are influenced by soil quality, moisture, availability of water and distance above the sea level. For instance, farmers in the southern highlands, southern and northern zone are expected to have high yield through the use of improved maize seeds compared to other arid zone with less fertile sandy soils.

All the information regarding the definition of variables and the expected coefficient signs are summarised in Table 4.

Table 4: Expected signs for the coefficients

Variable (X_S)	symbol	Unit	Expected sign	Description
Sex (X_1)	G	Dummy	+	1= male 0= female
Marital status (X_2)	MAR	Dummy	+	1= if farmer is married 0= otherwise
Age (X_3)	AGE	Years	+	Measured in years
Education level (X_4)	EDU	Years	+	Measured in years spent in school
Access to extension service (X_5)	EXT	Dummy	+	1= if farmer access extension service 0 = no access
Household size (X_6)	HHS	Number	+	Measured in number of household members
Farm size (X_8)	FS	Acres	+	Measured in acres
Distance to market (X_9)	DIST	Kilometre	+	Measured in kilometer
Yield (X_{10})	YLD	Kg/ha	+	Measured in kg
Zone		Dummy	+	1= if farmer belongs to specific zone 0= otherwise

3.6 Type of Data and Source

The data which were used in this study originated from a survey that was conducted by the Tanzania National Panel Survey for which the household survey was carried out in 2012/2013. Prior to the survey, formal survey instrument was prepared and trained enumerators collected the data from the sampled maize producing households. The survey was conducted using face-to-face interviews. Data from the survey were stored in a database, accessible at the National Bureau of Statistics website.

The database has a total of 2,233 respondents. For the purpose of this study 930 households were selected from the database for data analysis according to the response of those who had information on improved maize seed varieties. Respondents were selected from all seven agro-ecological zones of Mainland Tanzania.

3.7 Sample size and Sampling procedures

The survey covered 2,233 sampled households as representative at the national population of maize growing farmers. Purposive sampling was employed in data collection to choose respondent who had used improved maize seed. The sample size of 930 households was selected from the database for data analysis. According to the National Bureau of Statistics the sample allowed analysis at three primary domains of inference, namely: Dar es Salaam, other urban and rural areas of mainland Tanzania.

3.8 Data Collection

Using a structured questionnaire data was collected from smallholder farmers in each agro-ecological zones in Tanzania. The survey collected data on input-use including labour, seed use, fertilizer, agricultural chemical and other variables characterized households. Those variables were included in the analysis of smallholder farmer's preferences to identify farmer's choice for improved maize seed varieties. The variables were age, sex, education level of farmer, household size, access to extension services, size of the cultivated land, and income from cultivated crop as well as farming experience in years.

3.9 Data Analysis

Data from the National Panel Survey were entered into Microsoft Excel spread sheets. Then the data were organized and coded for analysis using the Statistical Package for Social Science (SPSS) computer programme.

For the first specific objective, descriptive analysis was done computing frequency and percentages, obtain the proportions of farmers under different preference categories based on their age, sex, education level, marital status and access to extension services.

For the second specific objective, apart from computing frequencies and percentages, the Chi square test was used to assess whether there was a relationships between farmers' preference for the most preferred improved maize varieties and socio-economic characteristics as well as other factors related to the farmer.

The third specific objective was analysed using binary logistic regression based on the model in equation 15, to determine factors influencing the farmer's choice of improved maize seed varieties through empirical analysis.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

The study was conducted to determine smallholder farmers' preferences for improved maize seeds varieties in Tanzania, involving, 930 male and female farmers from seven agro-ecological zones of mainland Tanzania. The data for this study were collected in 2012/2013 by the Tanzania National Panel Survey using structured questionnaire in seven (7) agro-ecological zones of Tanzania. The study determined the farmers' preference for maize seed varieties from among 34 varieties that were at their disposal. The study also determined socio-economic and other factors which influenced farmers' choice of improved maize varieties.

4.1 Characterisation of Smallholder Farmers in All Agro-ecological Zones in Tanzania

The survey showed that more than half of the farmers had tertiary education (52.9%) and these farmers were in their productive age being less than 45 years. Out of the above propotion, 39.8% were males and 13.1% were females. Furthermore, 28.7% had primary education and the rest had secondary education and this represents a very high literacy rate (Table 5). Other sources of data however indicate that more than half the population had attained primary education and very few have attained secondary or tertiary education. For example, the study conducted in Mbeya and Morogoro (Monela, 2014) demonstrated that majority of farmers (61.5%) had attained primary education and only 1% had tertiary education.

However, when disaggregated by gender, it was found that male farmers were more educated than females at all levels of education. For example 43.2% of the farmers with tertiary education were males compared to only 11.6% for females (Table 5). This implies that smallholder maize production in Tanzania is dominated by farmers in their productive age, majority being men and literate, most having tertiary education. In relation to this study, a study conducted in Nigeria by Adeogun *et al.* (2010) revealed that young farmers are energetic and spends time in obtaining information on improved technologies. Similarly, Busari *et al.* (2015) found that younger farmers tend to be more innovative than older farmers. Furthermore, educated farmers are generally open to innovative ideas and new technologies as reported earlier by Weir and Knight (2000).

