ADOPTION OF DROUGHT TOLERANT MAIZE VARIETIES AMONG SMALLHOLDER MAIZE FARMERS IN KAMULI AND MASINDI DISTRICTS

BY

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DECLARATION

I, JOSEPH KAKURU declare that this thesis is not a duplication of another researcher’s work and that to the best of my knowledge, this work has not been submitted to any institution including the Directorate of Research and Graduate Training of Makerere University for any award.

Signature .................................... Date .................................. 15/02/2019

This thesis has been submitted to the Directorate of Research and Graduate Training for examination with approval of my University supervisors.

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DEDICATION
To my parents late Kamuratsi Gerivazio and Mrs Paskazia Kamuratsi who led me on my first day to School.
ACKNOWLEDGEMENT

I would like to extend my sincere appreciation to all people who assisted me in making my Master’s degree and this research work a success. Special thanks go to my supervisors, Dr. Peter. N. Walekhwa, Dr. Gabriel Elepu, and Dr. Robert Mulebeke for their technical support and guidance.

I also acknowledge RUFORUM and Kyambogo University for the financial support rendered towards my Master’s degree, without which I couldn’t have made it.

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In a special way I want to thank my wife Edith Kakuru and our daughters Akankwatsa Precious and Ainembabazi Treasure for withstanding my little time at home during the study period.

May the almighty God reward all of you abundantly.
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<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>MAAIF</td>
<td>Ministry of Agriculture Animal Industry and Fisheries</td>
</tr>
<tr>
<td>OPVs</td>
<td>Open Pollinated Maize Varieties</td>
</tr>
<tr>
<td>UBOS</td>
<td>Uganda Bureau of Statistics</td>
</tr>
<tr>
<td>NARO</td>
<td>National Agricultural Research Organization</td>
</tr>
<tr>
<td>FAO</td>
<td>Food and Agriculture Organization of the United nations</td>
</tr>
<tr>
<td>USAID</td>
<td>United States Agency for International Development</td>
</tr>
<tr>
<td>MT</td>
<td>Metric tons</td>
</tr>
<tr>
<td>SPSS</td>
<td>Scientific Package for Social sciences</td>
</tr>
<tr>
<td>FAOSTAT</td>
<td>Food and Agriculture Organization Statistics</td>
</tr>
<tr>
<td>WEMA</td>
<td>Water Efficient Maize for Africa</td>
</tr>
<tr>
<td>OECD</td>
<td>Organization for Economic co-operation and Development</td>
</tr>
<tr>
<td>JB</td>
<td>Jarque Bera</td>
</tr>
<tr>
<td>OFSP</td>
<td>Orange Flesh Sweet Potatoes</td>
</tr>
<tr>
<td>DTM</td>
<td>Drought Tolerant Maize</td>
</tr>
<tr>
<td>DTMFs</td>
<td>Drought Tolerant Maize Varieties</td>
</tr>
<tr>
<td>PSFU</td>
<td>Private Sector Foundation Uganda</td>
</tr>
</tbody>
</table>
ABSTRACT

Drought tolerant maize varieties (DTMs) are a great contributing factor in addressing the challenge of low maize yields for most rural households who continue to suffer prolonged drought periods as a result of climate change. The overall aim of this study was to assess the status of adoption of drought tolerant maize varieties (DTMs) by smallholder farmers in Masindi and Kamuli districts. Using survey data from 190 farm households, the study sought to characterise smallholder maize farmers in the two districts, assess Drought Tolerant maize attributes preferred by smallholder maize farmers, determine the rate of adoption and factors that influence the adoption of drought tolerant maize varieties in Masindi and Kamuli districts. The results indicated that adopters and non-adopters of drought tolerant maize (DTM) varieties significantly differed in terms of marital status, main occupation, access to credit, self-sufficiency in maize production, age, income, years of schooling, land owned, area under maize, experience in maize production and quantity of maize produced. Results also showed that limitations such as high prices, limited awareness, fertilizer requirement, limited access to seed and susceptibility to pests and diseases were responsible for poor adoption of DTMs. In addition, the most highly ranked DTM variety attributes by farmers was grain yield (66.3%). Other attributes that were preferred by farmers included; drought tolerance (18.9%), early maturity (13.7%), grain-flour ratio (9.5%), pests and diseases resistance (5.3%), tolerance to poor soils (1.1%) and lodging resistance (0.5%). The key factors influencing adoption of DTM were; awareness of drought tolerant maize varieties, experience in maize farming, level of formal education, distance to the source of seed, occurrence of drought and the price per kilogram of maize seed. It is thus recommended that more emphasis be put on extension and farmer trainings to increase awareness of the available DTMs. In addition to this, government programmes involved in provision of maize seed to farmers, such as Operation Wealth Creation (OWC) and other development partners should consider procurement of DTMs for supply to drought prone areas. Drought tolerant maize breeding programmes should try to incorporate early maturity, high yielding, weight, bigger grain, more cobs per plant since they were highly ranked by smallholder.
CHAPTER ONE
INTRODUCTION

1.1 Background to the Study

1.1.1 Overview of the Maize Sector in Uganda

Maize is one of the strategic crop enterprises in Uganda selected for development by government because of its increasing contribution to household income, foreign exchange earnings and food security (MAAIF, 2015). In terms of area planted, maize is the third most cultivated crop after banana and beans with the crop replacing sorghum, millet, cassava and banana in some regions as a staple food (UBOS, 2012). The maize sector is a source of livelihoods to about 3.6 million households, with close to 1,000 traders and over 20 exporters also deriving their livelihoods from the crop (FAO, 2012). In the districts of Kapchorwa, Kiryandongo, Mbale, Masindi, Iganga, Kamuli and Kasese, the crop is more of a cash crop with approximately 75-95% of the crop harvest being sold to earn income (NARO, 2010).

The main maize production agro-ecological zones are in the west, east, north and south east of Uganda with the eastern region accounting for over 50% of annual production. The area under maize has been increasing in the past years with the total crop production of 2,482,795 MT in 2016 produced from about 1.13 million hectares of land (UBOS, 2017). However, the same land area has the capacity of producing 7.5 million MT if high yielding and drought tolerant maize varieties and fertilizers are used (NARO, 2010). Production of maize is influenced by changing climatic patterns and the planting intentions of farmers especially the need to produce output that is in excess of their subsistence requirements. In the last two decades, the overall trend of production, area and yield shows that the growth in maize production has mainly been due to area
expansion rather than yield improvement. This is mainly due to the use of poor seeds and limited use of yield enhancing technologies such as fertilizers and drought tolerant varieties resulting from modern biotechnology as shown in Figure 1.

Figure 1: Maize Area, Production and Yield Trends in Uganda from 2008 to 2014.

Source: UBOS 2015.

From Figure 1, both the area and production of maize in Uganda have been increasing overtime. Harvested area increased from around 1.052 million hectares in 2008 to 1.103 million hectares in 2014. Production also increased from 2.315 million tonnes in 2008 to 2.868 million tonnes in 2014. However, maize yields increased only slightly from 2.2 tons per hectare in 2008 to 2.6 tons per hectare in 2014. This shows that increase in maize production is mainly due to increase in the land area under production which increased with increased production rather than increase in yields which stagnated throughout the same period. Therefore, maize production in Uganda is characterized by low yields which results in high per unit costs and low returns (FAO, 2012).
1.1.2 Consumption and Utilization of Maize in Uganda

The growing cost of traditional staple foods has led to increased consumption of maize and maize products especially in urban areas (USAID, 2010). In Uganda, over 70% of maize is consumed as food and about 10% is used as animal feeds in form of maize bran with the remaining balance used by factories to process formulations used in making local brew and export (Okoboi et al., 2012). The demand for value added products such as maize flour and animal feeds is increasing especially in urban centers where maize is gaining importance both as a major food item and poultry feeds for income generation (FAO, 2012). Uganda’s maize export potential is estimated between 200,000 and 250,000 MT per year but only about half of this is achieved (USAID, 2010). The main regional markets for Uganda’s maize include Kenya, Rwanda, South Sudan, Burundi, Zambia, and Democratic Republic of Congo with Kenya being the largest importer, through formal and informal market channels accounting for approximately 50% of the total maize exports (NARO, 2010). Maize is sold across borders through Mutukula for Tanzania, Busia for Kenya and Gatuna for Rwanda with most of cross border trade being informal. Of all the five countries neighboring Uganda, Kenya dominates the informal export destinations followed by DRC, Southern Sudan, Rwanda and Tanzania (FAO, 2012).

According to UBOS (2017), formal maize and maize flour exports in 2016 are estimated to have generated over USD 70.3 million export earnings from an estimated 268,465 tons which represents 12% of the maize produced in the same year but informal trade is thought to be exceedingly more than the formal trade which is estimated to be 724,155 tons of maize and 232,566 tons of maize flour in 2013. Annual time series data for domestic consumption is unavailable but about 40.5% of maize produced is consumed locally (UBOS, 2017). The value of
informal maize grain and flour exports to neighboring countries in 2014 and 2015 were estimated at USD 43.567 and 91.055 million, respectively (UBOS, 2017). This export potential offers a huge incentive for investment in strategies that increase maize production and productivity of which DTMs is a priority due to increased episodes of climate change.

1.1.3 Maize Yield Performance among Smallholder Farmers in Face of Climate Change

Smallholder farmers refer to households with small asset base and operating less than 2 hectares of crop land (World Bank, 2003). Smallholders can be geographical or biophysical, due to production technologies and institutional constraints such as lack of access to credit and insecure land rights. These constraints may limit the attractiveness and participation of smallholder farmers in the adoption of improved agricultural technologies (Barrett et al., 2010). In Uganda, these smallholder farmers produce nearly 100% of the maize grain consumed and marketed (UBOS, 2010). Therefore tackling challenges limiting such smallholder producers in regard to maize production goes a long way in increasing both production and foreign exchange earnings from such a lucrative enterprise.

Climate change has resulted into less than predictable rains thus affecting maize yields for the majority of smallholder farmers in Uganda. The increased water stress to crops as a result of climate change leads to more than 50% losses in the yields of smallholder farmers especially during the years of extended drought because of these farmers’ dependence on rain fed agriculture (PSFU, 2010). Maize crop failure due to drought has been rampant in many parts of the country causing up to 80% yield losses in the crop harvests especially amongst the drought prone areas of south western, eastern, north eastern and northern Uganda (NARO, 2010). Maize crop yields in the country have since 2008 been oscillating between 2.2 and 2.6 metric tons per hectare with the
years of 2009, 2012 and 2014 experiencing some slight increase in the yield per hectare compared to the previous years (UBOS, 2015). In the year 2014 alone, maize yields were reported lowest in northern Uganda at 1.4 metric tons per hectare and highest in eastern Uganda at 3.2 metric tons per hectare as in the table1 below. Low maize yields in the northern Uganda can be attributed to the low rainfall experienced in most parts of the region. The region experiences one rainy season that is usually followed by longer dry periods at the end of the season (Ronner and Giller, 2013).

**Table 1: Maize Production, Area and Yield by Region in Uganda in 2014**

<table>
<thead>
<tr>
<th>Region</th>
<th>Maize production (Mt)</th>
<th>Area (Ha)</th>
<th>Yields (Mt/Ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central</td>
<td>546,240</td>
<td>205,683</td>
<td>2.7</td>
</tr>
<tr>
<td>Eastern</td>
<td>1,346,062</td>
<td>422,776</td>
<td>3.2</td>
</tr>
<tr>
<td>Northern</td>
<td>371,312</td>
<td>269,459</td>
<td>1.4</td>
</tr>
<tr>
<td>Western</td>
<td>604,385</td>
<td>205,083</td>
<td>2.9</td>
</tr>
</tbody>
</table>

Source: UBOS, 2015

The on-farm yields in table 1 indicate lower than the research station yields of 8 Mt/Ha for hybrids and 5 Mt/Ha for Open Pollinated Varieties (OPVs) (Iga, 2013). This is an indication that better yields could be achieved through use of improved inputs such as drought tolerant maize varieties (DTMs) and yield enhancing technologies like fertilizers (Okoboi *et al.*, 2012). In addition to yield variations with respect to regions, maize performance has also been seen to vary in relation to the different varieties. Mugisha and Diiro (2010) reported the difference between the local and improved varieties with local varieties yielding 1.7 Mt/ha against 2.9 Mt/Ha for improved varieties in the districts of Nakasongola and Soroti. The variations in yield of the different improved varieties are shown in Figure 2.
The yields in the Figure 2 indicate varying levels for the different varieties grown by smallholder maize farmers. In all the varieties, yield is still below the expected station levels for the respective improved varieties. This is an indication that these improved varieties still perform below the expected yields. Therefore, a careful selection of improved varieties that are suitable for a particular region like, the drought tolerant maize varieties for drought prone areas with due consideration of other attributes like resistance to pests and diseases, tolerance to poor soils, grain-flour ratio, early maturity and lodging resistance is eminent for adoption of these drought tolerant maize varieties for improved maize production in Uganda. The increased production would increase food security and incomes of smallholder farmers since the crop has exhibited a great export potential to the neighboring countries.
1.1.4 Drought Tolerant Maize Varieties (DTMs)

Several drought tolerant maize varieties have been developed and released as a means of improving maize yields in Uganda. These varieties are mainly early maturing so as to escape the drought that comes after some short rains. Some of the DTM variety types, their year of release, maturity period and potential yields are summarized in the Table 2

Table 2: Selected DTM varieties and their Potential Yield in Uganda

<table>
<thead>
<tr>
<th>Variety name</th>
<th>Variety type</th>
<th>Year of release</th>
<th>Maturity period (days)</th>
<th>Potential yields (Mt/ Ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Longe 1</td>
<td>OPV</td>
<td>1991</td>
<td>115</td>
<td>4-6</td>
</tr>
<tr>
<td>Longe 4</td>
<td>OPV</td>
<td>2000</td>
<td>103</td>
<td>4-6</td>
</tr>
<tr>
<td>Longe 5</td>
<td>OPV</td>
<td>2000</td>
<td>115</td>
<td>4-6</td>
</tr>
<tr>
<td>MM3</td>
<td>OPV</td>
<td>2010</td>
<td>80</td>
<td>4-6</td>
</tr>
<tr>
<td>Longe 9H</td>
<td>Hybrid</td>
<td>2009</td>
<td>125</td>
<td>8-9</td>
</tr>
<tr>
<td>Longe 10H</td>
<td>Hybrid</td>
<td>2009</td>
<td>125</td>
<td>8-9</td>
</tr>
<tr>
<td>Longe 11H</td>
<td>Hybrid</td>
<td>2009</td>
<td>125</td>
<td>8-9</td>
</tr>
<tr>
<td>UH5051</td>
<td>Hybrid</td>
<td>2012</td>
<td>125</td>
<td>8-9</td>
</tr>
<tr>
<td>UH5052</td>
<td>Hybrid</td>
<td>2012</td>
<td>125</td>
<td>8-9</td>
</tr>
<tr>
<td>UH5053</td>
<td>Hybrid</td>
<td>2012</td>
<td>125</td>
<td>8-9</td>
</tr>
<tr>
<td>PAN 67</td>
<td>Hybrid</td>
<td>2000</td>
<td>120</td>
<td>6-8</td>
</tr>
<tr>
<td>WE 2101</td>
<td>Hybrid</td>
<td>2014</td>
<td>120</td>
<td>6</td>
</tr>
<tr>
<td>WE 2103</td>
<td>Hybrid</td>
<td>2014</td>
<td>120</td>
<td>4</td>
</tr>
<tr>
<td>WE 2104</td>
<td>Hybrid</td>
<td>2014</td>
<td>120</td>
<td>5</td>
</tr>
<tr>
<td>WE 2106</td>
<td>Hybrid</td>
<td>2014</td>
<td>120</td>
<td>6</td>
</tr>
<tr>
<td>WE2114</td>
<td>Hybrid</td>
<td>2014</td>
<td>120</td>
<td>6</td>
</tr>
<tr>
<td>WE2115</td>
<td>Hybrid</td>
<td>2014</td>
<td>120</td>
<td>6</td>
</tr>
</tbody>
</table>

Source: NARO, 2015

These Maize varieties are suitable for production in low and medium altitudes and are resistant to Maize Streak Virus (MSV), Northern Leaf Blight (NLB) and Grey Leaf Spot (GLP), the major foliar diseases that affect maize production (NARO, 2015). There is also another set of six drought tolerant maize varieties released in 2014 under the drought tolerant maize for Africa and the Water Efficient Maize for Africa (WEMA) project by NARO to farmers with an intention to
reduce the effects of drought using the most cost effective methods for African smallholder farmers (The African Centre for Biodiversity, 2017).

