FARMERS' ADAPTATION TO CLIMATE CHANGE: ARE THEY WILLING TO PAY FOR THE DROUGHT TOLERANT MAIZE SEED VARIETIES?

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

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ABSTRACT

Use of seeds that can increase yield under drought stress conditions is one among the techniques for farmers' adaptation to climate change. This study was conducted with the aim of analyzing farmers' willingness to pay (WTP) for the Drought Tolerant Maize (DTM) seed varieties in Mbozi District. Specifically, the study aimed to find out farmers' awareness of the characteristics of the DTM seed varieties, to estimate the monetary value that farmers are willing to pay and to assess the socio-economic factors that influence their willingness to pay. The survey was administered to 124 respondents who were obtained by multistage random sampling. Double-bounded dichotomous choice Contingent Valuation Method was used to elicit farmers' WTP information. Descriptive statistics was used to find out farmers' awareness of the DTM varieties and binary logistic regression was used in estimating the monetary value that farmers are willing to pay as well as factors influencing the WTP. About 46% of the respondents were aware of the drought tolerant characteristic, 42% were ware that the varieties have high yield while 7.3% were aware that the varieties are resistant to diseases. On the other hand, about 62% were willing to pay for the varieties at an average of 4790 TZS per kg of DTM seed varieties while 38% were not willing to pay. Overall age, income, household size, education, price, farm size, and access to weather forecast information significantly influence the WTP at $P<0.005$. The study concluded that farmer's awareness of DTM characteristics is still low and farmers are not able to pay at 6000 TZS per kilogram which is the initial price for the varieties and this is challenging for farmers to cope with climate change using DTM seed varieties. The study therefore, recommends that deliberate efforts are needed to promote the varieties so as to create more awareness of the characteristics of the varieties among farmers. In addition, price subsidization of the seeds about 20% per kilogram will be needed.

DECLARATION

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

_____ _____

Elia Hebel Mlagala **Date**

(MSc. Candidate)

The above declaration if confirmed by;

_____ _____

Prof. Joseph P. Hella **Date**

(Supervisor)

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DEDICATION

This dissertation is dedicated to my family especially my father Hebel Mlagala and my mother Octavina Nyenza.

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LIST OF ABBREVIATIONS

AERC	Africa Economic Research Consortium
CV	Contingent Valuation
CVM	Contingent Valuation Method
CYMMIT	International Maize and Wheat Improvement Centre
DSSAT-CSM	Decision Support System for Agro technology Transfer Cropping System Model
DT	Drought Tolerant
DTM	Drought Tolerant Maize
DTMA	Drought Tolerant Maize for Africa
GHG	Green House Gases
Ha	Hectare
IITA	International Institute for Tropical Agriculture
IPCC	Intergovernmental Panel on Climate Change
KG	Kilogram
OPV	Open Pollinated Variety
SATEC	Suba Agro Trading and Engineering Company
SNAL	Sokoine National Agricultural Library
SPSS	Statistical Package for Social Sciences
SUA	Sokoine University of Agriculture
TARI	Tanzania Agricultural Research Institute
TOSCI	Tanzania Official Seed Certification Institute
TZS	Tanzania shillings
UNFCCC	United Nations Framework Convention on Climate Change
URT	United Republic of Tanzania
WTP	Willingness to Pay

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background Information

Climate is one of the factors that influence agricultural production, therefore changes in climate variables such as unexpected temperature and rainfall fluctuations have impact to agricultural production and productivity (Ahmed and Masud, 2015). The consequence of these changes presents a significant risk on agro-based economies. UNFCCC (2007) reported that developing countries are particularly vulnerable to extreme climate events due to their high dependence on rain-fed agriculture and natural resources for their livelihood, limited knowledge on climate change and limited capacity to mitigate the impacts of climate change.

It is estimated that the production of three major cereal crops maize, wheat, and rice need to increase by 70% by 2050 to feed the world rural and urban population. However, climate change-related scenarios is a threat (Cairns *et al.*, 2013; Ojija *et al.*, 2017). Of particular interest is the effect of adverse drought in the production of maize which is the East and Southern Africa's most important grown crop (Wossen *et al.,* 2017). The crop accounts for 30% of the total area under cereal production and supports over 300 million people in the continent (Cairns *et al.*, 2013; Fisher *et al.,* 2015). It is estimated that 40% of African's maize growing areas under rain-fed face drought stress, which leads to the yield loss of 10% to 25% (Fisher *et al.*, 2015).

In Tanzania maize covers 45% of the cultivated area in the country and 70.2% share of planted area with cereal (Stephen *et al.,* 2014; URT, 2017). This means that it is the most important cereal crop in the country thus, shortage of the crop is synonymously to food

insecurity. However, the crop is negatively affected from climate change scenarios which is the major threat to productivity (Masud *et al.,* 2015; Ojoyi, 2017). Rowhan *et al.* (2011) claim that seasonal increase in temperature by 2^0C will reduce yield of maize by 13%, while increase in precipitation variability will decrease maize yields by 4.2% in Tanzania as projected by 2050. Moreover, the Tanzania climate action report (2016) projected that temperature will increase by 1^0C to 2.7^0C by 2060 and 1.5^0C to 4.5^0C by the year 2090 in the country. Therefore given such projected changes in climate variables it is important to investing in the agricultural production methods that can help farmers adapt to such changes.

Among the methods for climate change adaptation is the use of seed varieties with increased tolerance to abiotic stresses such as heat and drought. Concerning maize is the use of Drought Tolerant Maize (DTM) seed varieties. The varieties were initiated by the Drought Tolerant Maize for Africa (DTMA) project which was led by the International Maize and Wheat Improvement Centre (CYMMIT) and the International Institute for Tropical Agriculture (IITA) in 13 African countries (Rovere *et al.,* 2014). The DTMA works with private seed companies, research institutes, and community-based seed producers.

The varieties are bred using modern conventional methods, without genetic modification. According to Zhao *et al.* (2018) DTM seed varieties can produce up to 30% of its potential yield after suffering water stress for six weeks before and during flowering and grain –filling. According to Tanzania Official Seed Certification Institute (TOSCI), first certified DTM seed varieties released by DTMA in partnership with seed companies and research institutes were; Kilima, Katumai, Staha, Kito, Situka 1, and Situka M. Currently,

efforts of breeding and multiplication of the varieties is done by seed companies and research institutes.

Despite farmers' awareness of different agricultural technologies that can enhance an adaptation to climate change, some technologies including the use of DTM seed varieties requires farmer's willingness to pay. Westengen and Brysting (2014) asserted that farmers who are willing to pay are likely to switch from one agricultural technology to another as a response to climate change. Similarly, Kassie *et al.* (2014); Kato *et al.* (2011) also argued that failure by farm households' willingness to pay for different agricultural technologies inhibits further investment and economic growth both at households and the national level. Therefore, this study was carried out to assess farmers' willingness to pay for the DTM seed varieties given its attributes as a strategy for farmers' adaptation to climate change.

1.2 Problem Statement and Justification

The impact of climate change is increasingly becoming evident in various sectors all over the world. However; agriculture sector in Tanzania is particularly vulnerable to climate change due to its overdependence on rainfall (Kangalawe, 2012; Ojoyi, 2017). Climate change has negatively affected the country by deteriorating water quality and quantity, loss of biodiversity as well as decline in agricultural production and productivity. Notable among the impacts of climate change and variability is the severe drought that has been causing a decline in crops production which causes food insecurity (Ojija *et al.*, 2017).

Drought resistant is said to be achieved by escapes through shorter duration varieties and resistance to periodic intra-seasonal drought through varietal selection and development. Given the importance of maize in the country investment in research and development on

drought and diseases tolerant seed varieties is noted to be suitable strategy to adapt to climate change (Shemsanga *et al.*, 2010). Efforts have therefore been made by both government and seed companies to ensure the availability of DTM seed varieties both hybrid and Open-Pollinated varieties (OPV's) through importation and breeding of the varieties.

According to TOSCI, there are different breeding companies of the varieties including Syngeta Tanzania limited, Seedco Tanzania Ltd, Meru agro-tours, Panner Seed Company Ltd, Suba Agro Trading and Engineering Company (SATEC) and Tanzania Agricultural Research Institute (TARI). The companies and the research institutes intend to breed the varieties with improved drought tolerant attribute. However, the impact of these varieties depend much on the extent to which they adopted by farmers. As noted by Kassie *et al.* (2017) farmer's adoption decision for the improved maize seed varieties is guided by the willingness to pay for the different attributes.

Stephen *et al.* (2014) carried a survey to assess the status of the use of improved maize varieties in different agro ecological zones in Tanzania. The study found that susceptibility of the varieties to diseases and drought stress are the hindrances for the use of the improved maize seed varieties. The DTM seed varieties as mentioned have improved attributes that is high yielding, drought resistant, as well as disease resistant. Therefore given the improved attributes of the varieties the study aimed at assessing farmers' willingness to pay for the varieties as part of the efforts for farmers' adaptation to climate change. The result of the study intends to inform policies aimed at promoting successful adaptation to climate change through the use of seeds with increased tolerant to abiotic stresses so as to increase production given the climate change.

1.3 Objectives of the Study

1.3.1 General objective

To analyze farmers' willingness to pay for the Drought Tolerant Maize (DTM) seed varieties given their attributes as an adaptation strategy to climate change.