Moreover, smallholder farmers in Tanzania have social and economic characteristic that when fully utilized together with adequate and available extension services, maize production is more likely to increase significantly. In fact the readiness of maize farmers to use improved maize seed varieties increases due to the high level of literacy which make them open-minded when it comes to learning and implementing new technique as noted earlier by Adeogun *et al.* (2010) and Busari *et al.* (2015).

Table 5: Socio-economic characteristics of the respondents (n = 930)

Variable	Category	Frequency	Male (%)	Female (%)	Total (%)
Sex	Male	695			74.7
	Female	235			25.3
Age	14 - 45	492	39.8	13.1	52.9
	46 - 60	268	22.7	6.1	28.8
	60 +	170	12.1	6.1	18.3
Education	Primary	267	17.4	11.3	28.7
	Secondary	153	13.1	3.4	16.5
	Tertiary	510	43.2	11.6	54.8
Marital status	Single	16	0.9	0.8	1.7
	Married	771	70.5	12.5	83.0
	Divorced	71	2.5	5.1	7.6
	Windowed	72	0.8	6.9	7.7
Access to	Yes	98	8.3	2.2	10.5
extension	No	832	66.3	23.2	89.5

Source: Author

Generally, smallholder maize farming in Tanzania is labour intensive and depends on household manpower or available labour such as spouse, children and relatives for various farm operations (e.g. land preparation, planting, weeding, and harvesting). This study revealed that 83% of the household heads are married and therefore their spouse, children and relatives provides family labour force which helps the farmer to reduce cost of outsourcing labour force for various farm activities. These findings are consistent with those of another study conducted by Leake and Adam (2015) who reported that households with high labour force readily adopts new technologies such as improved upland maize varieties than those with less labour force.

In relation to source of information or new technologies, this study revealed that only 10.5% of the farmers had access to extension services, whereby 8.3% were males and 2.2% females (Table 5). Extension staffs form a major link between farmers and research institutes, centers, or breeders, helping farmers to adopt new innovations and improved farm management practices. However, the supply of extension services is low since only one out of ten farmers had access to extension staffs. This remains a stumbling block for farmers, limiting their ability to get information on new innovations.

In addition, the gender imbalance observed in accessing extension services seemed to push females far away from new innovations in all agro-ecological zones. This is however explained by the fact that women tend to spend extra hours after farm activities on various household chores and childcare. Meanwhile, men had more time to attend meetings, various social gathering, or even visiting extension staffs. Similar findings were reported by Omiti *et al.* (1999) who noted that constraints in accessing extension services leads to poor dissemination of new technologies to farmers. In addition, several studies has demonstrated the importance of extension services in adopting new technologies, increasing farmers' awareness to new technologies and its implementation (Paudel and Matsuoka, 2008; Tura *et al.*, 2010; Umeh and Chukwu, 2013; Tiamiyu *et al.*, 2014; Leake and Adam, 2015). Along the same lines, Kabanyoro *et al.* (2003) found that access to extension services significantly explains the farmer's willingness to adopt rice intercropping technologies.

Besides the fact that socio-economic characteristic of farmers do play an important role in the selection and adoption of agricultural technologies, the specific choice of a particular variety is highly influenced by the traits of seed variety. It is therefore equally important to give due consideration to such seed traits in crop breeding process.

4.2 Heterogeneity of Farmer's Preferences for Improved Maize Seed Varieties

The second objective of this study was to assess the heterogeneity of farmers' preferences for improved maize seed varieties. The farmers' opinion on maize seed varietieswas assessed to determine the most preferred improved maize seed varieties and the attributes they embody. Inferential Chi-square test was used to establish any existing relationship between agro-ecological zone and farmers' preferences.

(i) Farmers' opinion on most preferred improved maize varieties attributes

The choice of farmers for a particular variety was considered to be an expression of their maize variety preference. Out of 34 maize varieties reported by farmers, six of the most preferred improved maize seed varieties included PAN 6549, SC 627, SC 713, STAHA, KILIMA, and DK 8371. These were chosen by farmers in different zones depending on their ability to resist drought and diseases, potential yield and day to maturity. The optimum production of these maize varieties were recommended at altitude ranging from 500 to 1600 masl where most of the maize producing zones are located (Appendix 2). Opinions about their preference for six of the most preferred maize seed variety were assed based on three levels. A farmer indicated whether a variety was; (i) favoured, (ii) not favoured, or (iii) they had no opinion as presented in Table 6.