### 1.1.5 Role of Institutions in the Maize Sector

A number of institutions play various roles in the maize sector ranging from production to marketing. These include farmer co-operatives like Masindi Seed and Grain Growers Co-operative limited that train farmers in better agronomic practices, post-harvest handling, handling farming as a business, bulking and storage, demonstration plots for improved maize varieties, radio talk shows, seminars, extension visits and exposure visits to places with better farming practices. In addition, these co-operatives together with seed companies and Non-Governmental Organizations like One Acre Fund train farmers on improved maize varieties and help them to access seed on credit or through bulk purchases at lower prices (Ocaya and Kiwuwa, 2015).

Other organizations such as East African Grain Council, World Food Program, AFGRI, Warehouse receipt system under the commodity exchange and processors are involved in market access for the maize grain from the producers. However, despite all the above interventions smallholder farmers have difficulty meeting required quantity and quality standards limiting them from accessing markets used by large buyers and processors due to poor harvests caused by weeds, pests and climate change, improper post-harvest handling methods and poor access to improved seeds and fertilizers (Mwendya, 2012). Increased yields as a result of using DTMs enhance chances of obtaining better quantities which is a prerequisite for better markets. This in turn results into better revenues for smallholder farmers thus enabling such producers to afford value addition services such as post-harvest handling equipments for better quality maize.
1.2 Problem Statement

Maize production in Uganda is generally undertaken by smallholders with plot sizes averaging 0.58 hectares (UBOS, 2012). Production of the maize crop is to a larger extent characterized by low yields mainly due to various production constraints such as low soil fertility, limited use of improved maize varieties, erratic rainfall patterns as a result of climate change and drought stress during some seasons (Okoboi et al., 2012). Adoption of improved maize varieties could help increase maize yields among smallholder farmers since the two have been found to be associated although to yield levels that are still much less than the expected. The difference between the actual yields and potential yields has been attributed to risks associated with crop production such as drought together with pests and diseases (Mugisha and Diiro, 2010).

Crop failure as a result of drought for instance, can lead to about 80% crop loss with the magnitude of the problem being high in drought prone regions of eastern, western, north eastern and northern Uganda especially in the areas of Kasese, Karamoja districts, Kiruhura, Nakasongora and Bulisa (NARO, 2010). Increased use of drought tolerant varieties can translate into 25% increase in maize yields among farmers especially within drought prone areas (Abate et al., 2013). Such an increase in yields enhances food security, household incomes of smallholder maize farmers and government revenue generated through exports. In addition, drought tolerance is crucial for maize yields under drought prone conditions because of its influence on kernel formation which is essential for increased output (Edmeades, 2013).

However, distribution, awareness about and adoption of these DTMAs has remained low despite several interventions by seed companies and government (Cardno, 2015). Farmers mainly recycle seed and get maize seed mainly from agro input dealers. In addition, some seed companies have
established product ambassadors to help distribute seeds to smallholder farmers and eliminate counterfeits. This has been reinforced by establishment of training centers, use of mobile phones, advertising on radios and television, magazines, newspapers and product labels in a bid to increase farmer awareness about improved technologies (Larson and Mbowa, 2004, Cardno, 2015).

Despite the existence of many drought tolerant maize varieties on the market and concerted efforts by seed companies and government to promote DTMs, maize yields have continued to be very low and sometimes reaching catastrophic low levels especially during drought periods among the drought prone areas such as Kasese, Bulisa and Nakasongola. In other parts of the country, maize yields are also still far much below the national average yields as a result of climate change effects that result into less than predicted rains (NARO, 2010). This suggests that farmer adoption of drought tolerant maize varieties is still low in Uganda.

Past adoption studies conducted in Uganda have mainly focused on the adoption of improved varieties per se and their effects on yield and on factors affecting adoption of improved maize production technologies (Ntege-Nanyenya et al., 1997; and Mugisha and Diiro, 2010). Mugisha and Diiro (2010), studied adoption of only three drought tolerant maize varieties namely; longe series 1, 4 and 5. However, many other DTMS have since been released with more distribution centers especially through agro dealers. This is expected to have an influence on accessibility, awareness and price of seed. That notwithstanding, yields have still remained low especially among drought prone areas, mainly due to climate change. Yet amidst these vagaries of climate change, the major hope for maize famers is in DTMs as discussed above. It is against this
background that this study seeks to assess the adoption of drought tolerant maize varieties among smallholder maize farmers in Kamuli and Masindi districts of Uganda.

1.3 Objectives of the Study

The overall objective of the study was to assess the effect of increased release of DTMs and distribution centers using agro input dealers on awareness and adoption of drought tolerant maize varieties for improved maize yields among smallholder maize farmers in the face of climate change in Uganda.

1.3.1 Specific objectives

The specific objectives of the study included the following;

1. To assess limitations to increased adoption of DTMs among smallholder farmers in Kamuli and Masindi Districts.

2. To assess the key attributes of DTMs most preferred by smallholder farmers in Kamuli and Masindi districts.

3. To determine factors that influence adoption of drought tolerant maize varieties by smallholder farmers in Kamuli and Masindi districts.

1.4 Hypotheses

The study was guided by the following hypotheses;

i. Expensive seed is the major limitation to increased adoption of DTMs among smallholder maize farmers in the study area.

ii. Drought tolerance is the most preferred attribute by smallholder maize farmers.
iii. Socio-economic, institutional and technological factors, such as education of the farmer, price of seed and occurrence of drought respectively significantly influence the adoption of drought tolerant maize varieties

1.5 Justification of the study

This study is timely in Uganda since climate change patterns have increasingly become a key constraint to agricultural production. Given the fact that maize is a major source of food and income to most Ugandans with production mainly coming from smallholder farmers, it is critical to find out factors that influence the adoption of drought tolerant maize varieties as one of the ways of ensuring improved maize production in the country. Results from this study will inform breeders, researchers, extension agents and policy makers on how to make the maize crop enterprise more productive by increasing maize yields by smallholder farmers in drought prone areas of Uganda. For sustainable development of smallholder maize farming, adoption of drought tolerant varieties is paramount since drought has been a major cause of yield loss among drought prone areas of Uganda. Therefore, information generated from this study will help policy makers to formulate suitable policies that ensure increased access of smallholder maize farmers to drought tolerant maize varieties for sustainable development and increased production of maize in Uganda.

1.6 Scope of the study

The study was conducted in Kamuli and Masindi districts focusing at the smallholder maize farmers and the factors that affect adoption of drought tolerant maize varieties in Uganda. These smallholder maize farmers consisted of farmers holding up to 2 hectares of land on which they
grow crops including maize for livelihood purposes. Data for this study comprised the first and second season of 2014 (March to December 2014). Results presented in this study have been derived from these data and interpretations are limited to the findings therein. The sample composed of farmers that had previously grown drought tolerant maize varieties for at least two consecutive seasons. The farmers were expected to have purchased the drought tolerant maize variety for each season without recycling in order to be referred to as an adopter. Otherwise the farmer would be referred to as a non-adopter.

1.7 Limitations of the Study

This study was limited to only two districts of Masindi in Mid-Western and Kamuli in Eastern Uganda. Because of this, the findings of this study may not be generalized beyond the study area. Given differences in cultural and ecological conditions, care must be taken not generalize this information to other regions. The data collected from the farmers involved two seasons which sometimes was hard for the farmers to recall all the necessary information accurately given that most farmers were not keeping record of varieties grown, quantities planted and harvested.
2.1 Maize Production and Productivity in Uganda

Maize consumption culture is growing in Uganda as a result of increased costs of traditional staple foods such as banana. Maize is consumed in various forms; as whole, as cake or as porridge. There is also increasing demand for value added products such as maize flour and poultry feeds especially in urban centers where maize is gaining importance both as a major food item and for income generation (FAO, 2012). The biggest percentage of maize production (40.5%) is sold within the domestic market estimated at 350,000 to 400,000 metric tons per annum. Uganda’s maize export potential is estimated between 200,000 and 250,000 metric tons per year but the country has only managed to formally supply half of this amount (UBOS, 2013). This indicates a huge opportunity for the country’s maize production to invest in productivity enhancing strategies. Use of DTMs offers an opportunity since productivity is likely to increase even when vagaries of climate change continue to challenge smallholder farmers. Official figures indicate that in 2014, maize is estimated to have generated over USD 43,567 million in export earnings from an estimated 134,903 tons (UBOS, 2015). Therefore, increased productivity as a result of use of DTMs easily translates to more export earnings and thus better incomes for the maize farmers.

The maize crop importance in Uganda can be boosted by increased adoption of high yielding improved varieties which have the capacity to perform better under limited resources and water stress conditions from the present adoption rate of 9% to at least 50% (Ajambo et al., 2017). To achieve better yields from maize production requires increased growth in adoption of drought
tolerant maize varieties that have been bred for altitudinal ranges of between 1000-1600 meters above sea level which covers the bulk of maize growing areas in Uganda (Abate et al., 2013). Thus DTM forms an appropriate and timely solution to water stress environment mainly caused by climate change among all maize producing areas of Uganda.

Maize is largely grown in two agro-ecological zones of mid-altitude and highland areas of Uganda. However, most (85%) of the maize is grown in the mid-altitude and the rest (15%) is grown in the highlands especially the Mt Elgon region. Regionally, the largest maize producer is eastern at 38%, followed by northern at 24%, central region at 19% and western region at 19% (Abate et al., 2013). Eastern Uganda, northern Uganda and most parts of the midland altitude are increasingly facing a problem of drought that in most cases has constantly reduced the yields from the crops grown. The condition has been made worse by the changing climate that has resulted into adverse conditions of less than predicted rains and floods which together destroy the crops in gardens and storage (PSFU, 2010). The changing climate has increasingly called for increased use of improved inputs in maize production. These improved inputs include high yielding, disease resistant and drought tolerant varieties, use of agro-chemicals like fertilizers, pesticides, fungicides and herbicides to ensure faster growth, equipment for tilling and irrigation and knowledge for better decision making to improve production through better operations (Okoboi et al., 2012). DTM forms thus crucial for increased maize production and productivity in majority parts of Uganda where water stress episodes have become a common phenomenon.

Smallholder maize farmers in Uganda are still characterized with low adoption rates for improved inputs because many of them think these inputs are inappropriate or expensive thus leading to low yields and returns. This is common in places that experience little amounts of rainfall in addition
to deteriorating soil fertility, pests and diseases (Obaa et al., 2005). Farmers have in most cases ranked drought first among constraints that limit maize crop production followed by low soil fertility and limited availability of improved inputs especially seeds (Mugisha and Diiro, 2010; Derera et al., 2006). This is supported by the findings of Obaa et al (2005) that drought and pests and disease tolerant maize varieties are preferred by farmers to high yielding varieties only because of the fact that even when the variety is high yielding only the prevalent drought and pests together with the diseases cannot allow the farmer to realize even the smallest yield from the crop. This means that maize varieties that are bred to withstand stress-prone environments and limited resources like fertilizers are most likely to be preferred by farmers. Otherwise, farmers have always preferred maize attributes in the order of high yielding, early maturity, tolerance to drought, pests and diseases, low cost of seed and tolerance to infertile soils (Obaa et al., 2005). Smallholder maize farmers being resource constrained need to embrace at least one of the many DTMs for better livelihoods as a result of increased yields, incomes and food security.

2.2 Benefits from Production of Drought Tolerant Maize Varieties

Drought has been one of the main risk factors to smallholder maize farmers in Uganda. These farmers largely lack access to and knowledge about small scale irrigation strategies that are suitable for their scale of operation and also lack knowledge on the use of soil conservation practices that maintain soil moisture (Mugisha and Diiro, 2010). Adoption of drought tolerant maize varieties is believed to increase maize productivity under drought stress conditions faced by smallholder farmers by 20-30% (La Rovere et al., 2014). Farmers that grow drought tolerant maize varieties prefer them because they are early maturing varieties. This quick maturity is an essential attribute that helps the maize to escape drought and give better yields unlike varieties
which may not escape drought due to more time before maturity. This makes the farmer lose everything planted to the drought that has become rampant as a result of climate change (Obaa et al., 2005). Adoption of drought tolerant maize varieties, therefore, increases farmer’s welfare gains and makes the farmers more resilient to drought and climate variability (Kostandini, 2015).