1.3.2 Specific objectives

Specifically the study aim;

i. To find out farmers' awareness of the characteristics of the DTM seed varieties.
ii. To estimate the willingness to pay for the DTM seed varieties.
iii. To assess the socio-economic factors that influence farmer's willingness to pay for the DTM seed varieties.

1.3.3 Research questions

i. Are the farmers aware of the characteristics of (DTM) seed varieties?
ii. What is the mean willingness to pay for the DTM seed varieties?

1.3.4 Hypothesis of the study

Farmers' socio-economic factors do not influence the willingness to pay for DTM seed varieties.

Mathematically the null Hypothesis for the second objective is presented as follows

$$H_0: \beta_{i1} = \beta_{i2} = \beta_{i3} = \beta_{i4} \dots\dots\dots \beta_{ij} = 0$$

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

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

1.4 Organization of the Dissertation

This dissertation is organized into five chapters. The first chapter presents the study background, problem statement and justification, overall and specific objectives of the study. The second chapter reviews the literature on topics that are relevant to the study. The third chapter presents the research methodology and the fourth chapter presents the results and discussion. The final chapter presents the conclusions and recommendations based on the study findings.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Definition of Key Terms

2.1.1 Climate change

Refer to the long term changes in weather conditions and patterns of unusual extreme weather events (Wu and Zhou, 2016). These changes are over long duration ranging from a decade to millions of years and are usually caused by dynamic processes on earth, external forces including variation in sunlight intensity and of recent human activities. According to the Intergovernmental Panel on Climate Change IPCC (2007, 2014) the contribution of human activities is due to the development of industrial activities that have led to an increase in the Green House Gases (GHG) into the atmosphere that has resulted in weather changes. Other causes of climate change include natural and anthropogenic factors (IPCC, 2007), cited by Ojija *et al.* (2017) Natural factors include volcanic eruptions, variation in solar output, natural erosions emissions, and variation in the earth's orbital characteristics. Anthropogenic causes involve burning of fossil fuels, industrial activities and cement production, land-use changes and deforestation.

2.1.2 Adaptation to climate change

According to United Nations Framework Convention on Climate Change UNFCCC (2009), cited by Tripathi and Mishra (2017) refers to the adjustments or changes in the system to minimize the negative impacts and optimize the positive impacts of climate change. IPCC (2001) defines adaptation to climate change as the adjustment in the human environment system in response to actual or anticipated different climatic conditions in order to avoid the associated risk. Therefore, adaptation to climate change can generally mean how people adjust to the adverse effects of climate change. IPCC (2014) stated that

adaptation helps to reduce harm and exploit beneficial opportunities presented by climate change and this makes an urgency policy priority. For farmers to choose the adaptation technique it depends on different social, economic and environment factors (Bryan *et al.*, 2013). Depending on such factors this makes adaptation to be at different levels of government for example regional, national, sub-national and local levels. According to Deressa *et al.* (2010) adaptation to climate change is a two-way process, first, a farmer must perceive that climate is changing and then respond to the changes through adaptation.

2.1.3 Drought tolerant maize (DTM) varieties

Refer to the varieties with the ability to maintain its biomass production during arid of drought condition. A Drought Tolerant (DT) variety can produce approximately 30% of its potential yield after suffering water stress for six weeks before and during flowering and grain-filling (Magorokosho *et al.*, 2009). DT maize varieties do not only exhibit drought tolerance but also has more yielding than most commercial hybrids. Other important attributes includes resistance to major diseases and protein content (Lunduka *et al.*, 2017: Fisher *et al.*, 2015). According to the National performance trials at TOSCI people use the term interchangeably with drought escape, however the terms are not similar. Drought escape refers to the varieties that have shorter maturity duration. The varieties tend to mature early so as to escape the adverse effect of drought. On the other hand a variety is said to be drought-tolerant if it can adapt to very dry conditions for prolonged periods of times.

The DT maize seed varieties have been tested in the field and on-farm trials. In on farm trials DT maize has exceeded the yields of other sown commercial varieties when the rains are good and had 20% to 30% more yields under moderate drought conditions (CYMMIT, 2013). The DT maize varieties have the same input requirement and seed cost

as other non-DT commercial varieties (Fisher, 2015).Moreover the varieties have similar labour requirements as other commercial seed varieties which are not drought tolerant. Therefore DT maize varieties offer some insurance over mid-season drought conditions.

2.1.4 Willingness to Pay (WTP)

Is the price that an individual is willing to spend or give up to obtain a good or service. Theoretically, it measures the maximum amount of money an individual is willing to give up to obtain a product with a certain quality. The principle behind the WTP is that the maximum amount of money an individual is willing to pay, portrays the value that an individual attaches to the good (Lusk and Hudson, 2004). From consumer theory, the aim of a consumer is to maximize utility. Therefore, if a good or service has a high utility a consumer will be willing to pay more for his or her satisfaction (Mussa, 2015). However in this study the willingness to pay was assessed on the producer perspective. Therefore willingness to pay is the maximum amount of money that a farmer is willing to pay for the DT maize seed varieties.

2.2 Conceptual Framework

Adaptation to climate change will be needed if there are undesirable impacts experienced economically, socially or environmental. The impacts influence farmers' choice for the coping strategy. Farmer's willingness to pay among other things is the function of knowledge and awareness of the coping strategy, in addition, the awareness of the coping strategy is influenced by the socio-economic factors. In this case is the awareness of the attributes of the DTM seed varieties. Farmers' willingness to pay for different agricultural technologies across time and space is influenced by different factors awareness of the technology is one of the factors.

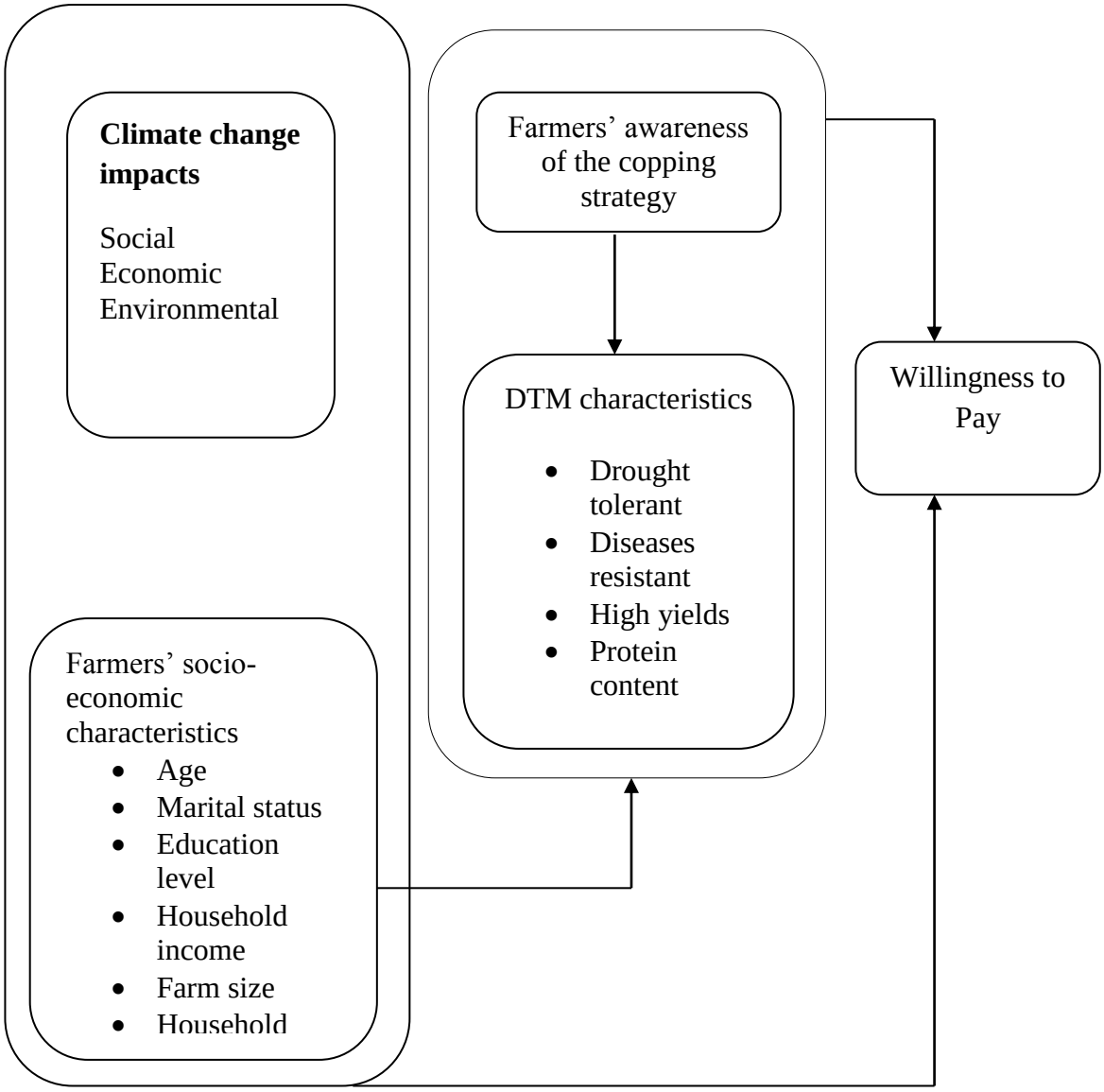

Figure 1: Conceptual framework

According to Kenneth and Natal (2012) demographic and socio-economic characteristics such as age, gender, and household size influence an individuals' willingness to pay. These factors also influence the awareness of the severity of the perceived impacts of climate change. Studies have been conducted to look into the direction and magnitude of the influence of different factors on the WTP for agricultural technologies. However, a factor which is found to influence the WTP in one local area may be found to hinder or irrelevant in influencing the willingness to pay in another local area.