Table 6: Farmers preference of maize variety of Maize Seed Preference by zone

	Maize Varieties	PAN6549 N=124	SC 627 N=215	SC 713 N=160	STAHA N=79	KILIMA N=61	DK 8371 N=51	Others N=240	Total N=930
	Preference	Number of respondents							
Lake	Favoured	9	12	13	1	15	1	16	67
	No opinion	13	24	26	1	5	2	33	104
	Not favoured	16	39	46	1	4	0	23	129
Northern	Favoured	4	3	3	0	3	4	14	31
	No opinion	3	18	8	0	0	16	15	60
	Not favoured	2	11	6	0	0	9	9	37
Eastern	Favoured	2	2	1	8	3	0	6	22
	No opinion	4	6	4	20	0	0	7	41
	Not favoured	1	0	3	14	0	0	10	28
Southern Highland	Favoured	3	4	2	0	6	0	7	22
	No opinion	4	14	8	1	0	1	7	35
	Not favoured	1	10	5	0	0	0	19	35
Southern	Favoured	2	4	2	2	3	2	17	32
	No opinion	9	6	2	10	1	2	7	37
	Not favoured	6	12	5	7	0	6	10	46
Western	Favoured	10	8	4	0	8	1	12	43
	No opinion	8	16	8	1	4	1	9	47
	Not favoured	14	19	9	1	2	1	14	60
Central	Favoured	7	1	1	2	6	0	0	17
	No opinion	2	5	1	2	1	0	2	13
	Not favoured	4	1	3	8	0	5	3	24

SUMMARY FOR ALL ZONE

	Maize Seed Variety							
Preference	PAN 6549 N=124	SC 627 N=215	SC 713 N=160	STAHA N=79	KILIMA N=61	DK 8371 N=51	Others N=240	Total N=930
	% Response in all zone							
Favoured	4	3.6	2.8	1.4	4.7	0.9	7.7	25.1
No opinion	4.6	9.6	6.1	3.8	1.2	2.4	8.6	36.3
Not favoured	4.7	9.9	8.3	3.3	0.6	2.3	9.5	38.6

Farmers' varying preferences for improved maize seed variety across zones may be attributed to zonal differences in disease incidences, soil fertility and climate. The main criteria farmers use in choosing maize varieties they grow depends on the traits of variety as presented in Appendix 1. These traits include days to maturity, yield, colour of maize grain, stalk lodging, root lodging, drought and disease resistance of improved maize seed varieties.

In this study, among thirty four varieties that were tested, six varieties were highly favoured in all agro-ecological zones. These were; KILIMA, Pannar - PAN 6549, Seed Co - SC 627, SC 713, STAHA and DK 8371 (Table 6). Farmers preferred these varieties due to drought resistance, high yields and early maturity days –traits. It was noted that there is variation on how the traits influenced the farmers' preference. For example some farmers opted for high yielding traits with low days to maturity, while other farmers gave priority to disease and pest resistance. Although a farmer's choice of a particular improved seed variety is guided by many criteria, it was found that most farmers preferred to have most of the traits of their choice combined in a particular seed variety. Alternatively stated, farmers prefer maize varieties that carry different traits according to their feelings and needs.

High yielding varieties were highly preferred by most farmers than other traits of these varieties. However, farmers in Hai and Moshi rural districts demonstrated that attributes they consider to be important in selecting their maize seed varieties were; drought tolerance, disease resistance and early maturity (Sonda, 2008). Hence, when targeting for higher maize production it is better for the farmers to consider improved maize seed varieties that has several traits combined together as opined by Edilegnaw (2005) thata choice over high yielding capacity attribute for instance reflectsfarmers' view of maintaining yield or income maximization as an important criterion forselecting maize varieties.

Table 7: Relationship between agro-ecological zone and farmers' preference of improved maize seed varieties

Farmers' preference	zone				Chi square	P- value
	Favoured	No opinion	Not favoured	Total		
Lake (%)	11.3	6.5	14.4	32.2	56.133	.000
Northern (%)	8.7	2.5	2.4	13.6		
Eastern (%)	5.2	1.8	2.6	9.6		
Southern Highland (%)	5.1	1.6	3.3	10		
Southern (%)	4.5	2.4	5.5	12.4		
Western (%)	6.2	2.7	7.4	16.3		
Central (%)	1.5	1.0	3.4	5.9		
Total	**42.5**	**18.5**	**39**	**100**		

Furthermore, the agro-ecological zone variable has been identified as important factor influencing farmers' preferences of improved maize seed varieties used. The results in Table 7 shows that 42.5% of the respondents favoured the six most preferred improved variety. Respondents in the Lake zone reflected the highest proportion indicating preference (11.3%) whereas in the Central Zone reflected the lowest expression of preference (1.5%) for the most preferred improved maize seed varieties. The analysis also showed that 39% of the respondents did not favour the six most preferred improved maize seed varieties, while 18.5% had no opinion. The highest proportion of the respondents who did not prefer those six improved maize seed varieties (14.4%) were in the Lake zone and the least (2.4%) were in the Northern zone. The chi-square value of 56.133 ($p<0.001$) indicated that there is high significance different in percentage of farmers using the six most preferred improved maize seed varieties, which is used in this study as a proxy for their preference.