The adoption rates for drought tolerant maize varieties have been recorded low in most countries of Africa yet the continent is largely drought-prone with the vast majority of agriculture being rain-fed. As a result of these low adoption rates, the effects of drought such as crop failure, hunger, poverty and climate change have continued to manifest. The replacement of the adopted improved maize varieties with drought tolerant maize varieties only have been predicted to bring about the economic gain of $ 967 million under conservative gains or $ 1,535 million under optimistic gains by 2016 and thus contributing to poverty reduction in addition to reduction in hunger among all maize growing countries of Africa (La Rovere et al., 2014). Drought tolerant maize varieties provide long term benefits against drought related losses by stabilizing incomes and reducing production variability among smallholder farmers thus reducing their vulnerability to poverty and increase their welfare. This is because these varieties generate increased yields which translate into reduced unit costs to producers (Kostandini et al., 2009). Adoption of drought tolerant maize varieties and improvement in the cultural practices to conserve moisture for the crop helps farmers to maintain a minimum level of cash income and this would also cause an upward shift in the supply curve (Sserunkuma, 2002). Therefore, adoption of DTM is in itself not a sole solution to drought management but rather smallholder maize farmers need to be acquainted with soil fertility and moisture management knowledge. This includes among others use of affordable fertilizers, use of cover crops to conserve moisture and crop rotation.
2.3 Awareness of Improved DTMs and Technology Adoption

Getahun et al. (2000) defined adoption as the degree of use of a new technology in a long-term equilibrium when a farmer has all of the information about the new technology and it’s potential. Adoption of technological innovations in agriculture has attracted considerable attention among development economists. This is because, the majority of the population in less developed countries (LDC) depends on agricultural production and new technologies seem to offer an opportunity to increase production and income substantially (Feder et al. 1985).

Awareness of any agricultural technology is thus important for the adoption process and involves the farmers learning of the Existence of an innovation. Previous studies have revealed that farmers’ socio-economic characteristics play a great role in awareness, knowledge and adoption of new practices of farming. Study by Zivanomoyo and Mukarati (2013) revealed that the ability of farmers to adopt new farm practices depended on their awareness, financial position and nearness to extension personnel. To determine the factors that influence the adoption of recommended maize production technologies, there is need to know if the farmer is aware of the programme and sources of awareness. For successful adoption of any new technology, farmers must not only know about it but must also be able to follow the recommendations given. This then means that they must have the knowledge before they can follow the recommendation (La Rovere et al., 2014). Different regions are affected differently by the growing climate change effects thus requiring a shift to drought tolerant maize varieties in varying degrees (Abate et al., 2013). Drought tolerant maize varieties are grown mainly due to their early maturity, high yield and tolerance to field stress including pests and diseases (NARO, 2010).
According to Abate et al., (2013), Drought Tolerant Maize Variety adoption is influenced by climate (temperature and day length), soil characteristics and good agronomic practices and awareness of improved varieties which is mainly accelerated by access to media which suggests that there is potential for increasing the diffusion of new varieties through existing formal institutions and methods in the dissemination of information on improved varieties (Cardno, 2015). Accordingly, necessary efforts such as creation of awareness about the potential benefits inherent in the adoption of drought tolerant maize varieties should be increased in farmers’ education programs, more publicity about the varieties released through the media should also be intensified. According to Abate et al, (2013) more investment into the extension service delivery to sensitize maize farmers on the advantages of adopting DTMs in the face of increasing effects of climate change. There is therefore a general consensus that awareness forms an important precondition for adoption to occur, farmer knowledge of the improved varieties is neither random nor universal and may suffer from selection bias. Thus institutions involved in dissemination of improved varieties like DTMs which are crucial for smallholder maize producers need to ensure massive awareness to ensure that the great proportion of the population get information about these technologies. This study therefore, seeks to ascertain the level of awareness of DTMs among smallholder maize farmers since it forms a prerequisite to their adoption.

2.4 Adoption Process and Determinants of Technology Adoption

Adoption of DTMs is faced with numerous challenges that are mainly socio-economic and infrastructural problems. These include issues of smallholder farmers such as the availability of little excess capital to accommodate risks associated with new varieties such as drought tolerant maize varieties. This limits the adoption of such new varieties despite their low cost and
widespread availability. In addition, the presence of infrastructure necessary for accurate product information is also limiting. Also farmers prefer keeping their own seed which is only supported by open pollinated varieties and not for hybrids which are yet in most cases more yielding. Other challenges faced in the adoption of drought tolerant maize varieties include the regulatory framework especially for safety of genetically modified technologies and the need for extension since it plays a central role in exposing farmers to any improved technology (Edmeades, 2013). The adoption process takes time and requires commitment from institutions involved in the promotion of agricultural production and smallholder farmers who are expected to adopt these technologies. The adoption process involves a five-stage model which is called the “innovation-diffusion model”. Diffusion is defined as the spread of an innovation at the aggregate level viewed over time. This makes diffusion a cumulative process of adoption measured in successive time periods of five categories: innovators, early adopters, early majority, late majority and laggards (Rogers, 1993). DTMs have been released since 1991 to the latest ones in 2014. This has been enough time to evaluate their adoption process in terms of awareness, preferences and factors that influence their adoption. This is hoped to provide knowledge and information to concerned stakeholders for increased efforts to ensure better livelihoods among smallholder maize farmers.

2.4.1 The Adoption Process

The decision to adopt an innovation is a behavioral response arising from a set of alternatives and constraints facing the decision maker who in this case is a smallholder farmer (Ingold, 2002). Literature provides different definitions and explanations about adoption. Rogers, (1993) stated that adoption of a new technology must be preceded by technology diffusion. With diffusion here
being taken as a link between research, development and adoption. Several studies have reported that different agricultural technologies developed through research have been disseminated to the farming community in different parts of the region. However, only a small portion of the small-scale farmers adopt majority of the technologies (CIMMYT, 1993).

According to the economic constraints model, resource endowments are the major determinants of observed adoption behavior, where lack of access to capital and inadequate farm size could significantly impede adoption decisions (Rogers, 1993). The more technically complex the innovation, the less attractive it may be to many farmers. The decision on whether or not to adopt a new technology will be based on careful evaluation of a large number of technical, economical and social factors associated with the technology. The economic potential of new technology in terms of output, costs of production and profit is also very important factor for adoption decision. Typically, however, the economic impact of an innovation is not known in advance with certainty. Unfamiliarity with the new technology makes the initial impact on yields and input usage uncertain (Colman and Young, 1989). In this study, limitations to adoption of DTMs are evaluated to come up with remedies and ensure increased production and productivity.

2.4.2 Empirical Studies on Adoption of Agricultural Technologies

Empirical studies show that adoption is affected by several factors. CIMMYT (1993) identified factors affecting diffusion of a new technology as: socio-economic factors like wealth status which is expected to affect technology use for a number of reasons, including the fact that wealthier farmers have greater access to resources and may be more able to assume risk. The degree of risk aversion can affect levels of adoption and adoption rates (Omobolanle and Samuel, 2006). Also, in the study by Makokaha et al. (2007), it was found out that technological attributes
such as supply/availability, economic and yield benefit and convenience had a significant influence on adoption decision. According to Greene (2005), elements that affect the interrelationship, norm, and social behaviors influence members of the community to react according to their socio-cultural and psychological context. Ethnicity, group norms, leadership, social status, local participation, religious attribute, such as the degree of conservatism in religious norms and ethics of groups and individuals and demographic characteristics also influence adoption of an agricultural technology.

Several studies have reported positive relationship between age and adoption behavior of farmers. For example, Senkondo et al. (2004) found age significant in explaining the adoption of new technology. However, a study conducted by Wakjira (2002) on adoption of dairy production technologies in Ethiopia highlands indicates that age had no influence on adoption of dairy production technologies but formal education does have a positive and significant influence on adoption. Situational factors of the farmer as indicated by Caswell et al. (2001) findings indicate that the decision presents a shift in farmers’ investment options. Therefore adoption can be expected to be dependent on cost of a technology, and on whether farmers possess the required resources and knowledge required to acquire the same technology.

2.5 Empirical Studies on Determinants of Adoption of DTM

According to Swinkles and Franzel (1997), the choice of varieties depends on the feasibility, profitability and acceptability of farmers. There are four conditions necessary for farmers’ adoption of innovation systems; awareness of the innovation, perception that it is feasible to try, perception that the innovation is worth adoption and appreciation that the innovation promotes the farmers’ objectives (Ghulam et al., 2011). Also Kaliba et al. (2000) reported that cooperative
groups ensure that their members derive awareness benefits on improved crop varieties, such benefits are not derived individually. Farmers belonging to groups or cooperatives/associations are therefore expected to translate into quick and easy awareness of new ideas that could help the farmers in their access to drought tolerant maize farming activities in terms of inputs, access to loans and easy access to information that can improve their production. It is argued that depending on the preferences, resources and constraints individual farmers face, a beneficial attribute for one farmer may be a negative one for the other or the balance between the positive and negative traits may be acceptable for one farmer but not for another (Bellon, 2001). There are several factors that are believed to influence adoption; they range from institutional, product attributes and farmer characteristics as below.

2.5.1 Socio-economic Factors Influencing Adoption of DTMs

2.5.1.1 Availability of extension services and farmers’ preferences

According to Kaliba et al. (2000), in the analysis of the factors affecting adoption of improved maize seeds and use of inorganic fertilizer for maize production in the intermediate and lowlands of Tanzania, availability of extension services was influential in determining the farmers’ choice of varieties. Also it is argued that understanding farmers’ variety preference serves as an input for future development and diffusion of improved varieties (Bellon, 2001). Exposure to information reduces subjective uncertainty and therefore increases the likelihood of adoption of new technologies. Access to extension services, attendance of demonstration tests and participation in on-farm tests are commonly used by researchers to capture the impact of information on adoption of agricultural innovations (CIMMYT, 1993). The effectiveness of extension service is one of the factors influencing the use of improved technologies (Chilot et al. 1996). Makokaha et al. (2007)
found that contact with extension agents had a significant influence on perceptions and adoption decisions of farmers. In the same way, Berhanu, (2002) and Yirga, (2007) found that extension contact had a positive and significant effect on the adoption of crossbred dairy cows in the central highlands of Ethiopia. Similar results were reported in Tanzania (Abdulai and Huffman, 2005). Different from other findings, Bulale (2000) indicated that extension had no influence on adoption of dairy production technologies.

Various studies in developing countries, including Ethiopia, report a strong positive relationship between access to information and the adoption behavior of farmers Yirga, (2007) and Umar et al. (2011) reported that lack of awareness and knowledge about vaccination, deworming and adding value to milk products were major constraints for dairy farmers adopting improved dairy farming practices in the central highlands of Ethiopia. Similarly, (Notter, 1999) indicated that most (91.4%) farmers in villages where adoption took place in North-Western zone of Nigeria had access to extension services more than farmers in villages that composed of non-adopters (28.6%). In addition, lack of knowledge about the maintenance of Boer goats constrained the goat breeding program for farmers in Indonesia (Azizah, 2011). Fawole (2006) found out that despite the existence of extension institutions and other various sources of information in almost every developing country, the coverage of farm families is still very limited.

2.5.1.2 Land Ownership

Ghulam et al. (2011) in their assessment of the factors affecting sunflower varieties in Sindh, India, noted that socioeconomic factors like tenancy status on land such as land owned, rented or borrowed and source of income influenced their adoption. Robinson and Kolaval (2010) found out that high per-unit costs affected the choice of tomato varieties in Ghana. When farm gate
prices for the outputs were high, it was not such a concern for individual farmers in Greater Accra to incur large irrigation costs while yield remained low to grow crops for the off-season. Likewise Muhammad et al. (1999) conducted a study on the factors affecting the adoption of hybrid maize varieties in the irrigated Punjab and found that farm size significantly contributed to the adoption of maize varieties.

Farmers with higher incomes are less risk averse, have more access to information, possess a longer-term planning horizon and greater capacity to mobilize resources (CIMMYT, 1993). Further, the initial adoption of agricultural technologies is highest with high-income earners and lowest with low-income earners. The difference arises from the large pieces of land owned by high income earners. Rogers (1993) reported that poor people are characterized by smaller land holdings and subsequently low adoption. Off-farm income was found to be positively significant, and therefore the likelihood of adoption of technologies including drought tolerant maize varieties is low which implies that it widens the possibility of adopting an innovation by mitigating the shortage of capital input. Households without off-farm income are likely to be highly risk averse and therefore the adoption of technologies including drought tolerant maize varieties is low. Thirtle et al. (2003) also reported similar results among farmers in South Africa.

2.5.1.3 Level of Education

It is evident from existing documents that through orientation of farmers on the potential of varieties usually attracts improved farming. Accordingly, Muhammad et al., (1999) conducted a study on the factors affecting the adoption of hybrid maize varieties in the irrigated Punjab and found that education significantly contributed to the adoption of maize varieties. Other studies, like CIMMYT (1993), Weir and Knight (2000) and Abay and Assefa (2004) reported a positive
and significant relationship between education and adoption of new agricultural technologies. Generally, education is expected to create a favorable mental attitude for the acceptance of new practices (Waller et al. 2005 and Caswell et al. 2001). Rogers (1993) showed that technology complexity negatively impacted on adoption. However, education is considered as a key factor in reducing the level of complexity perceived in new technologies and hence the more the years spent in school the higher the likelihood of adopting a new technology.

2.5.1.4 Size of the Farm

A study carried out in Zimbabwe on adoption of improved sorghum varieties found out that the size of the farm owned by each household was one of the factors that tended to influence the growing of both traditional and new sorghum varieties. An increase in farm size results into an increase in probability of growing traditional sorghum varieties (Zivanomoyo and Mukarati, 2013). This may be because when the farmers have large pieces of land they can afford to apportion the land and grow different varieties on the same land. Also, studies by Gabre-Madhin and Haggblade (2001) reported that adopters of tractors in Kenya operated large farms. Umar et al. (2011) also reported that farm size was highly correlated to the adoption of agricultural innovations. However, Fernandez-Cornejo and McBride, (2002) who studied adoption of improved farm practices in Turkey, together with Yenealem (2006) found no significant relationship between farm size and adoption. Nayenga (2008) reported that land was the most important asset for production and that there was a significant relationship between farm size and adoption. Berhanu (2002) suggests that resource endowments are the major determinants of observed adoption behavior where lack of access to capital and inadequate farm size could significantly limit adoption decisions. Nkonya et al. (2006) argued that those with large farms
were likely to be better informed and able to take-up risks associated with the experimentation of new agricultural practices. Berhanu (2002) also indicated that farm size of cropland had a positive influence on the adoption of improved technologies.