Although some known determinants tend to have general applicability; thus it is difficult to develop a universal model of the process of WTP for agricultural technology with the determinants that hold everywhere due to the dynamics and distinctive nature of the areas.

2.3 Impacts of Climate Change on Maize Production

Climate change poses challenges for sustainable development of the human society by affecting the sustainability of agriculture. This is a challenge as it makes the vulnerable people who depend on local food production to be negatively affected (Müller *et al.,* 2011). Agriculture is one of the sensitive sectors to be affected by the climate change and this lead to the decline of the crop agricultural production (Wenjiao *et al.,* 2013). Developing countries including African countries are vulnerable to climate change due to the fact that most depend on the rain-fed agriculture (Sarker *et al.,* 2012). The IPCC (2007) third assessment report projected that between 75 and 250 million people in Africa will be exposed to increased water stress due to climate change by 2020.

The loss of agricultural crop yields is due to the climate change induced impacts such as rising temperature, droughts, floods and diseases (Sharma *et al.,* 2017). Maize is one of the crops that have negatively been affected by the climate change induced impacts. Maize is the principal staple crop in most of the African countries (Klutse *et al.,* 2013). However, the induced impacts of climate change such as increased water stress and increased temperature has undermined the crop yield (Barimah *et al.,* 2014). This was further supported by Fosu-Mensah (2012) who reported that, water stress at the grain filling stage of maize production has an adverse effect on the grain size and weight which ultimately lead to the reduced yields.

In contrast, Rowhani *et al*. (2011) reported that rainfall and temperature are the two important climatic variables in maize production thus; seasonal variability of these two

variables negatively affects the production of the crop. Abera *et al.* (2018) on assessing the impacts of climate change on maize production in three representative sites of maize growing areas in Ethiopia. Maize yields was found to decrease by 43 % and 24% by the end of the century in the two stations, temperature and rainfall variability were found to be the explaining factors for the yield decrease. Furthermore increase in rainfall explained the simulated yield increase.

Studies also conducted in Tanzania such as Mtongori *et al.* (2015) who used the Decision Support System for Agro technology Transfer Cropping System Model (DSSAT-CSM) evaluated the impacts of climate change and variability, and crop management on yield of maize in southern Tanzania. A series of sensitivity experiments were conducted to evaluate the response of maize yields to a range of principal changes in rainfall and temperature. Dry spells caused yield loss of about 43% for the prolonged spells of 20 days, while decrease in rainfall intensity during the growing season caused a loss of yields between 40-100%. Dry spells may affect crop growth and final yields, even without significant reductions in seasonal rainfall totals (Barron *et al*., 2003). However the severity of dry spells on plant growth and hence yields depend on the stage of plant growth. Maize appears to be less tolerant at the vegetative growth stage when there is water deficit but not tasselling and ear formation (Çakir, 2004).

Another study done by Luhunga *et al.* (2017) assessed the impact of climate change on rain-fed maize production in Wami-Ruvu basin in Tanzania. The projection from different models showed that due to climate change maize yield will decrease. Therefore given the dependence of the maize production on rainfall and having observed the impact of the change of both rainfall and temperature, it is obvious that any alteration on the climate change variables the crop will negatively be affected. The response of the crop to these

changes enables the development of the effective adaption measures (Schlenker and Lobell, 2010). Adaptation to changing climate is an effective tool that enables farmers and their farming to changes and variability in climate along with avoiding projected damages.

2.4 Farmers' Adaptation to Climate Change

Climate change has proven to have negative impacts to the rain-fed agriculture and the world has responded through two broad response mechanisms namely mitigation and adaptation (Elum *et al.*, 2017). The two mechanisms aim at moderating adverse effects of climate change however the common mechanism among farmers is the adaptation to climate change. Adaptation is therefore critical and concern in developing countries where vulnerability is high (Mustafa *et al.,* 2017). According to Alam *et al.* (2017) farmers' adaptation strategies differ across communities, regions and countries.

In examining adaptation strategies developed by local farmers against climate change in Kilombero district in Tanzania Balama *et al*. (2013) found that; crop diversification, changing cropping calendar, and adapting to modern farming techniques as the farmers' adaptation to climate change. However, the study by Abid *et al.* (2016) on the adaptation to climate change and its impacts on food productivity and crop income in rural Pakistan, in addition to the mentioned farmers' adaptation techniques others included soil conservation, changing irrigation and crop varieties. Another study by Bunclark *et al.* (2018) conducted a study in Burkina Faso and found that farmers use water harvesting technology to alleviate drought vulnerability in semi-arid cropping systems.

Lubanwa and Shirima (2017) investigaing the adaptation strategies adopted by smallholder farmers in Manyoni district in Tanzania and found that most of the adaptation

strategies were farm based. Apart from the strategies mentioned in the previous strategies this study found also a staggering cropping. In this strategy farmers use more than one plot for crop production where by crops are planted before rain on uncultivated plots and in other plots immediately after rain. This practice aims at distributing farming effects given the study area which is said to be semi-arid in nature (Lubanwa and Shirima 2017). In contrary Alam *et al.* (2017) identified both farming and non-farming adaptations strategies for climate change. Adaptation strategies such as new crop varieties, changing planting dates, homestead gardening; planting trees and migration were identified.

Given the impact of climate change in the form of increased temperature and fluctuation in precipitation especially in South Asian countries including Pakistan, Fahad *et al.* (2017) identified different adaptation measures by farmers such as; change of crop type, change of crop variety, change in irrigation, change fertilizer, pesticide, change in seed quality, plant shades trees, farm diversification, and store water. During rainy season crops were exposed to pest attacks then different pesticides were used to cope with the diseases and risks. During the dry season farmers used irrigation for their desired production.

Generally the studies reviewed shows that farmer's adaptation techniques to climate change are content specific and change over time, from area to area and even within a particular society. Ali and Erenstein (2017) also argued that some of the adaptation methods to climate change are localized and cannot be directly opted and implemented in other regions or agriculture setting. However despite the fact that the studies have identified different adaptation strategies the use of bred resistant varieties has received little attention which was the basis for conducting this study.

2.5 Farmers Awareness on DTM Characteristics

Awareness of a particular agricultural technology is important so as to take the full advantage of both government and non-government development efforts. According to

Kumar *et al*. (2011) to realize the benefit of the particular technology in agriculture then awareness components is crucial in enhancing willingness to pay. Furthermore, Kagoya *et al.* (2017) assert that awareness plays a vital role in adopting a particular technology. Also the study asserts that socio-economic factors influence the level of awareness of a particular technology.

Awareness of the improved attributes of the product influenced the willingness to pay, it is the improved attribute that influences the maximum amount an individual is willing to pay (Kassie *et al.,* 2017). According to Ayedun (2018) in assessing the adoption of DT maize varieties and its determinants found that awareness of the varieties was significant as it promotes demand for the seeds. The study further states that one of the preferred characteristic by maize farmers was the drought tolerant. The results imply that DTM will likely be adopted if farmers are aware of the varieties as only 37% were reported to be aware of the varieties. For the DTM attributes only 11.1% were aware of the drought tolerant attribute while 64.4% were aware that the varieties gives high yields (Ayedun, 2018).

Katengeza and Holden (2016) also found that farmers fail to respond to drought shock by adopting DT maize varieties because of the limited awareness of the varieties benefits. The result also could imply that there is a limited awareness of the characteristics of the varieties which leads to the delay in the adoption of the varieties. Also Kassie *et al.* (2017) stated that promotion along with raising the awareness of the DTM can speed up the rate of adoption of the varieties in the drought prone areas. Not only that but also the preferred attributed by farmers such as yield and other attributes should be emphasize for the adoption of the varieties.

Behind adoption of the DTM is the willingness to pay which is influenced by the attributes of the varieties. Awareness of the characteristics of the DTM has been analyzed in the present study since it has proven to be a significant factor in any new agricultural technology.

2.6 Estimation of Willingness to Pay

The concept of willingness to pay has commonly looked at the utility maximization of consumers. However, evidence has shown that the concept can be extended to producers. Agribusinesses such as seed and chemical companies, technology and equipment dealers, and agricultural service providers might also are interested in producer (farmer) WTP for a new product or service (Hudson and Hite, 1990). In this present study the improved attribute that is taken into consideration in analyzing willingness to pay is the drought attribute of the varieties.

There are several methods in estimating consumer or producer WTP for novel goods or change in the quality of the existing goods. According to Loureiro and Umberger (2002), willingness to pay can be estimated by using three techniques namely; conjoint analysis, contingent Valuation and Experimental Auctions. Experimental auctions usually deal with real situations where consumers determine how much they can pay for the good or service. However Harrisson *et al.* (2002) highlights the some limitations of this method such as recruitments and paying the laboratory fee for the participants which may introduce bias into the resulting potential bids and limit sample size. In addition bids must be truncated and censored by the outside alternatives or substitutes not available in the experiment.