From among the six varieties it was further established that three varieties reflected a higher level of preference in all agro-ecological zones, they includes SC 627, SC 713, and PAN 6549. These same varieties are also recommended by TOSCI (2009) for low and higher –altitudes ranging from 500 – 1500m above sea level. Similarly, Ransom *et al.* (2003) and Kaliba *et al.* (2000) found that there is a positive relationship between altitude and adoption of improved maize varieties, for example farmers in lowland areas use improved maize varieties more than farmers in highland areas; On the contrary Cavane and Suvedi (2009) reported that farmers on the highlands of Mozambique were readily adopting improved maize seed varieties that had traits for drought tolerance and high quality maize meal, which are found in SC513. It can therefore be said that preference to improved maize seed variety depends on variety traits and its adaptability to a particular zone. Moreover, findings from this study indicate that there is variation in the use of improved maize seed varieties across the seven agro-ecological zones in Tanzania, which is in line with the hypothesis that there is variation in farmers' preference of improved maize seed varieties between farmers in agro-ecological zones in Tanzania.

While the knowledge that farmer's choice is based on various maize traits is useful by plant breeders and policy makers, yet this does not inform about those factors which influence the farmers' choice of improved maize seed varieties. It is therefore important to find identify those factors which significantly influence the farmers' choice so that can be taken into consideration when developing and disseminating information on improved maize seed varieties for specific areas. Also, apart from the fact that the analysis which has been presented shows the behaviour of farmers in adopting maize seed varieties it is only a partial analysis comparing two factors at a time. In practice, these factors interact simultaneously. It is therefore important to assess the collective effect of all the independent variables on the farmers' choice of seed varieties.

4.3 Factors Influencing Farmers' Choice of Improved Maize Seed Varieties

The binary logistic regression model was used to determine the effects of socio-economic and agro-ecological zone on the smallholder farmers' choice of improved maize seeds varieties as presented in equation 15. Results from the binary logistic equation indicate that the variables influencing the use of improved maize seed varieties did contribute to the variation of the dependent variable between 17.1% and 22.9% as explained by Cox and Snell R square and Nagelkerke R square values (Table 8). According to Tabachnick and Fidell (2001), the best goodness of fit for binary logistic regression model is indicated by "p" values of the Omnibus tests and Hosmer and Lemeshow tests. For statistical significant probabilities of these tests should be less than 0.05 and greater than 0.05 respectively. Based on this, the model was statistically significant (P = 0.0001) as shown by the Omnibus tests of model coefficients with a Chi square value of 174.027. Similarly, Hosmer and Lemeshow test indicates that the model represents good fit of the data as indicated by the Chi square value of 4.3 and significant level of p=0.829 which is greater than 0.05 (Table 8). Results in Table 8 show that the Wald statistics for all variables are non-zero values. According to Norusis (1990) and Powers and Xie (2000), the non-zero Wald statistic values indicate the presence of relationships between the dependent and explanatory variables. Thus, on the basis of the results of this study the null hypothesis was rejected in favour of the alternative hypothesis stating that socio-economic factors significantly influence the use of improved maize seed varieties at 5% level of significance.

Table 8: Factors influencing farmer's choice of improved maize seed varieties

Variables	B	S.E.	Wald	Df	Sig.	Exp(B)
Sex	.144	.171	.708	1	.400	1.155
Age	.005	.005	1.273	1	.259	1.005
Marital status	.018	.161	.013	1	.910	.982
Education level	.041	.171	.057	1	.812	.960
HH size	.052	.027	3.762	1	.050**	.950
Farm size	.434	.196	4.926	1	.026**	.648
Harvested yield	.001	.001	5.253	1	.022**	1.000
Distance to market	-.001	.166	.384	1	.535	.902
Access to ext.	.103	0.258	1.970	1	.160	0.697
ZONE						
Lake	1.373	.318	18.638	1	.000***	3.946
Northern	2.492	.380	43.109	1	.000***	12.086
Eastern	-.835	.358	5.453	1	.020**	2.305
Southern Highland	1.125	.364	9.547	1	.002***	3.081
Southern	.545	.368	2.191	1	.139	.580
Western	19.556	40187.631	.000	1	1.000	.000
Constant	16.015	40187.631	.000	1	1.000	9024713.411
Cox and Snell R^2	17.1%					
Nagelkerke R^2	22.9%					
X^2	coefficient	df	p-value			
Omnibus test of model	174.027	16	.000			
Hosmer and Lemshow test	4.300	8	.829			

Note: $p \leq 0.05$ **
$p \leq 0.01$***

Dependent variable: choice of seed either certified or non-certified

Based on the model presented in Table 8, it was found that among 10 variables tested only four variables had significant coefficients, which are the household size, farm size, harvested yield and some agro-ecological zones (Lake, Northern and Southern Highland - zone). The coefficient for the Eastern zone was also highly significantly different from zero but it was negative implying that the farmers from Eastern zone had a lower preference for the six most preferred improved maize seed varieties compared to respondents in the Central zone. The remaining variables were positive and significantly different from zero included: household size, farm size and harvested yield. Other variables including; age, sex, marital status, education level and extension services had positive coefficients but they were not significant different from zero. Discussion for variables presented in Table 8 is detailed in following sections.