**2.5.1.5 Location of the farmer**

Study done on factors influencing adoption and intensity of Orange Flesh Sweet Potato (OFSP) varieties in Rachuonyo in Nyanza and Busia in Western Kenya, found out that the location of farmers determines the degree of adoption of varieties (Kaguongo et al., 2010). A farmer in Busia was 50 times more likely to adopt than a farmer in Rachuonyo. This was attributed to several underlying factors, which included the fact that sweet potato was more commercialized in Rachuonyo District than in Busia District and the yields of the local varieties grown in Rachuonyo were comparable to the yields of OFSP varieties being introduced. More importantly, the short time of programme implementation may not have had sufficient effect on traders’ preferences who were not willing to trade in the less familiar OFSP in Rachuonyo District.

**2.5.1.6 Age of the farmer**

Several studies have reported positive relationship between age and adoption behaviour of farmers (Haji, 2003; Senkondo et al., 2003; Mesfin, 2005 and Yenealem, 2006). However, the study by Bulale (2000) on adoption of dairy production technologies in Arsi highlands indicated that age had no influence on adoption of dairy production technologies. Senkondo et al. (2003) findings about technology adoption indicated that age may positively or negatively affect adoption depending on the individual farmer and technology involved. For instance, older farmers
may have more experience, resource and authority that allow them more possibilities of trying a new technology.

2.5.1.7 Gender of the Farmer

It has been argued that women are generally discriminated against in terms of access to external inputs and information (Doss and Morris, 2001), which limits their adoption potential of various agricultural technologies. Most adoption studies in developing countries have therefore reported lower adoption levels among women. For example, the adoption studies of fish farming in Malawi (Kapanda et al. 2005) and mixed inter-cropping of Crotalaria and Maize in Kabale District of Uganda (Buyinza and Wambede, 2008). In many developing countries Uganda inclusive, women do not own land making them less effective in making decisions related to resource management (Eilor and Giovarelli, 2002). Men as land owners make most of the decisions on how to use land and yet rarely work on it. Thus, this factor may be a major determinant of adoption of agriculture technology among female farmers. Even where both men and women have access to land, ownership and control over land is ultimately with men (FAO, 2011). A study undertaken in Mpigi and Lira districts on the factors inhibiting land rights for women, children and orphans revealed that most land use decisions were made by husbands (Eilor and Giovarelli, 2002).

2.5.2 Technological Factors Influencing Adoption of DTMs

2.5.2.1 Technology

Among the factors influencing the farmers’ choice of varieties, technology plays a significant role. The rate of adoption of new technology is subject to its profitability and the degree of risk
and uncertainty associated with it (Ghulam et al., 2011). It is assumed that technology and crop choice is sequential to farmers who choose the technology first and then decide which crops to grow that suit the chosen technology (Mangisoni, 1999). Yet, it is an established fact that farmers are also capable of commenting on the design of particular technology and suggest changes which would make such technologies and innovation more appropriate for their needs. Taking farmers’ input on technology design seriously would accelerate the ultimate adoption of technologies (Johi and Bauer, 2006).

2.5.2.2 Climatic factors

Research shows that sometimes natural factors like climatic changes always affect the farmers’ choice of varieties (OECD, 2008). This is supported by Kaliba et al., (2000) who posit that climatic factors among others were influential as far the determining the farmers’ choice of varieties in Tanzania. Genetic improvement programmes based on selection within local populations are generally recommended in low-input systems where crops that are well adapted and reasonably productive are required, to preserve the hardiness traits which are supposed to be present in these varieties (Edmeades, 2013). Indigenous populations are a source of adaptability for specific environmental challenges such as disease and extreme climatic conditions, and a reservoir of worldwide genetic diversity for possible future changes in the current production systems. Also, these populations could be a potential source of the transgressive or cryptic alleles. These alleles are superior genes for some productive traits supposed to be “hidden” in unselected varieties that are inferior for these traits (Notter, 1999).
2.5.2.3 Variety characteristics

It is widely known that the nature of varieties coupled with their yielding capacities often dictate on the farmers’ choice of a given variety (Pingali et al., 2001). Kaliba et al., (2000) in their analysis of the factors affecting adoption of improved maize seeds and use of inorganic fertilizer for maize production in the intermediate and lowlands of Tanzania established that variety characteristics was influential as far the determining the farmers’ choice of varieties. Obaa et al. (2005) argued that perceived attributes of the technology affects adoption behaviour of farmers. This means that, even with full farm household information, farmers may subjectively evaluate the technology differently from scientists. Thus, understanding farmers’ perceptions of a given technology is crucial in the generation and diffusion of new technologies and farm household information dissemination.

Farquhar and Surry (1994) listed five perceived attributes upon which an innovation is judged. They argued that, technology can be tried out (trialability), results can be observed (observability), it may possess an advantage over other innovations (relative advantage), may not be very complex to learn or use (complexity), and fits or is compatible with the circumstances into which it will be adopted (compatibility). Farmers’ perceptions of technology characteristics significantly affect technology adoption decision (Adesina et al. 2000). The more complex the innovation, the less attractive it may be to farmers. The decision of whether or not to adopt a new technology may be based on careful evaluation of a large number of technical, economic and social factors associated with the technology. Makokaha et al. (2007) found that technological attributes such as convenience had significant influence on adoption decisions.
2.5.2.4 Occurrence of Drought

According to Mugisha and Diiro (2010, in the study to explain the adoption of improved maize varieties and its effect on yield among smallholder maize farmers in central and eastern Uganda the rate of occurrence of drought was found to influence the adoption of drought tolerant maize varieties. Also, according to La Rovere et al. (2014), the increased occurrence of drought episodes as a result of climate change necessitate increased adoption of drought tolerant maize varieties in most Sub-Saharan African countries to ensure better and sustainable yield performance in the region.

2.5.3 Institutional Factors Influencing Adoption of DTM

2.5.3.1 Availability of the market

Nature and composition of demand are the factors that may increase the future variability in world prices (OECD, 2008). Johi and Bauer (2006) conducted a study on the farmers’ choice of modern rice varieties in the rain fed ecosystems in Nepal using a multinomial logit model. The study included both production and consumption attributes valued by the farmers and farmer related variables. The results indicated that both categories of variables were significant in determining the demand for a specific variety. Moreover when markets are thinner and prices in domestic markets do not follow those in international trade because of insulating policies or market imperfections the choices of the farmers are limited. World market prices must change more to accommodate an external shock to traded quantities, or else equal, such market characteristics are expected to remain a permanent feature in the volatility of price, hence affecting the farmers’ choice of varieties (OECD, 2008).
2.5.3.2 Policy

Most researchers who give a thought to concerns regarding factors which influence the farmers’ choice of varieties often focus on policy developments (Johi and Bauer, 2006; Bellon, 2001). For instance, OECD (2008) documenting on the causes and consequences of rising food prices highlighted that the current policy setting appears to represent a permanent factor in price formulation thereby affecting the farmers’ choice of varieties.

2.5.3.3 Availability of credit

Zivanomoyo and Mukarati (2013) also attribute adoption of varieties to availability of credit to farmers. Credit increases the probability of growing different varieties by farming households. The credit facility to farmers will enable farmers to afford certified seeds of both traditional and new varieties which are highly productive. Thus when farmers have access to credit they can grow the traditional varieties or new varieties and be able to have increase yields. Inadequate access to financial markets, such as savings, credits, and insurances, hinders the ability of rural people to invest in activities that are important to them and determines an individual or household’s decisions to engage in other income generating activities (De Janvry et al. 1991). Where formal financial markets for rural households are poorly developed, keeping livestock represents a means of finance and self-insurance and thus a risk-coping strategy for many rural people (Katsushi et al., 2010). A study in Tanzania confirmed that farmers’ adoption of improved technology is influenced by access to credit. Furthermore, empirical evidence showed that access to credit had a positive and significant influence on technology adoption (Abdulai and Huffman, 2005).
However, Bulale (2000) in his adoption study of dairy production technologies in Arsi highlands found that credit had no influence on adoption of dairy production technologies. Availability of credit eases the cash constraints and allows farmers to buy purchased inputs such as fertilizer, improved crop and livestock. Research on adoption of agricultural technologies indicates that there is a positive relationship between the level of adoption and the availability of credit (Yirga, 2007; Pattanayak et al. 2003).

### 2.5.3.4 Seed prices

Muhammad et al (1999) conducted a study on the factors affecting the adoption of hybrid maize varieties in the irrigated Punjab and suggested the reduction in seed prices as the key aspect as far as improving adoption of varieties. Zivanomoyo & Mukarati (2013) argue that price of seeds significantly influences the probability of farmers to grow different varieties. Input price tends to increase the probability of growing traditional varieties which are readily available to farmers but tends to decrease the probability of growing new and mixed varieties. Since most of these rural farmers have limited income sources, increase in the price of new seed render it unaffordable to most farmers thus grow the traditional seeds from previous year’s harvest. Similarly, Uaiene (2004) reported that lack of information about prices of production inputs and outputs, about places and their best periods for selling their products, about potential buyers as well as quality requirements, frustrate producers to the extent that they may resort to production for subsistence. Moreover the variability of input and product prices has increased since the deregulation of agricultural commodities in the mid 1990’s (Dossa et al., 2008). A study on the determinants of adoption of new agricultural technologies conducted in Mozambique found out that choice of varieties was determined by the availability of improved open-pollinated maize varieties (OPV),
hybrid maize seed, input packages (for example fertilizer, pesticide), improved farm storage techniques, and small scale irrigation technologies (Uaiene, 2004). Cost is an important factor that limits adoption especially in rural areas of Africa where farmers are faced with a multitude of economic constraints in agriculture. Variable costs involved in obtaining and maintaining the innovation negatively affect its adoption (Khanna, 2001; Dossa et al. 2008).
2.6 Conceptual Framework

Adoption of drought tolerant maize varieties is viewed as a link between various actors that enable flow of information and seed to the farmer and then output from the farmer to the market in exchange for money to improve the standard of living.

The decision to adopt an innovation is a behavioral response that takes place as a result of a set of alternatives, opportunities and constraints facing the decision maker (Ingold, 2002). Also, adoption of agricultural productivity-improvement technologies like the drought tolerant maize varieties is mostly constrained by social and cultural contexts among smallholder farmers (Machida et al., 2014). As a result of the entire above, farmer’s awareness and training coupled
with an enabling policy and environment enables the same farmer to know the use and relevance of drought tolerant maize varieties in agricultural production. Attributes of the drought tolerant maize seed offered for instance costs and nature of the seed/technology influence farmers’ decisions. Farmers’ attributes like education, incomes, age, family size, objective of production, Land size farmed and others enable or disable the farmer’s decision to adopt the drought tolerant maize variety. Market attributes like, distance to markets, nature of roads, availability of seeds and costs incurred in obtaining information physically also influence adoption of drought tolerant maize varieties. The adoption of such drought tolerant maize varieties is a savior for the majority of the population in most parts of Africa that depend on agricultural production and yet live among drought prone parts of the country side to increase production, livelihoods and income substantially from a crop of maize whose economic importance is becoming more significant from time to time.

2.7 Review of Analytical Methods on Adoption of Technology

Several factors are responsible for farmers’ decision to adopt an agricultural technology. Extension creates awareness about the existence of any agricultural technology. The farmers assess whether the technology is acceptable to them given their marketing strategy, farm size, experience, labor availability, expected improvement, gender, age, family labor, years of formal education, availability of credit, pest pressure and abundance, area under crop and expected yield.

Several studies on the factors responsible for farmers’ decision have employed binary models (Bahta and Bauer, 2007; Moser and Barret, 2002), Binary Logit Linear Model (Nyirenda et al., 2011) and Multinomial logit for responses that involve more than two dependent variables (Thamaga et al., 2004; Bonabana, 2002). However, given that in this specific study, an individual
Farmer is faced with decision to adopt a drought tolerant maize variety or not makes Multi-level regression models not appropriate. However, given that an individual farmer is faced with a decision to adopt or not to adopt any one among the many drought tolerant maize varieties in a way to ensure better yields in the face of climate change gives rise to the dependent variable taking on a binary form of yes or no. This makes the Zero Inflated Negative Binomial Regression Model, multinomial logit, cumulative logit, multivariate probit and Tobit regression inappropriate for this study that seeks to determine factors influencing adoption of DTMs as a binary choice dependent variable.

Farmers’ choice to adopt an agricultural technology is as a result of his preference for that particular technology. Farmers will always adopt a technology which has the highest preference and utility. The utility that a farmer associates with a technology is specified to be the sum of deterministic and random component (Pryanishnikov and Katarina, 2003). The deterministic component is a function which depends on the observed attributes of the technology and observed individual characteristics of the decision maker, while the random component is a random process representing the effect of unobserved attributes of the alternative and unobserved characteristics of the decision maker. Most choice models have a random component of the utilities of the different alternatives that are assumed to be independently and identically distributed with a type 1 extreme value distribution (Johnson and Kotz, 1970). This results into a binary logit choice model (McFadden, 1974) which will be used to study the factors that influence the adoption of the drought tolerant maize varieties among smallholder maize farmers in Masindi and Kamuli districts of Uganda.
CHAPTER THREE
METHODOLOGY

3.1 Research Design

The study adopted a cross sectional survey design. The survey involved household interviews for smallholder maize farmers in the districts of Masindi from mid-western Uganda and Kamuli from eastern Uganda. The farmers from the two districts were interviewed based on the two classifications as adopters and non-adopters of drought tolerant maize varieties.

3.2 Study Area

The research was carried out in Masindi and Kamuli districts. Masindi District is located in the mid-west part of Uganda. The district compromises of a total area of 9,326 sq.km of which 8087sq.km is the land area, 2,843sq.km is a wildlife protected area, 1,031 sq km is under forest reserve, and 8, 14.4 sq.km is covered by water. The arable land covers a total area of 7,332sq.km. The large size of arable land with its good climate makes highly favors maize production. The major economic activities carried out in high rainfall zones include pit sawing especially in Budongo Forest, maize production, cassava production, sugar cane production, tobacco, and banana growing. The high agricultural production has contributed to increased household incomes enabling the population to sustain their livelihoods as well be able to export their commodities to the neighboring districts (Kibirige, 2014). In addition, Ajambo et al. (2017) noted that Masindi district provides a good climate for agricultural production especially maize, however, the authors reported low yields from maize crop production mainly due to use of low yielding maize varieties especially OPVs. According to FAO (2013), the district is characterized by rain-fed mixed
farming of maize, pulses, root crops, coffee and livestock rearing with the main maize varieties being longe 5, longe 6H (Ssalongo), longe 7H and longe 10H. Masindi **District is among the leading producers** of maize in Uganda with the majority production taking place among smallholder farmers (Kibirige, 2014).