Conjoint based choice method of valuation uses survey responses to elicit the willingness to pay of consumers just as contingent valuation method (Munene, 2004). In this method

usually a consumer is confronted with choice between alternative products with defined several attributes such as price and quality. Therefore consumers are asked which product they will purchase given several products descriptions (Adamowcz *et al.,* 1998), as cited by (Lusk and Hudson, 2004). The major limitation of this method is that it is difficulty to incorporate and other explanatory variables into the conjoint based models. Furthermore as reported by Johnson and Desvousges (1997) subject responses may be inconsistent across choice questions or influenced by the choice task complexity. However among the three methods the study used the Contingent Valuation Methods (CVM) to elicit information on the willingness to pay due to the statistical efficiency of its approach as it overcome the limitations of the other explained methods.

2.6.1 Theoretical review of contingent valuation method (CVM)

Contingent Valuation Method (CVM) aims at recovering information about preferences of willingness to pay from direct questions (Haab and Connell, 2002). Peoples' preferences are elicited carefully by designed surveys that will give meaningful results if they are properly grounded in a consumer or producer maximization framework (Hanemann and Kanninen, 1998). Given the attributes, the estimation of willingness to pay can be through open-ended questions or close-ended questions and payment cards. However, Hanemann *et al.* (1991) states that people find it difficult to mention the amount of money they are willing to spend in an open-ended question, though such questions provide a direct estimate on the willingness to pay and are easy to analyze but it may lead to the problem of missing values.

Lusk and Hudson (2004) assert that close-ended questions are often the method of choice since it is closer to real-life situations. In this case WTP is not directly observed but the assumption about its distributions and parameter can be made from the data by estimating

the mean WTP in monetary terms. Therefore approaches developed in close-ended questions including Single-bounded, Double-bounded and Multiple-bounded dichotomous choice. In single bounded dichotomous choice the price of the new product is varies across surveys and average WTP is estimated by examining how the YES response varies at alternative price levels. This approach is not statistically efficient as it requires a large sample. In the Double-bounded contingent Valuation approach, the second question is contingent upon the first response. According to Hanemann *et al.* (1991) this method integrates integrate information of individual willingness to pay hence it provides more efficient estimates. The method is extensively used in valuing non-market goods as well as assessing consumer acceptance of improved technologies (Kimenju *et al.*, 2005).

The multiple-bounded choice method offers multiple bids and multiple choices; it becomes useful in the case where limited information is initially available to decide which bids to include (Alberin *et al.*, 2003). The multiple choices offer the possibility of including options for uncertainty. The weakness of this approach is that it is subject to design bias and is influenced by the variety of bids included. Therefore this study used the double-bounded contingent Valuation which provides more efficient estimates.

2.6.2 Analytical review of CVM

One of the main objective of estimating an empirical WTP model based on the contingent survey responses is to derive a central value or mean of the WTP distribution Hanemann *et al.*, 1991). This needs an econometric modeling which allows undertaking a number of valid tests that will add the credibility on the WTP estimates (Gunatilake *et al.*, 2006). According to Lema and Beyene (2012) CVM is frequently applied to descrete survey responses to elicit options on various matters. Therefore, when the dependent variable in regression model is binary the analysis could be conducted using linear Probit or Logit

models which allow the estimation that an event will occur or otherwise are used (Pindcyk and Rubinfeld, 1981; Wang and Elhag, 2007). Thus in this study the dependent variable is whether farmers are willing to pay or not which allows the use of Probit model or Logit model.

Fakayode *et al.* (2010) used the logistic regression model to determine the mean farmers' willingness to pay for irrigation facilities because of its ability to deal with dichotomous dependent variable. Furthermore Roopa (2000) argues that logistic regression allows the probability that an event will occur or not through prediction of binary dependent variable from a set of independent variables. Studies on WTP show that an econometric model does not only give result on the estimates of the mean WTP but also the explanatory variables affecting the WTP. Studies such as Ogunniyi *et al.* (2011); Banda *et al.* (2004); Tim *et al.* (2007); Baidoo and Amoatey (2012); Chandrasekaran *et al.* (2009) have used CVM in estimating WTP and Logistic regression or Probit model was used to estimate the mean WTP because both models for the dependent with binary response.

With regard to the present study the logistic regression model was used in estimating the mean WTP and in analyzing the factors that influence the farmers' willingness to pay for the DT maize seed varieties. The advantage with logistic regression is that it does not allow non-zero correlation (Cameron and Giggin, 1994; Jeanty *et al.,* 2007). After running the dependent variable with Yes or No indicator on a constant and independent variable of price the mean willingness to pay is calculated by taking the coefficient of the intercept dividing by the slope coefficient of the bid price (Gujarati, 1990). In addition in assessing the explanatory variables the logistic regression model allows the use of the both odds ratio and marginal effect in making interpretation.

2.7 Empirical Studies on CVM

Studies that have been reviewed have reported the willingness to pay estimates for the different agriculture technologies. Therefore this section reviews the willingness to pay studies, the methodology used and the choice for the methodology.

According to Lusk and Hudson (2004) there is a need to recognize the objective of willingness to pay elicitation which is different depending on whether the application is agribusiness related versus environmental policy. With the growing novel food products agricultural economists have turned their attention in estimating the willingness to pay for the for the novelty products. To assist agribusinesses with adoption decisions to elicit consumer willingness to pay for the novelty product experimental and contingent valuation techniques has been developed.

Chandrasekaran *et al.* (2009) in assessing farmers' willingness to pay for irrigation water CVM was employed. To elicit the WTP interview schedule was used. It consisted of both closed and open-ended questions. In the case of close-ended questions, farmers were asked whether or not they will be willing to pay a specific amount under the improved levels of water supply from the tanks for irrigation. While for the open-ended questions farmers were just asked how much they will be willing to pay at the improved water supply conditions both in the dry and wet season. The result revealed that the majority of the farmers are willing to pay for the irrigation water under improved supply and the willingness to pay was influenced by the social economic factors.

Lema *et al.* (2012) employed a Contingent Valuation technique to estimate respondents' willingness to pay (WTP) for improved rural water supply. The study used double dichotomous questions in collecting data. To examine the determinants of WTP both

binary and ordered Probit model was used. The results indicated that households who earn better annual income, who are using unreliable water sources and who are spending more time collecting water are more likely to pay.

Ayana (2017) conducted a study to assess farmers' willingness to pay for the soil conservation practices double-bounded contingent valuation was used to elicit the WTP information because of its usefulness to correct the strategic bias and improve statistical efficiency. It was found that initial bid affect negatively their WTP. Han *et al.* (2011) in estimating the willingness to pay for environmental conservation employed the CVM using a questionnaire-based survey. However, in eliciting WTP the study employed a payment card whereby respondents were provided with nine different offers from which they had to choose a single amount. The results indicated that the majority of the respondents were willing to pay less than the mean willingness to pay.

2.8 Socio-economic Factors Affecting Farmers' Willingness to Pay

John and Prabuddha (2011) researched the joint estimation of farmers' stated willingness to pay for agricultural services in the case of the west and central Africa. Multivariate Probit approach was used to investigate farmers' stated willingness to pay. The results of the study showed that land ownership matters as well as household income significantly increases the probability of willingness to pay for the agriculture services.

In assessing farmers' perception and adaptation to climate change so as to enhance policy towards tackling the challenges of climate change in Ghana Acquah and Onumah (2011) urged that; Age, gender, years of education, years of farming experience, own farmland and other income generating activities are significant predictors of the WTP for the climate change. Also, the results of the study showed that the willingness to pay tends to

increase with the increase in income, education level and age. While the regression covariates such as gender, age, household size, years of farming experience and household income were found to significantly influence negatively the WTP for the climate change mitigation policies. However, Nan (2013) urged that positive relationship exists between willingness to pay and the socio-economic factors. This is not always the case since the influences of the socio-economic factors on the WTP are content specific. The socio-economic factors that influence positively the WTP in one area may influence negatively the WTP in another area.

The study conducted by Ogunlade *et al.* (2010) investigating factors affecting farmers' ability to pay for the irrigation facilities in Nigeria. Large sums were invested in the irrigation subsector of the Nigerian agriculture. However the outcome of the investment seemed to be of dismal failure. The logistic regression of the results showed that there are different factors that affected farmers' ability to pay for the irrigation facilities. Coefficients of age, land size, household income and household expenditure were found to have significant influence on the willingness to pay for the facilities. However, the amount charged for the facility was found to be insignificant and this was due to the fact the amount that was charged for the facilities per hectare was too low. Similarly Ogunniyi *et al.* (2011) used a Tobit model to explain household preferences for quantity and quality of domestic water supply. The results of the study confirmed that household age and income were statistically significant in influencing WTP for both quantity and quality water supply.

In investigating how willing would the farmers be to pay for the agricultural extension service in Nigeria Ozor *et al.* (2013) employed the stochastic payment card. Farmers were allowed to indicate their WTP a particular amount or not as their share of the cost of

improved Extension service. The factors which were found to influence most of their willingness to pay included the state of origin, item paid for, major occupation, minor occupation, number of years in school, size of farmland planted, membership of farmer/Cooperative organizations and the sale of farm produce.