4.3.1 Sex

Male-headed households was hypothesized to be more inclined to the use of improved maize seed varieties compared to female headed ones, because they have more resources, better access to information and therefore able to access seeds through the formal sources than female-headed households.Furthermore, the package of adoption process requires a lot of labour thus high adoption rate is expected from male-headed households. Results from Table 8 showed that sex influenced positively but statistically insignificant to farmers' preference of using improved maize seed varieties.

4.3.2 Age

Age of the household head was thought to be a very important variable because it is believed that age is related to the experience with regard to use of agricultural technologies but based on the Wald statistics of the independent variables, it was found to have a positive but statistically insignificant influence on the farmers' preference of using improved maize seed varieties.

4.3.3 Marital status

Marital status of respondents was thought to influence farmers' adoption of improved maize seed varieties for the assumption that, marital status and the roles played by the different members of a given household, directly determines the transfer of agricultural technology. In addition, marital status of households is usually used to determine the stability of a household in African families. Besides, economic welfare of a household is affected by the marital status of the household head. In general, economic welfare is lower for households with a household head who divorced, as compared to the one who remains married or remarries (Montalto and Gerner, 1998). Results for the study showed that marital status of the household heads was positive and insignificant influencing farmers' preference of using improved maize seed varieties.

4.3.4 Education level

Another very important aspect expected to influence farmer's adoption of improved maize variety was educational background of household heads. People with higher educational levels are more able to cope with new technologies than those who have less education. Contrary to that assumption, results from Table 8 showed that education level has a positive but insignificant influence on farmer's adoption of improved maize variety.

4.3.5 Household size

Household size has a positive and significant influence on the choice of improved maize variety. An increase in household labour tends to increase the level of using improved maize seed varieties. For each additional family member in the household, there is an increase of 5 % more likely to use improved maize seed varieties, holding other variables constant. This suggests that a large family size provides more labour for farm operation and an increased incentive to produce more farm output at the same time cutting the cost of hiring labour from outside. Household size was used as a proxy for labour availability in the family and it may influence income earnings as well as expenditure. As Conteh *et al.* (2015) pointed out farming in most rural areas in developing countries depends on human labour, hence household size influences diversification in farming activities as multiple activities within the household requires more labour. Moreover, the findings of this study conform to those obtained by Feder *et al.* (1985) in a study about adoption of agricultural innovations in developing countries. Feder, established that family size positively influenced adoption of agriculture innovations because of labour requirements for various farm activities. For that matter, an increase in household size creates an opportunity of increasing farm size due to labour availability as previous indicated by Wilson and Lewis (2015).

4.3.6 Farm size

The coefficient for farm size was positive at 0.434, being significantly different from zero ($p \leq 0.026$). This implies that a farmer who has a large farm size is more likely to use improved maize seed varieties compared to those with small pieces of land for crop production because farmers with large farms size seeks for profit. Farmers who own large pieces of land can afford to be more experimental because for them even a relatively small percentage of their total land may be large enough to support land-intensive technology. Land size could influence the use of improved maize seed varieties as farmer may portion a certain part of land for testing the newly certified improved seed varieties compared to people with small land sizes. Similarly, Simtowe *et al.* (2012) reported that farm size influenced adoption of various improved agricultural technologies, as observed earlier that the adoption or uptake of an innovation such as the use of improved maize seeds, fertilizer use, disease control and many more in farming enterprise tend to increase crop yield per unit area. Hence, with an increase in farm size there is a possibility of an increase in maize yield per unit increase of the crop area. It never ends there, but also this improves farm productivity and farmers' well-being.

4.3.7 Harvested yield

Yield is an important factor that can influence the use of improved maize seed variety among farmers. The results showed that harvested yield positively and significantly influenced the likelihood of farmers using improved maize seeds varieties ($p<0.022$).

These findings confirm the hypothesis that potential yield expectation for a particular variety positively influences the choice of improved maize seeds varieties.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, establishing that technology profitability in terms of high yields was significant in influencing adoption decision for using improved maize seed varieties. Nevertheless, different varieties of maize crop may show variations in crop yields in various agro-ecological zones, regardless of the fact that some maize varieties like SC 627 and SC 713 are recommended for a wide range of agro-ecological zones. It is therefore imperative for farmers of a particular zone to choose and use varieties recommended for their respective agro-ecological zones. It is therefore worth saying that, from this study the yield potential of a particular maize seed variety plays a crucialrole in influencing farmers' preference of a particular maize seed variety.

4.3.8 Distance to market

The coefficient for distance to the market was negative but not significantly different from zero, implying that as the distance covered to the market increases, it lowers the farmers' preference for improved maize seed variety.

4.3.9 Access to extension services

This variable measured the number of times a farmer had with the agricultural extension officers. Contact between farmers and the agricultural extension staff was found to be of low frequency. It implies that most of farmers were visited only once and were given agricultural information orally. Without field demonstrations, they perceived the information as irrelevant to their region in relation to their farming habits and usual skills.