One the other hand, Kamuli District is located in the south-eastern part of Uganda. The district compromises of a total area of 4,301.5 sq.km of which 3,255.3sq.km is the land area, 231 sq km is under forest reserve, and 815.2 sq.km is covered by water. The arable land covers a total area of 3,132sq.km. The large size of arable land with its good climate makes highly favors agricultural production. The major economic activities carried out include; maize production, groundnut production, sugar cane production, and banana growing (UBOS, 2015). The high agricultural production has contributed to increased household incomes enabling the population to sustain their livelihoods as well be able to export their commodities to the neighboring districts. According to FAO (2013), the main crops grown in the district include; mostly rain-fed cultivation of cereals, oil seeds and pulses with Paddy rice mainly grown in drained swamps. The main maize varieties grown in the district also include; longe 5, longe 6H, longe 7H and longe 10H (FAO, 2013).

### 3.3 Sample Size Determination and Selection

The sample size was determined using Cochran (1963) formulae;

\[ n = \frac{(Z^2pq)}{e^2} \]  

(1)

Where \( n \) = Sample size

\( Z \) = the standard normal deviate at the selected confidence level which is 1.96 for 95% confidence interval.
P = Proportion in the target population estimated to have characteristics being measured which is 0.85 for this study (85% of the farmers in the two districts are smallholder maize farmers)

q = 1 – 0.85 = 0.15

e = the desired level of precision (5% to 10%)

\[ n = \frac{(1.96^2 \times 0.85 \times 0.15)}{0.05^2} \]

n= 196. The size was adjusted to 200 maize farming households

However, during entry and cleaning, 5 adopters were found with incomplete data especially with regard to maize variety grown, quantity harvested among others. This left the data for adopters at 95 thus pairing that with the non-adopters to make 190 households. The respondent selected was a household head in the family that produced maize. This was informed by the fact that in most smallholder farming communities, the household head remains the main decision maker especially with regard to crops that are grown for income generation. Thus to explore well the adoption of DTMs among smallholder maize farmers household heads were presumed as the leading decision maker since the technology requires time for training and some finances to purchase the much coveted seed.

A multi-stage sampling technique was used to select the sample for this study. First the districts were purposively selected because of being among the leading producers of maize in the country (UBOS, 2015) in addition to being among the districts where DTMs have been promoted by different stakeholders especially One Acre Fund. One Acre Fund trains farmers on DTMs and gives them seed on credit with an objective of increasing resilience to climate change. It was expected that the districts would provide an authentic sample composed of farmers with vivid experience in maize production. In each of the two districts of Kamuli and Masindi, one sub-
county in which DTMs were being provided by one acre fund was randomly selected from the rest. This resulted into Pakanyi Sub County in Masindi District and Kitayunjwa Sub County in Kamuri District. In each sub-county 5 parishes where DTMs were being provided by the same organization were also randomly selected from the list of parishes. This resulted into Labongo, Kyihaguzi, Kyatiri, Kyakamese and Kiruli in Masindi in addition to Buganza, Kitayunjwa, Busota, Butende and Nawango in Kamuli district. In each parish, the list of villages where DTMs were being provided was generated from which 1 village was randomly selected. This resulted into Kihonda, Kyihaguzi, Nyakasagazi and Kibirami in Pakanyi Masindi in addition to Bubambwe, Bugwanti, Butaama, Bugulusi and Bawaya villages in Kamuli district. Finally in each village, 20 farmers were randomly selected from the sampling frame of DTM farmers from one acre fund and non-DMT farmers from the farm generated with help of LCI chairperson.

For this study, an adopter of DTM is defined as one who for the two seasons has been purchasing and growing maize seed of the DTM variety. This excludes any farmer that may be growing any recycled DTM seed. Adopters of drought tolerant maize varieties were identified with the guidance of One Acre Fund Project which was identified to have been distributing drought tolerant maize varieties of Longe5, longe7 and longe10H to farmers on credit since 2012. And for each adopter interviewed, another maize farmer in the neighbourhood would be interviewed as a non-adopter. Respondent in each sampled household was the head of the household or another adult member of the household that was greatly involved in the maize production. Finally, the sample of 200 smallholder maize farmers was considered for this study. This composed of 100 adopters and 100 non-adopters. The respondent was a member of the household that produced maize either for subsistence or commercial use. However, during the interviews some incomplete questionnaires were encountered due to inconsistencies with production records and challenges of
recalling some data on varieties grown, acreage and seed sources. This resulted into only 95 full filled questionnaires under each category of adopters and non-adopters.

### 3.4 Data collection

Primary and secondary data were both used in this study. Primary data was collected using questionnaires administered to respondents. Close ended questions were used to capture numerical and quantitative data that links theory to research. Open ended questions were used to record observations and qualitative attributes also referred to as interpretive research methods. According to Erickson, (1986), these were useful in collecting qualitative data that provides deeper meanings of the statistical data generated by quantitative methods and enables understanding of subjective realities of respondents. The data collected included; age, land owned, area under maize, main occupation, experience in maize production, quantity of maize produced, varieties of maize grown, source of seed grown, distance to source of seed, occurrence of drought, access to extension visits and self-sufficiency in maize production among others.

### 3.5 Data Analysis

Data was cleaned, coded and entered using Excel data builder. Thereafter, the analysis preceded using Excel, SPSS, and STATA to generate patterns that explain the behaviour of smallholder DTM farmers in the study area, key attributes of drought tolerant maize varieties preferred and the factors that influenced the adoption of drought tolerant maize varieties in Kamuli and Masindi districts. The analysis was based on the two groups of farmers in relation to DTM growing. This included; adopters and non-adopters. For each theme under the study, the nature and behaviour of farmers was analysed in relation to the two categories.
For objective one and two, descriptive statistics were used. These included frequencies, means, percentages, standard deviation, cross tabulations and t-tests. According to Langyintuo et al. (2005), frequencies are important for explaining attributes of individual farmers. A Jarque-Bera (JB) test and general exploratory data analysis was carried out to establish the skewness, kurtosis and distribution of the data for the continuous variables like age, education, family size, income, distance, costs and experience. According to Gujarati (2004), combined measures of skewness and kurtosis enable to show if a random variable follows a normal distribution. He further stated that if generated coefficients of skewness (S) and kurtosis (K) are not 0 and 3 respectively, then such a variable did not follow a normal distribution. Together with histograms the results were used to show whether the continuous variables followed a normal distribution and thus the need for transformation. Raw data was transformed to control heteroscedasticity and Correlation tests were done using STATA software to check for multicollinearity.

For objective 3, the binary logistic regression model was used. Binary responses were obtained from farmers in regard to the decision to grow drought tolerant maize varieties or not. When introduced to drought tolerant maize varieties, farmers either adopt or decline to adopt, given differing resources, education, aims and utility preferences. Qualitative choice models are the most feasible when analyzing such decisions for example the probit, logit and linear probability models as Tambi et al. (1999) advised.

### 3.5.1 Theoretical Specification of the Binary Logistic Model

According to Greene (2002), choice models are based on random utility, where the $i_{th}$ adopter is exposed to $J$ choices. If the utility function of $j$ was $U_{ij}$, then

$$U_{ij} = \sum \beta Z_{ij} + \epsilon_{ij}$$

---
Hence if an adopter takes the j choice, then the assumption that $U_{ij}$ was the maximum of all $J$ utilities holds, therefore the model is moved by the probability that the $j^{th}$ choice is taken and thus;

$$\Pr(\text{ob}(U_{ij} > U_{ik}) \text{ for all other } K \neq j)$$

Both logit and probit models can be used based on the above utility format. However, the mathematical friendliness of the logit model makes it easier, and thus it was used in this research.

Assuming that $Y_i$ represents the choice taken, then with $J$ disturbances being distributed identically and independently. The theoretical logit model is specified as follows;

$$\Pr(Y_i = j) = \frac{e^{\sum \beta_j z_j}}{\sum_{j=1}^{J} e^{\sum \beta_j z_j}}$$

But utility is based on particular aspect features of the person and the choice he/she makes ($X_{ij}$), therefore it is necessary to understand both the personal aspects and the choice attributes separately.

Greene (2002), adds that in case of several choices, the model for a specific choice is as follows:

$$\Pr(Y_i = j) = \frac{e^{\sum \beta_j x_j}}{\sum_{j=0}^{J} e^{\sum \beta_j x_j}} \text{ where } j = 0, 1 \ldots J$$

He also adds that the binomial logit is the unique case where $J = 1$, specified as below and it was used to determine factors that influence smallholder maize farmers adoption of drought tolerant maize varieties. The odds ratios were used to interpret the chances of adopting drought tolerant maize varieties given a change in the independent variable.
3.5.2 Empirical Binary Logistic Model for the Study

The empirical model was specified as follows:

\[ Y_i = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_{10} X_{10} + \epsilon_i \]

Where \( Y_i \) = Dependent Variable, which is adoption of DTMs. Defined as (1 if farmers grew drought tolerant maize seed for at least two seasons consecutively, 0 Otherwise)

\( \beta_0 \) = Intercept

\( \beta_1 \ldots \beta_{10} \) = Parameter estimates

\( X_1 \ldots X_{10} \) = Vector of Explanatory Variables

\( \epsilon_i \) = Error term

Specifically the Explanatory Variables incorporated in the model were;

\( X_1 \) = Gender of household head, 1 if male, 0 otherwise

\( X_2 \) = Education of the household head, measured in number of years of formal schooling

\( X_3 \) = Price per kilogram of drought tolerant maize seed in Uganda shillings

\( X_4 \) = Experience of the household head in maize farming, measured in years of growing maize

\( X_5 \) = Size of farmer’s household, measured in number of persons per household

\( X_6 \) = Distance from the household to the nearest town where DTM is bought, measured in Kilometers

\( X_7 \) = Size of land farmed in the previous season, measured in acres.

\( X_8 \) = Number of extension visits concerning maize production in the previous season

\( X_9 \) = Access to credit for maize production by the farmer, 1 if yes, 0 otherwise

\( X_{10} \) = Farmers perception on drought occurrence measured by the number of times that drought has occurred in the last two years.
CHAPTER FOUR
RESULTS AND DISCUSSION

This chapter presents a detailed account of results from the study. Results and discussion in this chapter are based on the set objectives of this study. The first section presents the socio-economic characteristics of farmers as a comparison between adopters and non-adopters of drought tolerant maize varieties. This is followed by the analysis of the drought tolerant maize varieties grown by the farmers, sources of the seed grown by the adopters and non-adopters of the drought tolerant maize varieties, sources of credit for adopters and non-adopters of drought tolerant maize varieties, occurrence of drought for adopters and non-adopters, access and sources of extension for adopters and non-adopters. Thereafter, DTM attributes preferred by adopters, reasons for not growing drought tolerant maize varieties by non-adopters and finally the model results for factors influencing the adoption of drought tolerant maize varieties are presented.

4.1 Socio-economic Characteristics of Maize Farmers in Kamuli and Masindi Districts

Socio-economic characteristics of maize farmers in the study area are presented as categorical and continuous variables. Categorical variables included; sex, marital status, main occupation, access to credit, self-sufficiency in maize production and fertilizer use. On the other hand, continuous characteristics included; age of the farmer, monthly income of the farmer in Uganda shillings, level of education of the farmers measured by years of schooling, land area owned and urea under maize in hectares, time taken to source of seed in minutes, experience of the farmer in maize production and quantity of maize produced. The characteristics were discussed in comparison of adopters and non-adopters of drought tolerant maize varieties as presented in Tables 3 and 4.
Results from Table 3 indicate that the majority sample was composed of males as compared to females. This indicates that the maize growing enterprise in both districts was dominated by males with a small proportion of females involved. This could be attributed to the fact that males are in most cases the household heads and given that maize production in most of these places tend to be grown for cash other than home consumption. This largely leaves the enterprise in the hands of males who being household heads tend to control all income generating activities. This finding is consistent with Mugisha and Diiro (2010) and Okoboi (2012) who both found out that maize production is dominated by male farmers mainly because in most cases the crop is grown as a source of income rather than a food crop. However, there was no significant difference between the male and female adopters and non-adopters. This was in disagreement with the findings of Kapanda et al. (2005) and Buyinza and Wambede, (2008) who both reported that more males tend to adopt new technologies as compared to females.
The sample was also composed of majority married farmers, followed by separated farmers, widowed farmers and finally single farmers in that reducing order. This indicated that maize production is dominated by married households. The marital status of maize farmers was found to be statistically significant different between the adopters of drought tolerant maize varieties and their counterparts that were non-adopters. More married farmers were adopters while more single and separated farmers were non-adopters. This could be attributed to the fact that married farmers try many improved technologies as a way to generate more income to meet the many household requirements including food. This makes married farmers to take up any avenue that is seen to result into increased output and income.

The main occupation among the sampled farmers was reported as follows; majority farming, followed by business, civil services, and finally casual workers in declining order. This indicates that majority maize farmers were generally deriving their livelihoods from agricultural production. However, the percentage of farmers was higher for adopters than non-adopters. The results indicate that more farmers and civil servants were adopters and more business men and casual workers were non-adopters. This could be explained by availability of more information regarding crop production among farmers and civil servants as compared to business men and casual workers. These results are consistent with other literature that over 60% of Ugandans derive their livelihoods from agriculture which is the backbone of the economy. They are also in agreement with the preposition that maize farming is increasingly becoming a major enterprise for both food and income and that as food maize is increasingly substituting sorghum, millet, cassava and banana as a staple in some regions of the country (UBOS, 2012). The main occupation of the farmer was significantly different between the adopters of drought tolerant maize varieties and non-adopters of the drought tolerant maize varieties. This is in agreement with Ghulam et al.
(2011) who found out that source of income influence the adoption of improved varieties. According to the author, farmers with another source of income apart from farming were found to adopt improved agricultural technologies more than their counterparts that had only farming as a source of income. This was attributed to better income that come with participation in off-farm incomes which increases the ability of such farmers to afford such improved inputs.