Overall, following Aryal *et al*. (2009), farmers' willingness to pay for given agricultural technology is a function of knowledge, attitude, and intention. Socio-economic characteristics such as age, sex, and income, years of education, years of faring experience, own farm land and income generating activities shape consumer's willingness to pay, because those characteristics affect attitudes toward agricultural technologies. Farmer is also expected to pay more with increased expected future temperature change, the willingness to pay more indicates that farmers value a given adaptation technology for the climate change that negatively affects agricultural production.

The empirical studies reviewed have shown that household willingness to pay for the different agricultural technologies as far as climate change is concerned is usually affected by the social economic, demographic and related variables. One variable may affect willingness to pay positively and significantly in one area while the same variable may be insignificant in another area and situation.

CHAPTER THREE

3.0 METHODOLOGY

3.1 Study Area

This study was conducted in Mbozi district and the decision for the selection of the site was based on the fact that the area has high potential for maize production. During the season 2016/17 it was among the leading maize producers (URT, 2017). Also the district is characterized with altitudinal temperature with dry and rainy seasons. This makes the area also suitable for the use of the varieties which are said to perform well both under rain and dry areas. Four wards were selected first to have the sample representative that will enable to make an inference for the district. But the major limitation in the study area was the lack of rainfall data in each ward that would have assisted in observing if there is any significant variation in rainfall between wards so as to observe the willingness to pay pattern.

3.1.1 Location

Mbozi district is found in Songwe region in the southern highlands of Tanzania, the district consists of 4 divisions, 18 Wards, and 118 villages. According to URT (2013) Mbozi district is located in the South Western corner of Songwe Region, between Latitudes 8^{o} and 9^{o} 12" South of the Equator and Longitudes 32^{o} 7' 30" and 33^{o} 2' 0" East of Greenwich Meridian. In the southern part the district is bordered by Ileje district, to the east, Mbeya Rural district to the North, extending to Lake Rukwa where it is bordered by Chunya district and in the West, it shares borders with Momba District. Fig. 2 is the map of Mbozi district showing the selected wards Myovizi, Nanyala, Ihanda and Isandula.

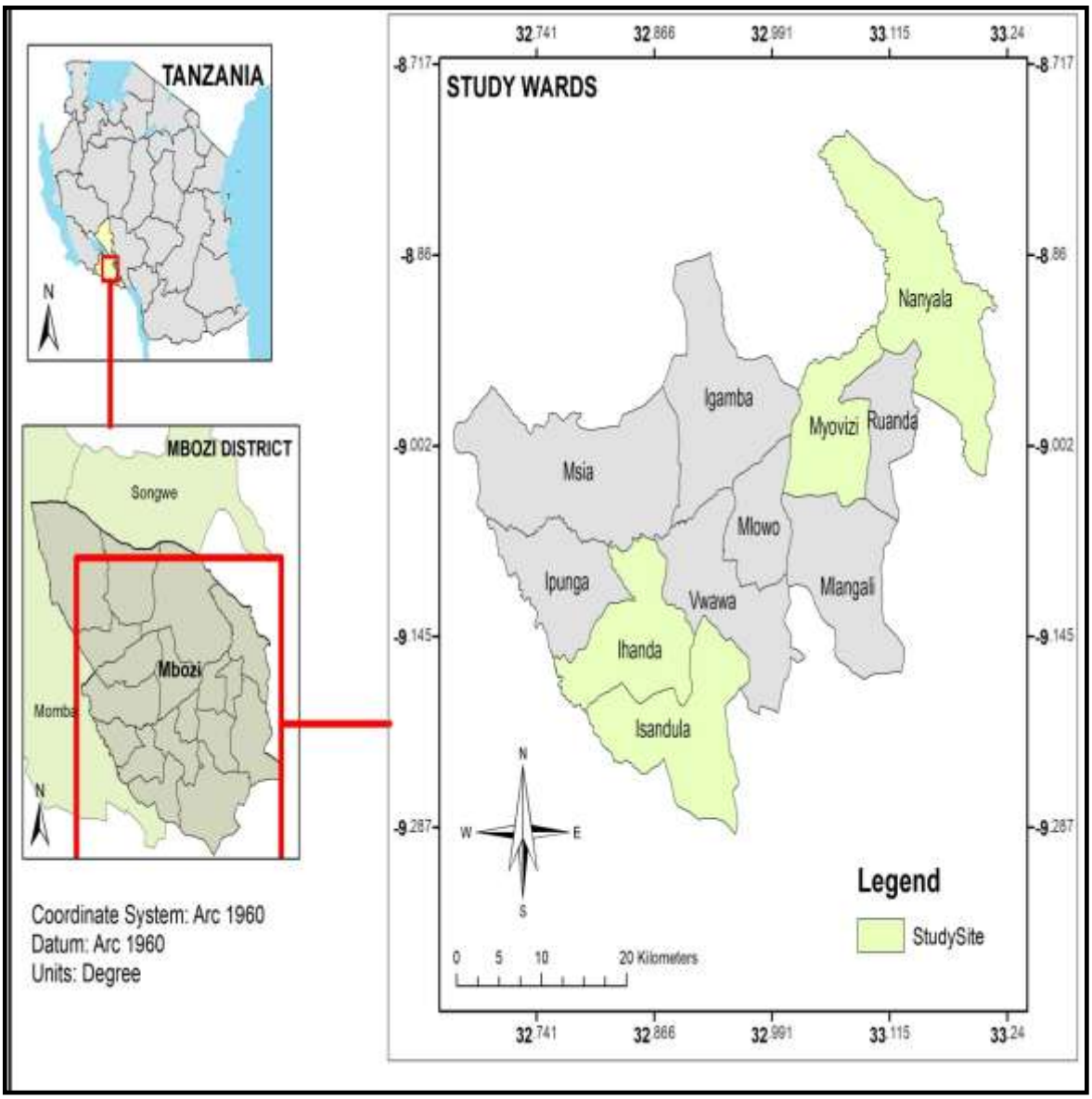

Figure 2: Map showing the study area

3.1.2 Climate

Mbozi District consists of two agro-ecological zones; the high land and lowland. The highland agro-ecological zone covers the eastern part of the district with an attitude ranging from 1400 to 2750 meters from the sea level. This zone is characterized by hills, rivers, and gently sloping hills. The temperature is moderate with high rainfall. Major crops grown in the zone include maize, beans, coffee, and banana. The lowland agro-ecological zone covers the western part of the district between 900-1400 meters above sea

level. It is characterized by deep-well drained volcanic soils. The zone is relatively hot with temperatures ranging from 25°C -28°C.