4.3.10 Agro-ecological zone

The binary logistic regression model results showed that out of seven agro-ecological zones, three zones had a statistical significant probability of the farmer choosing the six most preferred improved maize seed variety. These are Lake (β = 1.373, $p<0.001$), Northern (β = 2.492, $p<0.001$) and Southern Highland (β = 1.125, $p<0.002$). The Eastern zone (β = -0.835, $p<0.020$) was less likely to adopt the six most preferred improved maize seed varieties as compared to other zones. The implication of this finding is that agro-ecological zone influences the use of the six most preferred improved maize seed varieties, although in the Eastern zone there was a negative influence compared to the Central zone, which is used as the base. In fact the agro-ecological zones have different characteristics in terms of climate and soils qualities hence they are likely to support different types of maize seed varieties which is reflected in the farmers' uptake of the innovation within each zone. As such, the difference in farmers' preference for improved maize seed varieties in zones was statistically significant. These findings are consistent with reports from Nigeria and Nepal by Fadare *et al.* (2014) in Nigeria and Kafle (2010) which demonstrated that agro-ecological zone was a major determinants of the rate at which farmers use improved maize seed varieties.

The study findings revealed that majority (74.7%) of the households were male-headed and (83%) were married. About 90 percent of the farmers had no access to extension services that is supposed to play an important role in agricultural information dissemination. The most preferred improved maize varieties in all zones were PAN6549, SC 627, SC 713, STAHA, KILIMA and DK 8371due to higher production potential. A Logit model showed that agro-ecological zones, farm size, household size and yield positively influenced the likelihood of farmers' choice of improved maize seed varieties.

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The general objective of this study wasto determine attributes of improved maize seed varieties that are most preferred by different groups of smallholder farmers in Tanzania. In order to achieve the stated objective several activities were carried out, which include; characterizing smallholder farmers preferences for improved maize seed varieties in relation to their socio-economic characteristics, assessing the heterogeneity of farmers' preferences of improved maize seed varieties and determining factors that influence farmers' choice of the most preferred improved maize seed varieties based on the findings as presented in chapter four, the conclusion is pursued as follows.

Farmers' socio-economic characterizations showed that majority of the households head were married, therefore the spouse, children and relatives increased the manpower required for various farm activities. Whenever farmers have enough manpower they tend to look on the possibility of increasing their farm size so that they can increase production. Although over fifty percent of the farmers had tertiary education, only 10 percent had access to extension services. Farmers are therefore deprived of the right to agricultural information and their capacity for adoption of new innovations so that they increase farm production and productivity.

Farmers' varying preferences for improved maize seed variety across zones may be attributed to agro-ecologic zone differences in potential yielding, disease incidence, maturity day, drought and lodging. The most preferred varieties in all agro-ecological zones were SC 627, SC 713 and PAN 6549, which demonstrated to have higher yield compared to the rest of improved maize seed varieties.

Among socio-economic characteristics and others factors of the farmers that were found to significantly influence the farmers' choice of improved maize varieties were household size, farm size, and harvested yield as well as some of the agro-ecological zones. Moreover, except for the Eastern zone, the remaining agro-ecological zones had a positive significance influence on the use of improved maize seed varieties, and the variation in the use of the improved maize seed varieties across agro-ecological zones was significant for the Lake, Northern and Southern Highland zone.

5.2 Recommendations

In view of the major findings and the above conclusion, the following recommendations are drawn:

i. Maize being a staple food in majority of Tanzanian household and a cash crop for some households; its production and productivity is vital for social and economic well-being of smallholder farmers. For sustainable maize production it is recommended that breeder should focus their maize breeding efforts in those agro-ecological zones that perform best such as Lake, Southern Highlands and Northern zones while other crops that are well adapted to the other zones and are preferred by farmers in the other zones receive more research attention to breed for farmer-preferred traits for those crops as well for ensuring food security across the nation.

ii. The study revealed high preference of six improved maize seed variety in all agro-ecological zones. It is therefore recommended that dissemination of improved maize varieties to farmers should focus on these rather that spreading resources too thinly among 34 different varieties which is currently the case.

iii. This study revealed that farmer's choice for improved maize seed variety was determined by potential yield among other criteria. Therefore it is imperative for breeders to consider farmers views, accommodating their preference, and needs when developing maize seed varieties.

5.3 Recommendations for Future Research

i. There is a need for further researches concerning the role of extension service to enhance adoption of improved seeds varieties. The majority of rural people are using local seeds because they have little knowledge on the improved seed. This may be attributed to poor performance of extension services and this state of nature constitutes a big challenge to overcome for the government, researchers and donors. Despite the approval of the new Seeds Act, the certification and release of new seed varieties is still slow, indicating a need for improving the institution and framework for seed derivery which includes improving the extension services.

ii. More research should be done on seeds attributes that influence farmers' preferences. For example, most studies have researched on pest and diseases tolerance trait, drought resistance trait but few studies have researched on seed cook ability trait, palability trait and aroma. Researchers should therefore explore more on improved seed traits that tend to influence farmers' preferences for seed varieties containing those atributes.