Access to credit was also found to be significantly different between adopters and non-adopters of drought tolerant maize varieties with more adopters accessing credit than non-adopters. The results also revealed that 84% of adopters had accessed credit compared to only 23% of non-adopters in the previous year. This indicates that majority of adopters were accessing credit as compared to non-adopters. This indicates that adopters need more money for acquisition of technologies for better productivity. There is therefore need for credit among the majority of the maize farmers which indicates that credit plays a crucial role in agricultural operations for increased production and productivity. This is in agreement with Zivanomoyo and Mukarati (2013) and Abdulai and Huffman (2005), who both reported a positive relationship between availability of credit and adoption of improved technologies. The authors argue that credit increases the probability of growing different varieties by farming households. The credit facility enables farmers to afford certified seeds of both traditional and new varieties which are highly productive. Thus when farmers have access to credit they can grow the traditional varieties and new varieties and be able to have increase yields.

Household’s self-sufficiency in maize production is an indicator of whether such household produces enough maize for its subsistence needs. Self-sufficient in maize production the previous was significantly different between adopters and non-adopters of drought tolerant maize varieties.
A majority of adopters were found to be more self-sufficient in maize production the previous year as compared to non-adopters. This indicated that adopters were producing more maize that would enable them to be more self-sufficient in maize production than non-adopters. This could explained by the fact that drought tolerant maize varieties perform better than other maize varieties especially under water stress conditions that have become common as a result of climate change. The self-sufficiency in maize production among adopters also indicates better food security among adopters as compared to non-adopters. This is in agreement with Kostandini (2015) who reported that drought tolerant maize varieties increase farmer’s welfare gains and makes the farmers more resilient to drought and climate variability.

Use of fertilizers as yield enhancing technology is viewed as a key factor to improved yields. However, this study found low fertilizer use among maize farmers. Use of fertilizers was not significantly different between adopters and non-adopters of drought tolerant maize varieties. This indicated that fertilizer use is low among both adopters and non-adopters. However, the percentage of farmers not using fertilizers was higher for non-adopters as compared to adopters. This indicates that adopters were using fertilizers more than non-adopters but to a less extent. This could be explained by tendency of improved seeds to require fertilization. This limited use of fertilizers among both adopters and non-adopters is consistent with UBOS (2012) and Okoboi (2011) who both reported low use of fertilizers in the production of maize in Uganda.
### Table 4: Continuous Socio-economic Characteristics of Maize Farmers in Masindi and Kamuli Districts

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Adopters (Mean)</th>
<th>Non-adopters (Mean)</th>
<th>Overall (Mean)</th>
<th>t-value</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age of the farmer (years)</td>
<td>47.32(10.43)</td>
<td>41.61(11.76)</td>
<td>44.46(10.21)</td>
<td>-7.48</td>
<td>0.000</td>
</tr>
<tr>
<td>Monthly income (UGx)</td>
<td>161,950(97847)</td>
<td>64,022(51,924)</td>
<td>98,850(60,4500)</td>
<td>-10.65</td>
<td>0.000</td>
</tr>
<tr>
<td>Education level (years)</td>
<td>8.35(2.80)</td>
<td>6.24(4.16)</td>
<td>7.30(4.54)</td>
<td>-22.57</td>
<td>0.000</td>
</tr>
<tr>
<td>Land owned (Hectares)</td>
<td>2.21(1.67)</td>
<td>1.69(0.99)</td>
<td>1.82(1.22)</td>
<td>-12.52</td>
<td>0.003</td>
</tr>
<tr>
<td>Maize area (Hectares)</td>
<td>1.07(0.97)</td>
<td>0.57(0.79)</td>
<td>0.75(0.65)</td>
<td>-5.71</td>
<td>0.001</td>
</tr>
<tr>
<td>Time to seed source (Mins)</td>
<td>53.72(40.71)</td>
<td>53.0(37.38)</td>
<td>53.44(38.60)</td>
<td>-0.08</td>
<td>0.123</td>
</tr>
<tr>
<td>Experience (years)</td>
<td>14.86(10.39)</td>
<td>10.38(9.39)</td>
<td>12.62(10.57)</td>
<td>-11.78</td>
<td>0.000</td>
</tr>
<tr>
<td>Price of seed (years)</td>
<td>3991.22(165)</td>
<td>4179.79(234.99)</td>
<td>4021.21(345.32)</td>
<td>-0.13</td>
<td>0.211</td>
</tr>
<tr>
<td>Maize produced (Kgs)</td>
<td>5081.05(5103)</td>
<td>3889.47(2304.1)</td>
<td>4485.26(40.45)</td>
<td>-2.18*</td>
<td>0.095</td>
</tr>
</tbody>
</table>

Source: Primary field data, 2014; in the parentheses are standard deviations

The mean age was significantly different between adopters and non-adopters of drought tolerant maize varieties. The mean age of adopters was 47.32 years compared 41.61 for non-adopters of drought tolerant maize varieties. Adopters were older than non-adopters indicating that older farmers were more likely to take up drought tolerant maize varieties as compared to relatively young farmers. This could be explained by older age coming with more exposure on challenges of agricultural production thus becoming more receptive to new technologies for increased production, productivity and incomes. This is consistent with the findings of Haji (2003) and Senkondo et al. (2003) who both found out that older farmers tend to adopt technologies more than young farmers mainly because of the vast experience that the old farmers practice farming with more knowledge and comparison of the past and present circumstances. In addition, old farmers usually have more resources that can easily facilitate the acquisition of such new agriculture technologies for increased production and productivity (Yenealem, 2006).
Farming experience was also higher for adopters at 14.85 years compared to 10.24 years for non-adopters. Adopters of drought tolerant maize varieties had more experience than non-adopters, an occurrence that could be attributed to fact that experience comes with more knowledge about the availability of better technologies at the disposal of these farmers to try and when found to perform well they continue using these technologies. The positive relationship between experience and adoption was also reported by Yenealem (2006). The author explained that farmers with more experience are more likely to try a new technology and eventually adopt it if results are good. In addition, experience comes with more knowledge and information on how and from where to acquire new technologies cheaply and conveniently thus facilitating adoption of such new technologies by more experienced farmers.

The monthly income was also found to be significantly different between adopters and non-adopters of the drought tolerant maize variety. Adopters had higher income of UGX 161,950 compared to UGX 64,022 for non-adopters. This was in agreement with other findings that farmers with higher incomes are less risk averse, have more access to information, possess a longer-term planning horizon and greater capacity to mobilize resources hence tend to adopt new technologies more than their counterparts with low incomes (CIMMYT, 1993). The higher incomes are as a result of higher yields that are realized from growing DTMs. This shows that increased adoption of these varieties has the capacity of improving livelihood of smallholder maize farmers through improved incomes.

Farmers that adopted drought tolerant maize varieties had spent more years in school as compared to non-adopters. The adopters of drought tolerant maize varieties had a mean of 8.35 years of formal schooling compared to 6.24 years of schooling for non-adopters. These findings are
consistent with Weir and Knight (2000) and Abay (2004) who also found a positive relationship between education and adoption of improved agricultural technologies. Education is expected to create a favorable mental attitude for the acceptance of new practices (Waller et al. 2005 and Caswell et al. 2001). Also, Rogers (1993) showed that technology complexity negatively impacted on adoption. However, education is considered as a key factor in reducing the level of complexity perceived in new technologies and hence the more the years spent in school the higher the likelihood of adopting a new technology. This also supports the failure to reject the hypothesis that education of farmer influences the adoption of drought tolerant maize varieties.

The average land area owned by the farmer in the sample and area under maize was found to be 1.82 and 0.75 hectares respectively. The results imply that truly the sample was composed of smallholder farmers who according to literature are farmers whose operations are carried out on less than 3 hectares of land (Barret et al., 2010). The land owned and that under maize production were also found to be significantly different between the adopters and non-adopters of drought tolerant maize varieties with adopters owning more land and having more land under maize production. The mean land area owned by adopters was 2.21 hectares and the mean area under maize was 1.69 hectares for adopters compared to land ownership mean of 1.09 hectares for adopters and the mean area under maize as 0.57 hectares for non-adopters of drought tolerant maize varieties. The ownership of larger land and area under maize by adopters of DTMs as compared to non-adopters is consistent with Umar et al. (2011) and Nkonya et al. (2006). They urged that farmers with larger farms are in most cases better informed and are able to take up risks associated with experimentation of new technologies.
The mean of the quantity of maize produced by the farmers in the sample the previous main season was found to be 4485.26 kilograms per household. The quantity of maize produced was also found to be significantly different at 5% and 10% between the groups of adopters and non-adopters of drought tolerant maize varieties with adopters producing more maize than non-adopters. The mean quantity of maize produced by adopters was 5081.05 kilograms compared to 3889.47 kilograms mean maize harvest for non-adopters of drought tolerant maize varieties. The higher quantity of maize produced by adopters indicate that DTMs offer an opportunity for smallholder maize farmers to increase their production and productivity thus being able to enhance their incomes through increased maize sales. In addition, the increased production is essential for improved food security especially among communities where maize forms a staple food.

The mean of the time taken to the source of seed and price per kilogram of seed was found to be 53.44 minutes and 4021.21 shillings for the sampled farmers respectively. Both the time taken to the source of the seed and price per kilogram of the seed were also not significantly different between adopters of drought tolerant maize varieties and non-adopters. This means that both adopters and non-adopting farmers were sourcing seed from within same range and at almost similar prices.

4.2 Limitations to Adoption of Drought Tolerant Maize Varieties

This was evaluated in terms of reasons that limit the use of DTMs among the maize farmers that were interviewed for the study. Prevalence of the following reasons were reported to discourage farmers from adopting drought tolerant maize varieties which have been seen as a solution to low
maize yields in the face of increased episodes of drought and limited rainfall amounts in the country. These limitations are summarized in the Figure 3.

**Figure 3: Main Limitations to Adoption of DTMs in Masindi and Kamuli Districts, (%)**

![Pie chart showing main limitations to adoption of DTMs in Masindi and Kamuli Districts.](image)

- Expensive 57%
- Requires use of fertilizers 12%
- Lack of awareness 12%
- Limited accessibility of seed 12%
- Susceptible to pests and diseases 7%

Source: Primary field data 2014

Results indicated that the major limitations advanced by farmers for increased adoption of drought tolerant maize varieties. These included; expensive seed, fertilizer requirements of the varieties, lack of awareness, limited accessibility and susceptibility to pests and diseases. This indicates that the price of the DTM seed was major hindrance to farmers taking up production of such technologies. This was followed by fertilizers requirement lack of awareness and limited accessibility of seed at less but equal magnitude and finally susceptibility to pests and diseases. These findings are in agreement with Odendo et al. (2002) and Fisher and Mazunda, (2011) who separately reported that expensive seeds limit the adoption of improved agricultural technologies.

In relation to the above, the availability of government vouchers has been found to increase adoption of improved agricultural technologies mainly because of the cost subsidizing effect of these vouchers. It was also reported that the requirement by most improved seeds for more inputs
such as fertilizers also further limit the adoption of improved maize seeds. In addition, limited accessibility of improved seeds including drought tolerant maize varieties was reported among the limitations to the adoption of these improved agricultural technologies. These results indicate that we fail to reject the null hypothesis that the major limitation to increased adoption of DTMs is expensive seed.

4.2.1 Awareness of Drought Tolerant Maize Varieties

Awareness of any technology plays an important role in the uptake and adoption of the same technology. This awareness can be increased by exposing more information to farmers through extension visits, radio programmes and any other channel for knowledge sharing. This study analyzed the level of farmers’ awareness of drought tolerant maize varieties in the two districts. This could be as a major constraint to their adoption of DTMs. The results from the study indicated that 56% of the smallholder maize farmers sampled were aware of DTMs as compared to 44% that had no awareness of the DTMs. Awareness of drought tolerant maize varieties was found to be significantly different between adopters and non-adopters at 1%. All adopting farmers were aware of drought tolerant maize varieties as opposed to only 5.8% of non-adopters that were aware of drought tolerant maize varieties. The results indicate low awareness of DTMs among smallholder maize farmers in the districts of Kamuli and Masindi. These findings on adoption and awareness are consistent with Ghulam *et al.*, (2011) and Kaliba *et al.* (2000) who both reported that awareness is crucial for adoption of any improved technology. They thus suggested that improved awareness creating strategies such as trainings and demonstrations to farmer groups and cooperative need to be encouraged for quick and better awareness and improved adoption.
4.3 Maize Varieties Grown by farmers

Maize varieties that were grown by the farmers were divided into two categories of tables; the first category is shown in Table (5) for non-drought tolerant maize varieties and Table (6) shows drought tolerant maize varieties. Farmers were asked to name the main variety grown the previous season and the names were summarized with respect to the category of the farmer as adopter or non-adopter. Table 5 shows the non-drought tolerant maize varieties that were grown by farmers. These included; *Longe 6H*, *Longe 2*, and local seeds.

**Table 5: Non-DTM Varieties Grown by Farmers in the Districts**

<table>
<thead>
<tr>
<th>Variety</th>
<th>Kamuli (n=95) %</th>
<th>Masindi (n=95) %</th>
<th>Overall (n=190) %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Longe 6H</td>
<td>11</td>
<td>17.8</td>
<td>14.2</td>
</tr>
<tr>
<td>Longe 2</td>
<td>2</td>
<td>4.4</td>
<td>3.2</td>
</tr>
<tr>
<td>Local</td>
<td>11</td>
<td>1.1</td>
<td>6.3</td>
</tr>
</tbody>
</table>

Source: Primary field data, 2014

Table 5 shows adoption rates of the various drought tolerant maize varieties in the two districts of Kamuli and Masindi. These drought tolerant maize varieties grown by adopting farmers included *Longe 5, Longe 4, Longe 9H, Longe 10H, MM3, Longe 1* and *PAN67* with the majority of the farmers growing recycled seeds especially for *longe 5 and 4*.