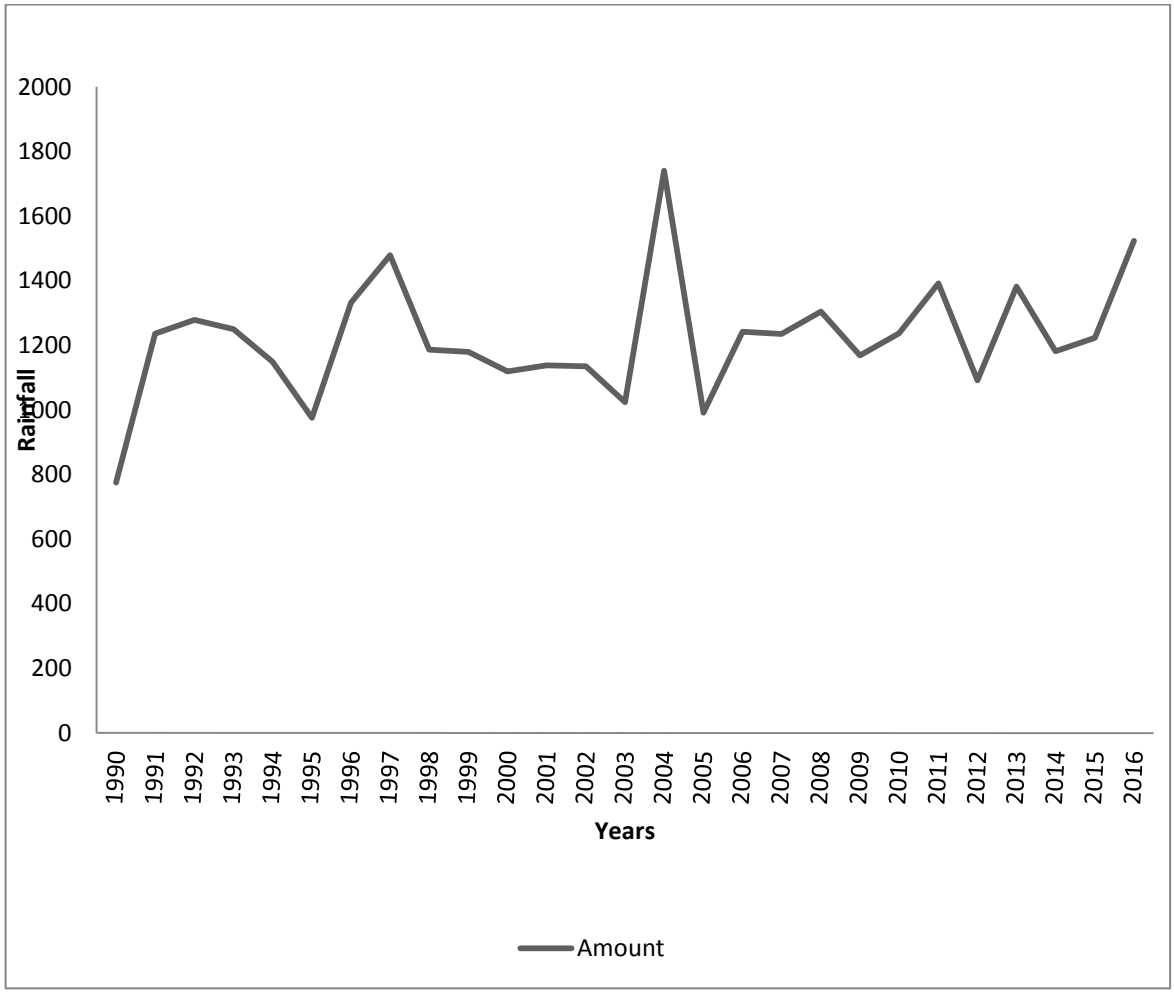

Figure 3: Rainfall trend in the study area

Rainfall trend data in the study area is shown in Fig. 3. The data show rainfall trend for the past 26 years from 1990 to 2016 were obtained from the weather station in the district. The trend shows that rainfall in the study area varies from year to year. Therefore, the use of the DTM seed varieties given the rainfall trend in the study area will be worth. The mean annual rainfall is 1200 ml. The lowest amount of rainfall recorded in the study area was about 800 ml in 1990 while the highest amount of rainfall recorded was about 1700 ml in the year 2004 as shown. The southern part of the district experiences low rainfall, and rainfall increases as you move towards the northern part of the district.

3.2 Research Design

The study used a cross-sectional research design. This design allows data to be collected at a single point in time from a sample to represent a large population. The design is suitable in the descriptive study and for the determination of the relationship between and among variables. Besides, the study design was considered to be sufficient for addressing the study objective.

3.3 Sampling Procedure

Multistage random sampling technique was used; Mbozi district was purposely chosen and four wards, (Myovizi, Nanyala, Ihanda and a Chimbuya) were randomly selected from the district out of 18 wards, in the second stage villages were randomly selected. One village was randomly selected from each ward making a total of four villages namely Nanyara, Ihanda, Mahenje and Chimbuya. In the third and the last stage, the households were randomly selected from each village.

In determining the sample size population size for the study was unknown, hence the suitable formula for determining sample size according to Bartlett *et al.* (2001) is given by; $n = \frac{t^2 * p * q}{d^2}$

Whereby;

$\boldsymbol{n}$ = Sample size

$\boldsymbol{t}$ = value of selected alpha (1.96 at 95%confidence level)

$\boldsymbol{p}$ and $\boldsymbol{q}$ percentage of picking choice expressed in decimal 0.5

But $\boldsymbol{q}$=1- $\boldsymbol{p}$

$\boldsymbol{d}$ =percentage error (0.05 at ±5%)

When calculated the formula gives the sample of 384 respondents however, the study used a sample of 124 respondents due to time constraints and the budget allocated. Meilgaard *et al.* (1999), suggests that, for social science studies, the standard sample size of 100 respondents for central location test are enough to represent the studied population. Sample distribution in the study area is shown in Table 1.

Table 1: Sample size distribution

Sex	Mahenje	Nanyala	Ihanda	Chimbuya	Total
Male	20	24	15	18	77
Female	13	9	10	15	47
Total	**33**	**33**	**25**	**33**	**124**

Relatively large number of respondents was obtained from Mahenje, Nanyala and chimbuya, while small number of respondents was in Ihanda and this is due to the inevitable social commitment. During the time for data collection there was a funeral ceremony hence it wasn't easy to interview the farmers as many were absent from their residents. From both villages the number of male respondents was higher compared to the number of female respondents.

3.4 Data Types and Methods of Collection

Data collected involve both primary and secondary data; for the primary data field survey was conducted using a questionnaire which consisted of four parts. The first part of the questionnaire was about the household characteristics the second part was about household occupation, income, and land ownership, the third part was about awareness and of the DTM seed varieties, the third part was about farmers' group membership, access to credit and weather forecasting information. The fourth and the last part consisted of the questions about farmers' willingness to pay for the DTM seed varieties. The double-

bounded contingent Valuation which provides more efficient estimates was used to get the information for estimating the value a farmer is willing to pay for the DTM seed varieties. Before being administered to the respondents the questionnaire pre-testing was done to 5 respondents in Mahenje Village to find out if there is any shortfall of the tool. Minor corrections were made especially the aspect of education level; it was found that numbers of years spent in formal education would suit the analysis than the level of education alone.

Secondary data such as rainfall data and the early released DTM varieties that were used to supplement the primary data. The data were obtained from sources such as the Internet, published and unpublished dissertations, Mbozi weather station, TOSCI and the Sokoine National Agricultural Library (SNAL).

3.5 Data Analysis

Data were coded before the analysis however; data cleaning was done by running frequencies of individual variables. Statistical Package for Social Sciences (SPSS) version 20 was used for the descriptive part in the analysis especially the first specific objective of the study. In addition, STATA version 14 was used in running the binary logistic regression to address the second and third specific objectives.

3.5.1 Descriptive statistics

This was used to address the first objective of the study which was to assess farmers' awareness about the characteristics of the DTM seed varieties. Descriptive statistics such as cross tabulation, means, percentages and frequency distributions, minimum and maximum was used in the analysis. Descriptive statistics was also used in analyzing the socio-economic of the respondents.

3.5.2 Estimation of willingness to pay

The double-bounded CV approach was used since it provides more efficient estimates of the mean willingness to pay and tighter confidence interval. Theoretically, it is assumed that the willingness to pay for a product at a price or bid $\boldsymbol{\beta}$ has a certain probability distribution function. The distribution can be seen as a function of the price, the higher the price the lesser the probability of being accepted. In applied research, the mostly commonly used function is the logistic distribution with effects of price entered indirectly in an argument called the index function denoted as $\boldsymbol{v}$. The most common index function is linear in the price or bid, $\boldsymbol{\beta}$.

$V = \alpha - \rho B$ ……(1)

Hence the probability density function for accepting the bid is given as

$\mathrm{G(B)} = (\mathrm{WTP} < B) = \mathrm{e(v)}/1 + \mathrm{e(v)}$ ……(2)

G. which present the proportional of the population of which their willingness to pay lies a certain value below $\boldsymbol{\beta}$ The probability density function for not accepting the bid is

$\mathrm{G(B)} = (\mathrm{WTP} < B) = 1/1 + e(v)$ ……(3)

A farmer who accepts an offer of *B*, WTP becomes greater than *B* and its probability is given as:

$\mathrm{P(WTP} > B) = \pi^{y}\mathrm{(B)} = 1 - \mathrm{G(B)}$ ……(4)

In the double-bounded contingent valuation framework a household is presented with two bids either to accept or reject. The second bid is dependent upon the reaction to the first bid, if the participant said "yes" to the first bid (β_i^1) the second bid (β_i^u) will be an amount greater than the first bid $(\beta_i^1 < \beta_i^u)$. If the response of the first bid (β_i^0) was "No" then the second bid (β_i^u) will be an amount smaller than the first bid$(\beta_i^0 > \beta_i^u)$.

Therefore there will be four possible outcomes; both answers “yes”, both answers “No”, a “Yes” followed by “No” and “No” followed by “Yes”. The likelihood of these outcomes is;

$\pi^{yy}, \pi^{nn}, \pi^{yn}, \text{and } \pi^{ny}$

And the four probabilities become as follows

$\pi^{yy}(B_0, B_1) = \Pr(\text{Max.WTP} \geq B_1) = 1 - G(B_1) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (5)$

$\pi^{yn}(B_0, B_1) = \Pr(B_0 \leq \text{Max.WTP} < B_1) = G(B_1) - G(B_0) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (6)$

$\pi^{ny}(B_0, B_1) = \Pr(B_1 \leq \text{Max.WTP} < B_0) = G(B_0) - G(B_1) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (7)$

By combining these probabilities from the four outcomes, the log-likelihood function becomes:

$$\text{Ln}(L) = \{d^{yy}\ln(\Pi^{yy}) + d^{yn}\ln(\Pi^{yn}) + d^{ny}\ln(\Pi^{ny}) + d^{nn}\ln(\Pi^{nn})\}.$$

Where d^{yy}, d^{yn}, d^{ny} and d^{nn} are binary variables with 1= Occurrence of a particular outcome and 0 otherwise. The household choice can be analyzed using binary response statistical models.

Mean WTP was estimated using the following relation:-

Mean WTP= -α/ρ

Where

α =Coefficient of intercept term

ρ= bid price.