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APPENDICIES

Appendix 1: Improved maize varieties attributes

VARNAME	COLOUR	MMATURITY (Months)	YIELD (Tons/Ha)	HCOB (m)	HPLANT (m)	Root*	STALK*	LEAFBRIGHT*	COBDISEASE*	DROUGHT*	MAIZESTALK*	GREYLEAFSPOT*	MSV*
C 5051	White	4.7	12.5	1.2	2.4	1	1	1	2	2	2	2	3
C 6222	White	5.3	12.5	1.8	3	2	2	2	2	2	3	3	4
CG 4142	White	4.5	4.8	1.1	2.2	1	1	1	5	2	3	3	4
CRN 3631	White	4.8	8.1	1	2	2	2	2	3	2	2	2	2
CRN 3891	White	4.6	8.5	1.6	2.7	1	1	1	2	3	2	2	3
DK 8031	White	4.3	6.5	1.4	2.5	1	2	1	2	2	3	1	2
DK 8051	White	4.7	7.5	1.1	2.4	2	2	2	1	3	2	1	2
DK 8071	White	4.8	8.5	1.6	2.6	1	1	1	2	3	2	1	3
katumani	White	3	3.25	1	1.5	1	1	3	2	3	2	3	3
kilima	White	4.5	5.5	1.1	2.2	1	1	3	2	4	2	3	1
Kito	White	3	2.5	1	1.5	1	1	3	2	4	2	3	3
PAN 4M-17	White	4.2	5	1.4	2.4	2	2	2	2	2	2	2	2
PAN 4M-19	White	4.4	5.5	1.5	2.5	2	2	2	2	2	2	2	2
PAN 6195	White	5	6	1.6	2.6	1	1	2	2	4	2	2	1
PAN 63	White	5.6	6.5	1.7	3	1	1	2	2	3	2	2	2
PAN 6549	White	5.3	6	1.6	2.6	1	1	2	2	2	2	2	1
PAN 691	White	6.8	7	2	3.2	2	2	1	2	1	2	1	2
PHB 30A15	White	4.5	7.5	1.6	2.7	1	1	1	1	2	2	1	2
SC 403	White	4.4	3.5	1.4	2.6	2	2	3	1	1	1	4	1
SC 407	White	4.6	4.5	1.4	2.6	2	3	2	3	2	3	3	2
SC 513	White	4.5	6.5	1.6	2.8	5	3	2	3	3	5	2	5
SC 627	White	4.8	7.5	1.7	2.9	4	3	3	3	3	2	1	2
SC 713	White	6.1	9.5	1.7	2.9	2	2	2	4	3	1	2	1
situka 2	White	4.4	5	0.9	1.9	1	1	3	2	1	2	4	2

Situka-M1	White	3.5	4.5	1	2	1	1	1	2	1	2	4	2
Staha	White	4.5	4.5	1.1	2.1	1	1	3	2	2	2	3	2
TAN 250	White	3.8	4.5	0.9	2	1	2	2	2	2	2	2	3
TMV 1	White	3.8	4.3	1.8	2.5	2	2	3	2	2	2	2	2
TMV 2	White	6.2	7.5	1.5	2.2	1	1	1	2	2	2	3	2
Tuxpeno	White	4	3.5	1.5	2.5	2	2	2	2	2	2	2	2
UCA	White	4.6	5	1.5	2.7	2	1	4	2	1	2	4	3
PAN 33	White	5.3	10	1.8	3	1	1	1	3	3	3	1	2
PAN 15	White	4.9	7	1.8	3	1	1	2	2	3	2	2	2
PAN 77	White	5	7	1.6	2.7	1	1	2	2	3	2	2	2

***Standability and disease reaction scores**

1 : Absence of symptoms

2: Low presence of symptoms

3: Moderate symptoms

4: Heavy symptoms, the whole plant bears the symptoms except the panicle

5: The plant is almost dying

Appendix 2: Maize seed varieties and their special characteristics

Variety	Year of release	Owner(s)	Optimal production altitude range (Masl)	Grain yield (t/Ha)	Special attributes/Remarks
Katumani	Late 1950's	KARI - Katumani	<1500	3.0 – 3.5	Suitable in areas with short rainfall
Tuxpeno	1976	ARI - Ilonga	0 -900	3.0 -4.0	Suitable in coastal and lowland areas
Kilima St	1983	ARI - Ilonga	900 -1500	5.0 – 6.0	Streak tolerant
Staha	1983	ARI - Ilonga	0 -900	4.0 5.0	Streak tolerant
Kito	1983	ARI -Ilonga	0 -1300	2.0 – 3.0	Suitable in drier areas
TMV – 1	1987	ARI - Ilonga	<1500	4.0 – 4.0	Streak and rust resistant
TMV – 2	1987	ARI - Uyole	>1500	7.5 – 8.0	Resistant to *Turcicum* leaf blight
CG4142	1993	Cargill Zimbabwe (PTY) Ltd	900- 1500	4.8	Ear rot, leaf blight and leaf rust resistant
C6222	1994	Cargill Zimbabwe (PTY) Ltd	900 - 1500	10.0 – 15.0	Tolerant to ear rot, leaf blight(*Helminthosporium turcicum* Pass) and leaf rust (*Pucinia sorghi*)
C5051	1999	Cargill - Zimbabwe	1000 - 1600	10.0 – 15.0	Resistant to blight leaf (*Helminthosporium turcicum* Pass), leaf rust (*Pucinia sorghi*), ear rot
CRN3631	1999	Monsanto Hybrid Seeds Co.	900 - 1500	8.1	Resistant to ear rot. Moderately tolerant to