**Table 6: Adoption rates of DTM Varieties**

<table>
<thead>
<tr>
<th>Variety</th>
<th>Kamuli (n=95)</th>
<th>Masindi (n=95)</th>
<th>Overall (n=190)</th>
<th>X²-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Longe 1</td>
<td>2</td>
<td>1.1</td>
<td>1.6</td>
<td>20.75**</td>
</tr>
<tr>
<td>Longe 4</td>
<td>9</td>
<td>8.9</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>Longe 5</td>
<td>44</td>
<td>37.8</td>
<td>41.1</td>
<td></td>
</tr>
<tr>
<td>Pan 67</td>
<td>0</td>
<td>2.2</td>
<td>1.1</td>
<td></td>
</tr>
<tr>
<td>Longe 9H</td>
<td>8</td>
<td>12.2</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Longe 10H</td>
<td>8</td>
<td>10</td>
<td>8.9</td>
<td></td>
</tr>
<tr>
<td>MM3</td>
<td>5</td>
<td>4.4</td>
<td>4.7</td>
<td></td>
</tr>
</tbody>
</table>

Source: Primary field data, 2014
The adoption rate of DTM varieties for the sampled farmers in the two districts was 1.6% for Longe1, 9% for Longe4, 41.1% for Longe5, 1.1% for PAN 67, 10% for Longe9H, 8.9% for Longe10H and 4.7% for MM3 as shown in Table 7 above. As indicated in the table above, longe5 was the most adopted DTM in both districts but with its adoption higher in Kamuli than in Masindi. However, the adoption of most recent hybrid DTMs like longe 9H and 10H were slightly higher in Masindi at 14.4% and 11.1% respectively than in Kamuli at 9% and 10% respectively. This could be explained by the higher concentration of seed companies in Masindi than Kamuli. These private seed companies contract farmers for their seed multiplication thus creating higher chances of increased awareness as compared to their counterparts in Kamuli district. Among the drought tolerant maize varieties, Longe 5 was the most adopted with the highest percentage as compared to the varieties grown by non-adopters. The findings are in agreement with Obaa et al (2005), that maize farmers prefer open pollinated maize varieties such as longe 5 and longe 4 because of their capacity to mature early and recycle the seed. This is because, the short maturity period enables the plant to escape drought and allow farmers to plant the crop twice a year thus exploiting the bimodal rainfall pattern and ensuring early and quick provision of cash and food.

4.4 Sources of Seed Grown by Farmers

Results indicated that farmers acquired seeds mainly from their last season’s harvest. Other sources of seed included; agro-dealers, private traders, local markets, research institutions, neighbors, relative, Non-Governmental Organizations, NAADS and seeds companies as shown in Table 7.
Table 7: Main Source of Seed for the Maize Farmers in Masindi and Kamuli Districts

<table>
<thead>
<tr>
<th>Source of seed</th>
<th>Adopters (n= 95)%</th>
<th>Non-adopters (n= 95)%</th>
<th>Overall (n=190)%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agro dealers</td>
<td>28</td>
<td>25</td>
<td>28</td>
</tr>
<tr>
<td>Own seed</td>
<td>26</td>
<td>20</td>
<td>23</td>
</tr>
<tr>
<td>Private traders</td>
<td>17</td>
<td>15</td>
<td>16</td>
</tr>
<tr>
<td>Non-governmental organization</td>
<td>6</td>
<td>8</td>
<td>7</td>
</tr>
<tr>
<td>Local markets</td>
<td>5</td>
<td>10</td>
<td>7</td>
</tr>
<tr>
<td>Fellow farmers</td>
<td>4</td>
<td>10</td>
<td>7</td>
</tr>
<tr>
<td>NAADS</td>
<td>7</td>
<td>9</td>
<td>8</td>
</tr>
<tr>
<td>Research institutions</td>
<td>4</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Relatives and friends</td>
<td>1</td>
<td>3</td>
<td>2</td>
</tr>
</tbody>
</table>

Source: Primary field data, 2014

The seed from the sources like local markets, fellow farmers, relatives and that saved from last season’s harvest to a larger extent represents recycled seed which indicates a high use of recycled seeds especially of Open Pollinated Varieties. Recycled seeds continue to make a big proportion of planted seeds among smallholder farmers because these farmers claimed that prices are high and unaffordable to the since most are resource constrained and cannot afford to buy seed every season as it should be for hybrid seeds (Odendo et al., 2002). To make matters worse, farmers expressed concerns about the high incidence of counterfeit seeds on the market as another discouraging factor. As a result, hybrid seeds and Open Pollinated Varieties that are not recycled are in most cases grown by farmers that are more educated, wealthier and closer to the markets plus a few farmers that get free seed from government, seed companies and other development agencies (Fisher and Mazunda, 2011).

4.5 Sources of credit

Source of credit has been recognized as crucial for commercial agricultural production. Some credit sources such as individual money lenders offer terms that are not favourable to agricultural production given its risky nature and the time taken for one to harvest and payback the loan. The
results from the study indicated that smallholder maize farmers were accessing credit from the various sources as indicated in Table 8.

Table 8: Sources of Credit to Maize Farmers in Masindi and Kamuli Districts

<table>
<thead>
<tr>
<th>Source of Credit</th>
<th>Adopters (n=95) %</th>
<th>Non-adopters (n=95) %</th>
<th>Overall (n= 190) %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Village Savings and Credit Co-operative</td>
<td>44</td>
<td>56</td>
<td>50</td>
</tr>
<tr>
<td>Commercial Bank</td>
<td>18</td>
<td>22</td>
<td>20</td>
</tr>
<tr>
<td>Microfinance</td>
<td>14</td>
<td>18</td>
<td>16</td>
</tr>
<tr>
<td>Family and friends</td>
<td>20</td>
<td>4</td>
<td>12</td>
</tr>
<tr>
<td>Money lenders</td>
<td>4</td>
<td>0</td>
<td>2</td>
</tr>
</tbody>
</table>

Source: Primary field data, 2014

These results from the study indicated that 55% of the smallholder maize farmers sampled had access to credit from the different sources as shown above. This leaves 45% of these smallholder maize farmers having not accessed credit which could help them in maize production operations. Both categories of maize farmers were obtaining credit from same source with the majority relying on Village Savings and Credit Co-operatives as their major source of credit. Accessibility of credit has a bearing on adoption of improved agricultural technologies. Therefore, limited access to credit could also limit the adoption of drought tolerant maize varieties since accessibility of credit has been found to be associated with the probability of adopting improved maize varieties among farming households. The credit accessed by farmers enables them to afford certified seeds of both traditional and new varieties including drought tolerant maize varieties which are highly productive. Thus when farmers access affordable credit, they are in better position to afford to buy both traditional varieties and new varieties and be able to have increased yields.
This in agreement with literature that inadequate access to financial markets, such as savings, credits, and insurances, hinders the ability of rural people to invest in activities that are important to them and determines an individual or household’s decisions to engage in other income generating activities (De Janvry *et al.* 1991). Smallholder maize farmers need agricultural credit to finance agricultural operations such as acquisition of improved technologies, opening up land and expansion of land under maize production so as to increase both productivity and production.

### 4.6 Access to Extension Services by Maize Farmers in Kamuli and Masindi Districts

Access to extension is important for adoption of improved agricultural technologies. Extension in most developing countries offer a reliable source of information concerning agricultural production. Results showed that 36% of the maize farmers in the sample had received advice in relation to maize production compared to 64% of the smallholder maize farmers that had not received extension in relation to maize production. The sources of extension for maize farmers are summarized in Table 9.

**Table 9: Sources of Extension Services to Maize Farmers in Masindi and Kamuli Districts**

<table>
<thead>
<tr>
<th>Source of Extension Services</th>
<th>Adopters (%)</th>
<th>Non-adopters (%)</th>
<th>Overall (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Government extension services</td>
<td>38</td>
<td>24</td>
<td>31</td>
</tr>
<tr>
<td>Non-governmental organization</td>
<td>20</td>
<td>14</td>
<td>17</td>
</tr>
<tr>
<td>Fellow farmers</td>
<td>10</td>
<td>14</td>
<td>12</td>
</tr>
<tr>
<td>Farmer association/group</td>
<td>10</td>
<td>18</td>
<td>14</td>
</tr>
<tr>
<td>Mass media like phones and radios</td>
<td>8</td>
<td>12</td>
<td>10</td>
</tr>
<tr>
<td>Input supply shops/Stockists</td>
<td>8</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>Seed companies</td>
<td>4</td>
<td>8</td>
<td>6</td>
</tr>
<tr>
<td>Private service providers</td>
<td>2</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Model/Lead farmer</td>
<td>0</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>

Source: Primary field data, 2014

Access to extension services, attendance of demonstration sessions and participation in on-farm tests have been found to be the most effective ways of passing on information to farmers for
effective adoption of agricultural innovations (CIMMYT, 1993). The effectiveness of extension services is one of the factors influencing the use of improved technologies (Chilot et al. 1996). Makokaha et al. (2007) found that contact with extension agents had a significant influence on perceptions and adoption decisions of farmers. In the same way, (Berhanu, 2002) and Yirga, 2007) found that extension contact has a positive and significant effect on the adoption of agricultural technologies. Similar results were reported in Tanzania by Abdulai and Huffman, (2005). This limited access to extension is, therefore, a hindrance to the adoption of drought tolerant maize varieties in the country. Extension services’ provision is an important source of information to farmers and this requires the government to put more emphasis on the improvement of extension services to farmers in order to increase the adoption of improved technologies. Among the adopters, 38% of the maize farmers accessed extension services from government extension services as compared to 24% of the non-adopters that had accessed extension from government extension services. Access of extension from private and non-governmental organizations was higher for adopters as compared to non-adopters. This indicates that adopters were receiving more training sessions and extension services than non-adopters.

This left the majority of the farmers in both categories accessing extension from private organizations and private enterprises. The heavy reliance on non-governmental organizations and private enterprises may be infiltrated with opportunistic tendencies which put the farmers at the mercy of these private traders. This has a risk of retarding agricultural production and rural development. These findings are in agreement with Fawole (2006) who reported that although extension institutions and other various sources of information exist in almost every developing country, the extension services coverage of farm families is still very limited and desiring, a reason for poor performance by most rural farmers.
4.7 Farmers’ Preference for Drought Tolerant Maize Varieties

Drought tolerant maize varieties form a possible solution to increased episodes of prolonged drought which has become popular with climate change. Farmers’ perceptions about the occurrence of drought influences the agency with which any person considers adoption of a drought tolerant maize variety.

4.7.1 Farmers’ Perceptions on Occurrence of Drought

The results from the study indicated that 99% of the smallholder maize farmers sampled had been negatively affected by drought at least two times in the last ten years. Both adopters and non-adopters of drought tolerant maize varieties reported having been affected by the drought in varying degrees as shown in Table 10.

**Table 1: Occurrence of drought in the last ten years in Masindi and Kamuli Districts**

<table>
<thead>
<tr>
<th>Times of drought occurrence</th>
<th>Adopters (n=95) %</th>
<th>Non-adopters (n=95) %</th>
<th>Overall (n=190) %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not at all</td>
<td>0</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Once</td>
<td>3</td>
<td>13</td>
<td>8</td>
</tr>
<tr>
<td>Twice</td>
<td>38</td>
<td>40</td>
<td>39</td>
</tr>
<tr>
<td>Thrice</td>
<td>22</td>
<td>18</td>
<td>20</td>
</tr>
<tr>
<td>Four times</td>
<td>22</td>
<td>22</td>
<td>22</td>
</tr>
<tr>
<td>Five times</td>
<td>3</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Six times</td>
<td>12</td>
<td>4</td>
<td>8</td>
</tr>
</tbody>
</table>

Source: Primary field data, 2014

The highest majority of the maize farmers (40%) reported to have been adversely affected by drought at least twice in past ten years. Of the above, 38% were adopters as compared to 40% who were non-adopters. In addition, 8% of the farmers that reported 6 times which they had been negatively affected by the drought in the same period of then years. This shows that 99% of the
smallholder maize farmers in the sample had been negatively affected by the drought at least once in the last ten years. This is in agreement with La Rovere et al. (2014) and Mugisha and Diiro, (2010), who found out that the increased rate of drought occurrence as a result of climate change and variability, necessitate increased adoption of drought tolerant maize varieties in most sub-Saharan African countries to ensure better and sustainable yield performance in the region. Drought tolerant maize varieties thrive under low soil moisture conditions which are a characteristic of most parts of Africa resulting into increased episodes of drought that has been predicted to increase as a result of the depleted ozone layer in addition to deforestation which has been reported to be rampant in most parts of the continent in the recent past.

4.7.2 DTM Variety Attributes Preferred by Smallholder Maize Farmers

Farmers indicated various attributes they preferred in a DTM maize variety in addition to drought tolerance. The farmers were asked to rank the most preferred characteristic of the DTM variety grown in the previous two seasons. The results are summarized in Table 11.

Table 11: Attributes of DTMs Most Preferred by Smallholder Maize Farmers

<table>
<thead>
<tr>
<th>Maize attribute</th>
<th>Percentage (n=95)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grain yield</td>
<td>66.3</td>
</tr>
<tr>
<td>Drought tolerance</td>
<td>18.9</td>
</tr>
<tr>
<td>Early maturity</td>
<td>13.7</td>
</tr>
<tr>
<td>Grain-flour ratio</td>
<td>9.5</td>
</tr>
<tr>
<td>Pests and diseases</td>
<td>5.33</td>
</tr>
<tr>
<td>Tolerance to poor soils (requiring no fertilizers)</td>
<td>1.1</td>
</tr>
<tr>
<td>Lodging resistance</td>
<td>0.5</td>
</tr>
</tbody>
</table>

Source: Primary field data, 2014
The results from Table 11 indicate that the most preferred maize attributes as grain yield, drought tolerance, early maturity, grain-flour taste, lodging resistance, tolerance to poor soils thus not demanding use of fertilizers, and pests and diseases resistance. Grain weight was mostly preferred by farmers that produce maize to sell. This is because the heavier the variety, the higher the revenue from the sale of the maize. Grain-flour ratio quality was found to be preferred by farmers especially those that were producing it mainly for home consumption and value addition for the sale of flour. This indicates a great potential for DTM if attributes like grain yield, grain-flour ratio, resistance to pests and diseases, tolerance to poor soils and lodging resistance are taken into consideration by breeders. These results reject the null hypothesis that drought tolerance is the main maize attribute preferred by farmers. This is because grain yield was found to be the most preferred by smallholder farmers interviewed for this study.

This was also in line with the findings that maize farmers prefer improved varieties from the production point of view due to their weight and grain size and also prefer local varieties from the consumption point of view because of posho taste and quality (Fisher and Mazunda, 2011). The findings are also in agreement with Obaa et al (2005), that farmers prefer various maize varieties due to their many desirable genotypic traits such as high yielding ability, drought tolerance, early maturity, resistance against field and storage pests and diseases and grain size. Also farmers preferred early maturing and uniform maturing maize because early maturing maize has higher chances of escaping drought and enables the farmer to harvest early maize for food and money.
4.8 Factors Influencing Adoption of Drought Tolerant Maize Varieties among Farmers in Masindi and Kamuli Districts

Factors that influence the adoption of DTMs among smallholder farmers in Masindi and Kamuli districts were analysed using a binary logit model. Results of the Logit model as presented in Table 12 indicated that price per kilogram of seed, awareness of drought tolerant maize varieties, experience of the farmer in maize production, the number of times that drought has occurred in the past ten years and distance to the source of seed together with the education of the farmer were significant in influencing the farmers decision to adopt DTMs.