3.5.3 Logistic regression

This was used to assess the socio-economic factors which were assumed to influence the willingness to pay for DTM seed varieties. The dependent variable is a binary choice with

those who are willing to pay coded as 1 and 0 otherwise. According to Gujarati (2004) the logistic cumulative probability function for those who are willing to pay is given as shown

$$\mathrm{Pi} = 1/1 + e^{-z} = e^{z}/1 + e^{z} \ldots \ldots \ldots \ldots \ldots \ldots (i)$$

Then $(1 - P)$ is the probability for those who are not willing to pay

$$1 - \mathrm{Pi} = 1 - (1/1 + e^{z}) \ldots \ldots \ldots \ldots \ldots \ldots (ii)$$

Then dividing equation (i) by equation (ii) in favor of those who are aware willing to pay

$$\mathrm{Pi}/1 - \mathrm{Pi} = \frac{e^{z}/1 + e^{z}}{1 - e^{z}/1 + e^{z}} = e^{z} \ldots \ldots \ldots \ldots \ldots \ldots (iii)$$

$$\mathrm{Pi}/1 - \mathrm{Pi}\,(\text{odds ratio}) = e^{z} \ldots \ldots \ldots \ldots \ldots \ldots (iv)$$

To estimate the logit model the dependent variable was transformed by taking the natural logarithm of the equation (iv)

Hence;

$$L = \ln(\mathrm{Pi}/1\text{-}\mathrm{Pi}) = \ln e^{z} = z_i \ldots \ldots \ldots \ldots \ldots \ldots (v)$$

Thus; the relationship between WTP for a farmer *'j'* choosing a DTM '*i*' and the social-economic variables was specified as

$$WTP = \alpha + \rho\beta_{ij} + \emptyset z_{ij} + \varepsilon_{ij} \ldots \ldots \ldots \ldots \ldots \ldots (vi)$$

The error term is assumed to follow the logistic distribution with zero mean and variance of $\pi^2/3$. Therefore the logistic model explaining the farmers' WTP is specified as

$$WTP = \alpha + \rho\beta + \emptyset z + \varepsilon \ldots \ldots \ldots \ldots \ldots \ldots (vii)$$

Whereby:

WTP=1 if a farmer is willing to pay and 0 otherwise

B= Bid price

Z= A vector of explanatory variables

Specifically, the logit model explaining the factors affecting farmer willingness to pay for the DTM varieties was specified as:

$$\begin{aligned}WTP = \beta_0 + \beta_1 AGE + \beta_2 SEX + \beta_3 MART + \beta_3 EDUC + \beta_4 I + \ \beta_5 HHS + \beta_6 LSIZE \\ + \beta_7\ EXT + \beta_8 WFI + +\beta_{10} CRDT + \beta_{11} BID + \beta_{12} DTM \\ + +\varepsilon \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots .\,.\ldots\ldots .\,.\ldots . \text{(viii)}\end{aligned}$$

Whereby:

AGE	Age of the household in years
SEX	Sex of the respondent
MARIT	Household marital status
EDUC	Household level of education
INCOME	Household level of income in Tanzanian Shillings (TZS)
HHS	Household size
LSIZE	Household land size
EXT	Farmers’ access to extension services
WFI	Farmers’ access to Weather forecast information
CRDT	Access to credit
BID	Price stated by a respondent
DTM	DTM varieties awareness

3.6 Description of the Variables

Age of a household head: It is the number of years of the household head, the age of the farmer is expected to have the positive effect on the WTP for the DTM seed varieties because of the accumulated experience of the farmer. However, because of the close relationship between age of the farmer and the farming experience, farming experience was excluded from the analysis.

Sex of the respondent: This is a dummy variable which takes the value of 1 if the household is male and 0 for female. Literature indicates that female headed- households

have less access to improved technologies. Therefore it is expected that male headed-households are better WTP for the DTM seed varieties.

Marital status: it is assumed that married households can handle their overall social and farm activities better than the households who are not married. Therefore married households are expected to be willing to pay for the DTM seed varieties thus; the variable is hypothesized to have a positive relation with the WTP.

Education: Education which is measured in number of years in school was expected to have a positive effect on the WTP, the assumption is that the more time (years) a farmer spent in school the more knowledgeable they become. Education also enables access to information and new ideas.

Household income: This is a continuous variable which is hypothesized to influence the WTP positively as shown in Table.2. Income in this study included both from farm and off-farm activities, therefore the higher the income the higher the WTP for the DTM seed varieties.

Access to extension services: The provision of extension services helps the farmer to be aware with new knowledge and skill to improve their production as well adoption of different agricultural technologies. It assumed that farmers with access to extension services will be willing to pay for the DTM seed varieties hence the variable is hypothesized to have a positive relationship with the WTP.

Table 2: List of variables and their definitions

Variable	Measurement	Expected sign
WTP	1=Willing to pay, 0 otherwise	
Price	price stated by the respondent	-
Age	Years	+/-
Sex	1=Male,0=Female	+/-
Marital Status	1=Single,2=Married,3=Separated	+
Household size	Number of household members	+
Education level	1=Primary education 2=Secondary education 3=Tertiary education 4=No formal education	+
Monthly income (TZS)	1= less than 100,000 2=100,000-199,999 3=200,000-300,000 4=Above 300,000	+
Farm size	Acres	+
Access to Credit	1=Yes, 0=No	+
Access to extension services	1=Yes, 0=No	+
Access to weather forecast information	1=Yes, 0=No	+
DTM awareness	1=Yes, 0=No	+

Access to weather forecasting information: weather forecasting information help farmers to plan for the farm activities in a season, information about rainfall and temperature help farmers to choose a suitable agricultural technology. Farmers with access to Weather forecasting information are expected to have higher WTP for the DTM seed varieties.

Household size: This referred to the total number of members who are currently living within the family. It is an indicator of labour availability for farming activities but also the

large the household size the large the requirement for food. Therefore, the variable hypothesized to have a positive relationship with the WTP.

Access to credit: An agricultural credit service is a source of finance to farmers who are WTP for the DTM seeds. Hence, it is hypothesized that access to credit will influence the WTP for the varieties.

Initial bid: This is the price of the DTM seed varieties in a given package, the higher the price of the Seeds the less the farmers will be willing to pay, Hence it is expected to have negative influence on the WTP.

DTM awareness: This entail about farmers knowledge on the DTM seeds characteristics, even the farmers who have just heard about the varieties from different information sources they are expected to have higher WTP for the seeds.

Land size: This refer to the total land size in acres owned by the household, in this study this also included the leased land. The larger the size of the land enables a farmer to have more allocation of the land to different crops and different varieties. The variable is hypothesized to have a positive effect on the WTP.

3.7 Limitation of the Methodology

The major limitation of the double bounded CVM is that they only elicit discrete choices that researchers only observe whether an individual would pay more or less than a particular price level. But again Cameron and Quiggin (1994) have shown that responses to the first and second dichotomous choice question may not be perfectly correlated bringing into question which estimate is most relevant. In addition the double bounded

approach may suffer from the starting point biases, the responses to the second question depend on the price offered in the first (Shogren and Herriges, 1996).

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Socio-economic and Demographic Characteristics of the Respondents

The socio-economic and demographic characteristics examined were sex, age, marital status, household family size, educational level, occupation, and monthly income of the household.

4.1.1 Age and sex of the respondents

Table 3 shows that the distribution of respondents by sex in all four villages. The number of male respondents was higher than that of the female. Male respondents were 62.1% while female respondents were 37.9%. This implies that the majority of the respondents in the study area were male. Sex has an implication in a society based on the roles and responsibilities; this shows that males in the study area are more involved in agricultural activities than females.

The age of the majority of respondents fall under the category of 36-55 years, occupying 58.9% as compared to other categories 18-35 and those above 55 which occupied 25% and 16.1% respectively. The overall mean age was 42 years showing that majority of the respondents are matured people and fall within the category of the active working group who can participate in the farming activities. Age determines individual maturity and ability to make a rational decision especially when it comes to what to plant and what technology to use.

4.1.2 Education and marital status

The education level of the respondents was categorized as primary education, secondary education, tertiary and informal education. Education plays a significant role in human

lives such as means of acquiring basic needs and how to manage production activities. The results in Table 3 show that majority have acquired primary education which is 77.4% of all the respondents while only 4.8% had no formal education. Also, the results show that few have attained a secondary and tertiary level of education, 14.5%, and 3.2% respectively. This entails that those with a primary level of education are involved more in farming activities as compared to other education categories.

Table 3: Socio-economic characteristics of the household

Variable	Category	Mahenje	Nanyala	Ihanda	Chimbuya	Total (%)
Sex	Male	20	24	15	18	77(62.1)
	Female	13	9	10	15	47(37.9)
Age	18-35	3	12	6	8	29(24.2)
	36-55	27	16	13	18	74(59.7)
	Above 55	3	3	7	7	20(16.1)
Education	Primary	27	24	22	23	96(77.4)
	Secondary	6	6	3	3	18(14.5)
	Tertiary	0	1	0	3	4(3.2)
	No formal	0	2	0	4	6(4.8)
Marital status	Single	2	7	3	0	12(9.7)
	Married	31	26	21	27	105(84.7)
	Separated	0	0	1	6	7(5.6)
Household mean size		5.85	5.79	4.64	6.21	
Mean age		44.24	37.94	44.36	44.64	

(Note: Numbers in brackets are percentages)

Marital status in the study was categorized as single, married and separated. Those who are widowed and divorced were both coded in the category of single while spouses who are not living together because of conflict and other family reasons were both coded in the

category of separated. The result indicates that majority of the respondent 84.7% are married followed by 9.7% single and 5.6% who are separated. This shows that the surveyed society is composed of a stable family and this has an implication in decision making. The assumption is that in such society decision is probably made jointly on farming activities and management as well as willingness to pay for different agricultural technologies.