					maize streak virus and grey leaf spot
PHB30A15	1999	Pioneer Seed Co. Ltd	1000 - 1500	5.0 – 10.0	Partial resistance to maize streak virus. Tolerant to grey leaf spot.
					Very resistant to leaf blight and ear rot
Situka-M1	2001	AR-Selian	1000-1500	3.0-5.0	Tolerant to maize streak and
					Grey leaf spot. Resistant to *Diplodia, Fusarium* leaf bright and *Puccinia sorghi*
Situka 2	2001	AR-Selian	500-1600	4.0-6.0	Tolerant to maize streak and grey leaf spot Resistant to *Diplodia, Fusarium,* leaf bright and *Puccinia sorghi*
CRN 3891	2001	Mansanto Hybrid Seeds Co.	900-1500	8.0-9.0	Moderately tolerant to maize streak virus
DK 8071	2001	Monsonto Hybrid Seeds Co.	1000-1600	8.0-9.0	Tolerant to grey leaf spot and rust
DK8051	2002	Monsanto Hybrid Seed Co.	120-140	6.0-9.0	Excellent tolerance to grey leaf spot
DK8031	2002	Monsanto Hybrid Seed Co.	100-110	5.0-8.0	Good tolerance to grey leaf spot.
SC 407	2003	SEED CO. Ltd	500-1400	1-8	Good stress tolerance and fairly good tolerance to Grey leaf Spot (GLS). Has good tolerance to Maize Streak Virus (MSV)
SC 403	2003	SEED CO. Ltd	500-1400	1-6	Very good adaptability and stress tolerance, good lodging resistant
					Very good resistant to MSV, good resistant to cob rots and leaf blight, and moderate rust rust

					resistance
SC 513	2003	SEED CO. Ltd	500-1400	4-9	Moderate resistant to Cob rots and good resistant to Leaf blight (*Helminthrosporium turcicum*) and Rust resistance
					Excellent tolerant to grey leaf spot
					Prone to *Phaeosphaeria* leaf spot
					Good adaptability and stress tolerance
SC 713	2003	SEED CO. Ltd	500-1400	6-13	It has excellent tolerance to Maize Streak Virus (MSV) and good tolerance to Gley Leaf Spot (GLS)
SC 627	2001	Seed Co. Ltd	500-1400	5.0-10.0	Excellent resistance to grey leaf spot. Moderately resistant to rust and resistant to leaf blight.
					Good stress tolerance, lodging resistance and prolificacy.
					Has very good adaptability
					Rust resistance: average
PAN 15	2001	Pannar Seeds Co. Ltd	500-1500	7.0	Tolerant to maize streak virus, grey leaf spot , northern leaf blight, Rust, ear rot
PAN 77	2001	Pannar Seeds Co. Ltd	>1500	7.0	Tolerant to maize streak virus , grey leaf spot, northern leaf blight , Rust, ear rot
PAN 691	2001	Pannar Seeds Co. Ltd	>1500	7.0	Tolerant to maize streak virus, grey leaf spot,

					northern leaf blight, Rust, ear rot
PAN 15	2001	Pannar Seeds Co. Ltd	500-1500	7.0	Tolerant to maize streak virus, grey leaf spot , northern leaf blight, Rust, ear rot
PAN 77	2001	Pannar Seeds Co. Ltd	>1500	7.0	Tolerant to maize streak virus , grey leaf spot, northern leaf blight , Rust, ear rot
PAN 691	2001	Pannar Seeds Co. Ltd	>1500	7.0	Tolerant to maize streak virus, grey leaf spot, northern leaf blight, Rust, ear rot
PAN 33	2003	Pannar (Pty) Ltd	850 - 1500	4-7	Good resistant to *Maize StreakVirus*, Cob rots, Leaf blight (*Helminthrosporium turcicum*) and Leaf rust
PAN 63	2003	Pannar (Pty) Ltd	850 - 1500	5-8	Good resistant to *Maize StreakVirus*, Cob rots, Leaf blight (*Helminthrosporium turcicum*) and Leaf rust
PAN 4 M-17	2004	Pannar (Pty) Ltd	0- 1500	4-6	Good resistant to Cob rots, Leaf blight (*Helminthrosporium turcicum*), and Leaf Rust
					Good adaptability, stress tolerance, lodging resistance, and prolificacy
PAN 6195	1995	Pannar Seeds Co.Ltd	1000 - 1500	6.0	Tolerant to maize streak, intermediate resistant to ear rot and leaf blight
TAN 250	2006	Tanseed International Ltd	Low to medium	3-5	Excellent resistance to Maize streak virus and Grey leaf spot, good resistance to Turcium leaf blight, Cob rot and Common rust
UCA	1976	ARI-Ukiriguru	900-1500	4.0 – 6.0	Suitable in drier areas