Table 12: Determinants of Adoption of DTM Varieties in Masindi and Kamuli Districts

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Odds Ratio</th>
<th>Marginal effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender of the farmer (Male/female)</td>
<td>-0.693</td>
<td>1.77</td>
<td>-0.011</td>
</tr>
<tr>
<td>Education of the farmer (Years of schooling)</td>
<td>0.026*</td>
<td>2.232</td>
<td>0.015</td>
</tr>
<tr>
<td>Experience of the farmer in maize farming (Years)</td>
<td>0.068 **</td>
<td>1.864</td>
<td>0.093</td>
</tr>
<tr>
<td>Awareness of drought tolerant varieties (Yes/no)</td>
<td>0.371 ***</td>
<td>3.462</td>
<td>0.017</td>
</tr>
<tr>
<td>Household size (Number of household members)</td>
<td>0.036</td>
<td>0.798</td>
<td>0.037</td>
</tr>
<tr>
<td>Distance to the source of seed (Kilometers)</td>
<td>-0.011 *</td>
<td>1.012</td>
<td>-0.003</td>
</tr>
<tr>
<td>Land area farmed by the farmer (Hectares)</td>
<td>0.151</td>
<td>1.550</td>
<td>0.004</td>
</tr>
<tr>
<td>Access to extension (Yes/no)</td>
<td>0.525</td>
<td>1.860</td>
<td>0.139</td>
</tr>
<tr>
<td>Occurrence of drought (Number of times)</td>
<td>0.527 **</td>
<td>1.336</td>
<td>0.038</td>
</tr>
<tr>
<td>Access to credit (Yes/no)</td>
<td>0.044</td>
<td>0.953</td>
<td>0.027</td>
</tr>
<tr>
<td>Price per kilogram of maize seed (Ushillings)</td>
<td>-0.001 ***</td>
<td>0.99</td>
<td>-0.142</td>
</tr>
<tr>
<td>Constant</td>
<td>2.982</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Logistic regression

Log likelihood = -56.460152

*, **, *** Represents significance at 10%, 5% and 1% levels respectively, in parentheses are standard errors

Source: Primary field data 2014

Number of observations = 190

LR chi²(12) = 31.10

Prob > chi² = 0.0019

Pseudo R² = 0.2159
Results showed that the education of the farmer increases the chances of a farmer adopting the drought tolerant maize varieties with the odd ratio of 2.232 which indicates that adoption is most likely to take place when the education of the farmer increases. The odds ratio for the education of the farmers was found to be 2.232. This indicates that an increase in the level of education of a farmer increases the chances of adopting the drought tolerant maize varieties by odds greater than one. The marginal effects of the model indicate that a unit increase in the level of education of a farmer increases the chances of adoption by 0.0145 chances. This relationship between education and adoption of DTMs can be explained by the increased ability to read, write and interpret messages. In addition, education gives confidence to people and creates a mental attitude for acceptance of new practices and technologies. This is in agreement with the findings of Abay (2004) and Waller et al. (2005) who found a positive relationship between education of the farmer and the adoption of agricultural technologies. The positive relationship between education and adoption of drought tolerant maize varieties with an odds ratio that is greater than one increase the chances of adoption. This can be explained by the fact that education increases the ability of the farmer to read and interpret any information available thus making the same farmer better positioned to adopt the technology. This is true especially for technologies that provide practical solutions to farmers’ problems such as drought tolerance. This result fails to reject the null hypothesis that education of the farmers is a socio-economic characteristic that greatly influences the adoption of DTMs among smallholder maize farmers in Kamuli and Masindi Districts.

Experience of the farmer in maize farming was also found to be positively related with the adoption of the drought tolerant maize varieties. A unit increase in the experience of the farmer was found to increase the chances of adoption by 0.0928 chances. The odds ratio for the farmer’s experience in maize farming was found to be 1.864 indicating that the increase in the experience
of the farmer greatly increases the chances of adopting drought tolerant maize variety by odds
greater than one. This is because experience comes with more knowledge about the existence of
different maize varieties from where the farmer also gets to know the existence of drought
tolerant maize varieties and thus taking them over to see their performance. These results are
consistent with those of Yenealem (2006) who reported a positive relationship between
experience and adoption of improved technologies among smallholder farmers.

Awareness of drought tolerant maize varieties had an odds ratio of 3.462 which indicates
increased adoption as a result of awareness. In addition, the positive marginal effects further
indicate that farmer’s awareness significantly increase the adoption of drought tolerant maize
varieties with the odds greater than one. An increase in awareness increases the chances of
adoption by 0.01645. Awareness could be as a result of extension visits aimed at encouraging
farmers to increased adoption of the drought tolerant maize varieties. Awareness plays a big role
in the uptake of new technologies since extension agents provide information on improved inputs
and technical advice and this enhances the rate of adoption. Extension service popularizes the
innovation by providing necessary information, knowledge and skills in order to enable farmers to
apply innovation. This relationship between adoption and awareness is consistent with Ghulam et
al., (2011) and Kaliba et al. (2000) who both reported that awareness is crucial for adoption of
any improved technology. This therefore confirms that there is an urgent need to increase
awareness of DTMs among farming communities in Uganda for increased adoption.

Distance to the source of seed was found to be negatively related with the adoption of drought
tolerant maize varieties with the odd ratio of 1.012 which is greater than one. This indicates that
the increase in the distance to the source of seed reduces the adoption of drought tolerant maize
varieties by the probability 0.00319. Increased distance to source of seed makes acquisition very
costly thus limiting seed access to resource constrained smallholder farmers. Some farmers in
remote villages use seed source to acquire knowledge and information pertaining varieties.
Therefore the source being far limits acquisition of both seed and knowledge. The negative
relationship between source of seed and adoption is consistent with the findings of Kaguongo et
al. (2010) that distance to source of seed discourages the adoption of the technology with farmers
near the source adopting more than farmers that are far from the source.

Occurrence of the drought was found to be having the odd ratio of 1.336 which indicates that it is
positively related with the adoption of drought tolerant maize varieties. This is because the odds
ratio is above one thus indicating the increased chance of adoption with increased drought
occurrence in the area of the farmer. The model marginal effects also indicate that an increase in
the occurrence of drought increases the adoption of drought tolerant maize varieties by the
probability of 0.0377. Occurrence of drought triggers a farmer to think for solutions to the
challenge for increased resilience. This search for solution results into more knowledge on
availability of DTMs. The farmers can then try such a technology and once it proves good, the
same is adopted for continued production. The positive relationship between adoption of DTMs
and occurrence of drought is consistent with La Rovere et al. (2014) who reported that the
increased drought occurrence has challenged farmers to look for strategies of overcoming the
effects of drought thus coming up with growing more drought tolerant maize varieties. This result
in addition fails to reject the null hypothesis that occurrence of drought as factor greatly
influences adoption of DTMs as technological solution to reduced yields as a result of increased
episodes of drought.
Price per kilogram of the seed had an odd ratio of 0.99 which being less than one indicates a reduced chance of adoption as price of the seed increases. This in addition to the negative and significant marginal effects which indicate that a unit increase in the price of drought tolerant maize variety reduces the chances of its adoption by the probability of 0.14168. The influence of price on farmers’ adoption of drought tolerant maize varieties at 1% level indicate that when prices increase the chances of adopting drought tolerant maize variety reduces. High price for seed increases the cost of production to a level that may be prohibitive to resource constrained smallholder framers. The negative relationship between adoption of DTMs and price of seed is in agreement with the findings of CIMMYT (1993) which indicated that the price of a technology plays a big role in the initial adoption of the same agricultural technology. Higher prices make it difficult for farmers especially smallholder to acquire and use such technologies since they tend to become expensive to purchase. Result on price fails to reject the null hypothesis that price of the seed is the factor that greatly influence adoption of DTMs. This further indicates that institutions relevant to seed industry need to work tirelessly to make the price of seed more affordable to smallholder maize farmers in the country.
CHAPTER FIVE
SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

This chapter presents the summary, conclusions and recommendations of the study. The summary describes a brief account of major results from which conclusions and recommendations were made for improved farmers’ adoption of drought tolerant maize varieties. The study also suggests further studies that can be carried out to enrich the subject matter.

5.1 Summary

This study was carried out to assess the adoption of drought tolerant maize varieties in Kamuli and Masindi districts of Uganda. A multistage sampling technique was used to select 190 farmers composed of 95 adopters and non-adopters from different sub-counties in the two districts. Primary data were collected on socio-economic characteristics of adopters and non-adopters of drought tolerant maize varieties, types of the different maize varieties adopted, limitations to increased adoption of DTMs and the sources of the drought tolerant maize varieties. Data were analyzed using SPSS and STATA statistical packages to generate descriptive statistics and logit model estimates.

Results showed that more males (84%) than female farmers had adopted and grown drought tolerant maize varieties. In addition, adopters of drought tolerant maize varieties were on average having more experience in maize growing than non-adopters and were more educated compared to non-adopters. Education improves the understanding of maize production and access to information, which stimulates adoption. Land size was significantly higher for adopters (5 Acres) compared to non-adopters (1.4 Acres) and farmers with larger land sizes are more likely to adopt and grow drought tolerant maize varieties compared to those with smaller farms.
Additionally, adopters had more access to credit (71%) compared to non-adopters (39%). For both adopters (82%) and non-adopters (67%), farming was the major occupation. Results also indicated a higher percentage of married farmers among adopters (83%) compared to non-adopters (20%). Interestingly, 89% of the adopting farmers were self-sufficient in maize production for the past year while 11% were not self-sufficient in maize production the previous year. Among the non-adopters, 69% were self-sufficient in maize production during the previous year compared to 31% of non-adopters that were found to be not self-sufficient in maize production the previous year.

Use of chemical fertilizers was not significantly different between adopters and non-adopters. In both sets, more farmers were not using chemical fertilizers. Among adopters, 88% of the farmers were not using chemical fertilizers as compared to 12% of the adopters that were using fertilizers. For the non-adopters, 99% were not using chemical fertilizers as a yield enhancing technology while 1% only used chemical fertilizers in their maize production.

Logit estimates showed that price per kilogram of seed and distance to the source of seed had a negative and significant influence on farmer’s adoption of drought tolerant maize varieties while rate of drought occurrence, awareness, education of the farmer and experience of the farmer in maize farming had a positive and significant influence on level of farmers’ adoption of drought tolerant maize varieties in Kamuli and Masindi.
5.2 Conclusions

Maize production systems in Masindi and Kamuli districts are characterized by low use of external inputs such as chemical fertilizers and credit. This in turn leads to low productivity and self-sufficiency in maize production with both use of external inputs and their associated effects of low productivity and self-sufficiency being much lower among non-adopters of drought tolerant maize varieties.

Farmers’ awareness of drought tolerant maize varieties is low. The most grown drought tolerant maize varieties were Open Pollinated Varieties mainly because of their ability to recycle seeds for other seasons. Furthermore, based on farmers’ desired attributes for drought tolerant maize varieties, grain yield and early maturity were the most preferred. Other attributes preferred by farmers included; resistance to field crop diseases, grain weight, grain size and cob size. The adoption rates are; Longe1 at 4%, Longe2 at 6%, Longe5 at 76%, Pan67 at 4% and Longe7 at 10%.

Adoption of drought tolerant maize varieties is constrained by among others; price of the seed, awareness of the availability of the seed with their attributes, distance to the points where seed can be accessed by farmers, education level of the farmers and experience in maize production. While factors that influence adoption included; education of the farmer in years of schooling, experience of the farmers in years of maize growing, awareness of drought tolerant maize varieties, distance to source of seed measured in time to seed source in minutes, occurrence of drought and price per kilogram of seed.
5.3 Recommendations

Promote farmers use of external inputs especially chemical fertilizers and credit through mobilization of farmers into groups and co-operatives. This would increase their bargaining power for increased access to cheaper inputs like seed, fertilizer and credit thus contributing to increased production and productivity.

Increase farmers’ awareness on the existence of high yielding drought tolerant maize varieties especially hybrid seeds through training and demonstrations. This would result into more use of hybrid seeds that are more yielding than Open Pollinated Varieties that are now the mostly grown. Government programmes already involved in the distribution of inputs especially maize seed should consider distributing hybrid drought tolerant maize varieties especially through Operation Wealth Creation. This would encourage farmers especially among drought prone areas to also purchase such seeds after experiencing how best they perform in face of increased episodes of prolonged drought and climate change. Consideration of variety traits such early maturing and grain weight in the breeding programs will continue to build confidence in farmers to grow drought tolerant maize varieties.

Develop extension programs both in private and public institutions that benefit farmers of all education levels. This would promote access to extension for all members of the community thus increasing awareness and knowledge of the benefits of growing drought tolerant maize varieties.
5.4 Suggestions for further research

Though the study has mainly concentrated on adoption of drought tolerant maize varieties, there is need to carry out a study to determine the efficiency of adopters in this enterprise. Furthermore, a study on economic evaluation of the different drought tolerant maize varieties can be conducted to see which varieties are performing better with farmers and the reasons behind such better performance. This will guide farmers on which varieties can perform better and the reasons for such better performance for higher economic returns.
REFERENCES


Caswell M., Fuglie K., Ingram C., Jans S. and Kascak C. (2001). Adoption of Agricultural production practices: Lessons learned from the US. Department of Agriculture area


Food and Agriculture Organization of the United Nations (FAO) (2013). Information from collected literature for Uganda to be used for crop modeling for Uganda. FAO crop calendar for maize, sorghum, millet, wheat, rice and barley.


Iga P. (2013). Promoting Modern Commercial farming through advising and encouraging local production and maximizing wealth from land.


Factors Affecting Maize Producers Adoption of Forward Pricing in Price Risk Management. The Case of Valharts.


Mugisha J. and Diro G. (2010).Explaining the Adoption of Improved Maize Varieties and its Effect on Yields among Smallholder Maize farmers in Eastern and Central Uganda


Mwendya A. (2012).Bulking as a promising strategy for market access by Smallholder farmers. A case study of Masindi District Farmers Association
NARO (2010). Enhancing maize Productivity in Uganda Through the WEMA project. Policy Brief


OECD (2008). Rising Food Prices: Causes and Consequences. OECD.


Ronner E. and Giller K. E. (2013). Background information on agronomy, farming systems and ongoing projects on grain legumes in Uganda. Milestone reference number: S 1.2.3.