4.1.3 Household family size

The average household family size of the respondents in the study area was 6 for Chimbuya, 5 for Mahenje and Nanyara and 4 for Ihanda. The overall mean household size was 5 while for those having 18 and above of age was 2.7. This implies that a household with a large number of family members is likely to be more productive than the one with small family size. The higher the family size the higher the labor for production.

4.1.4 Occupation and household income

The household occupation was in three categories namely; farming, business, and permanent employment. The results in Table 4 show that farming is the main activity in the study area as compared to business and permanent employment. About 85% of the respondents farming is their main activity while only 12% their main activity is business and 2% have permanent employment

The income of the household was estimated as an average monthly earning in Tanzanian Shillings (TZS). The minimum and maximum monthly income for each village is shown in the Table 4. The overall mean monthly income is 148 008 TZS while the minimum income was 40 000 TZS and the maximum monthly income was 450 000 TZS.

Table 4: Occupation and household income

Variable	Category	Mahenje	Nanyara	Ihanda	Chimbuya	Total (%)
Occupation	Farming	25	30	25	26	106(85.5)
	Business	8	2	0	5	15(12.1)
	Employed	0	1	0	2	3(2.4)
Monthly Income	< 100 000	9	11	18	12	50(40.3)
	100 000-199 999	16	20	6	14	56(45.2)
	200 000-300 000	6	1	0	6	13(10.5)
	Above 300 000	2	1	1	1	5(4.0)
Mean Inc		170 000	6221	63 508	90 070	
Min Inc		45 000	40 000	60 000	40 000	
Max Inc		450 000	350 000	350 000	450 000	

(Note: Numbers in brackets are percentages)

Most famers about 45.2% their monthly income is 100 000 TZS to 19 999 TZS followed by 40.3% of those with an income of less than 100 000 TZS while only 4% their monthly income is above 300 000 TZS. The result is also consistent with the occupation of the household in the study area whereby the majority of their income level falls under the first and the second category of income as shown in the table above. This could be justified by the vulnerability of agriculture as well as market challenges for the maize crop.

4.2 Farmers' Awareness of DTM Seed Varieties

The assessment of farmers' awareness of DTM seed varieties based on two aspects, first if a household has ever heard about the DTM seed varieties and secondly awareness of the characteristics of DTM seed varieties. About 97% responded that they are aware of DTM seed varieties and they have heard from different information sources such as media, extension officers, farmer groups and from seed companies. Only 3% are not aware and have not heard about the DTM seed varieties.

Further assessment was done to the household respondents about the awareness of DTM characteristics. According Fisher *et al.* (2015) four main characteristics of the varieties were assessed that is tolerance to drought, resistance to diseases and protein content. About 46% of the respondents seem to be aware of the drought tolerant trait of the varieties as compared to other traits, it was followed by 42% who were aware that the varieties have high yield while 7.3% were aware that the varieties are also resistant to diseases. Table 5 shows farmers' response on the awareness of the DTM characteristics.

Table 5: Farmers' awareness of DTM seed characteristics

Characteristic	Frequency	Percent
Drought Tolerant	57	46.0
High Yielding	53	42.7
Disease Resistant	9	7.3
None	5	4.0
Total	**124**	**100**

However, 4% of the interviewed households were not aware of any DTM seed variety characteristics. Also, none of the respondents mentioned the nutritional content of the varieties which is another characteristic of the varieties. Further, analysis was done to assess the awareness of the DTM seed varieties characteristics in terms of villages.

Therefore, DTM seeds varieties is not a new vocabulary among farmers in the surveyed area, in additional farmers' awareness of the DTM varieties was assessed basing on the three socio-demographic characteristics as shown in Table 6. The purpose was to find out what social-economic factors influence the awareness of a particular agricultural technology.

Table 6: Influence of demographic factors on DTM awareness

Variable	Category	DTM awareness		Total
		Yes	No	
Sex	Male	76	1	77
	Female	44	3	47
Education	Primary	92	4	96
	Secondary	18	0	18
	Tertiary	4	0	4
	Informal	6	0	6
Age	18-35	30	1	31
	36-55	71	2	73
	Above 55	19	1	20

The results show that male respondents are more aware of the DTM varieties as compared to female and this may be due to the male involvement in agriculture as compared to female in the surveyed area; on the other hand those with primary level of education and those who belong to the age category of 36-55 are more aware of the DTM varieties. Furthermore the analysis on the awareness of the DTM varieties was done by villages to find out the level of awareness of each village under the assumption that the repercussion of climate change is experienced differently among the villages.

Table 7: Farmers awareness of DTM characteristics by villages

DTM Characteristics	Village				Total
	Mahenje	Nanyala	Ihanda	Chimbuya	
Drought tolerant	16	21	8	12	57(45.9)
High yielding	15	11	14	13	53(42.7)
Disease resistant	2	1	1	5	9(7.2)
None	0	0	2	3	5(4.2)
Total	**33**	**33**	**25**	**33**	**124**

(Note: Number in brackets are percentages)

Drought tolerant characteristic was mentioned by 45.9% and it was frequently mentioned by farmers from Nanyala followed by farmers from Mahenje as shown in Table 7. This may probably be due to the location of the villages which according to the URT (2013) the villages fall under the agro-ecological part Characterized with will low rainfall and seasonal dry spells. High yielding characteristic was also mentioned by 42.7% of the farmers in both villages. However as it is shown from Table 7 few farmers in both villages are aware of disease-resistant characteristic. However, 4.2% of the respondents from Ihanda and Chimbuya villages were found to be not aware of any DTM characteristic

Lastly farmers were asked to mention specifically the maize seed varieties that they know are drought tolerant. The purpose was to compare with the attributes of the varieties from TOSCI which are said to be drought tolerant. However; from the mentioned varieties as shown in Fig. 4 these are drought escape and not drought tolerant varieties as it has been they have been used by farmers. The varieties are the one that are currently being used by farmers in the study area.

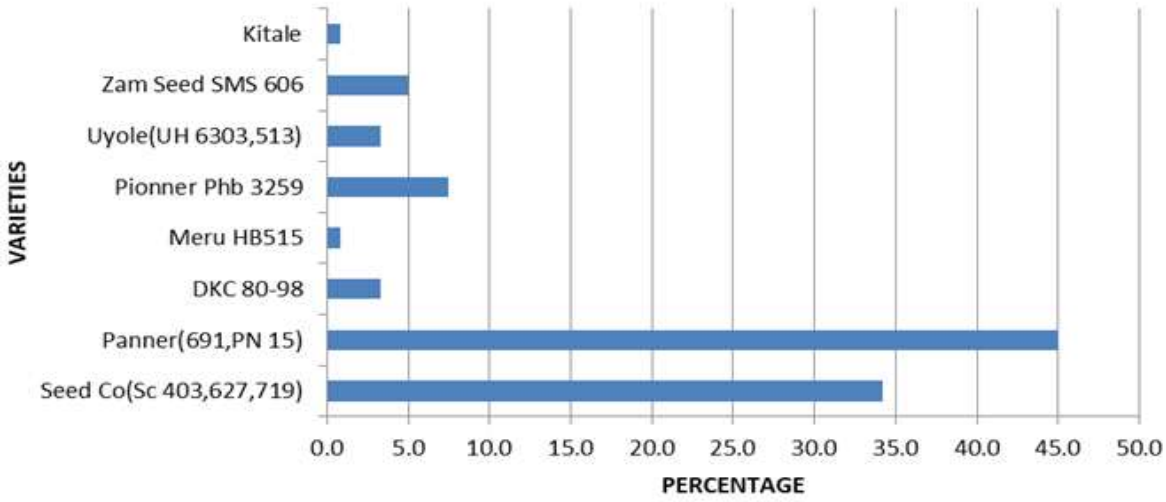

Figure 4: Maize varieties known by farmers

About 45% of the farmers mentioned panner which is suitable in areas with sufficient rainfall and it was more mentioned and used by farmers' Chimbuya and Ihanda. The current drought tolerant maize seed certified by TOSCI, 2019 are bred by TARI-Ilonga, Seed Co (Sc 419) and East African Seed (T) Ltd. And none of the variety was mentioned by farmers as a drought tolerant.

4.3 Farmers Willingness to Pay for DTM Seed Varieties

Before being asked as to whether they will be willing to pay for the varieties of not, an enumerator had to mentioned and explained the characteristics of the DTM seed varieties to the respondent. The characteristics mentioned include drought tolerant, disease resistance, high yielding which is more than Non- drought tolerant varieties and the protein content of the varieties.

In addition an explanation was given about the requirement of other key inputs since the varieties are improved they require other inputs like any other improved maize seed varieties. Such an explanation was given to farmers to deepen the understanding of the farmers about the varieties. The next step was to ask farmers whether they be willing to pay for the varieties. Farmers' willingness to pay for the DTM seed varieties is shown in Fig. 5. Among the respondents, 62% will be willing to pay for the DTM seed varieties and 38% will not be willing.

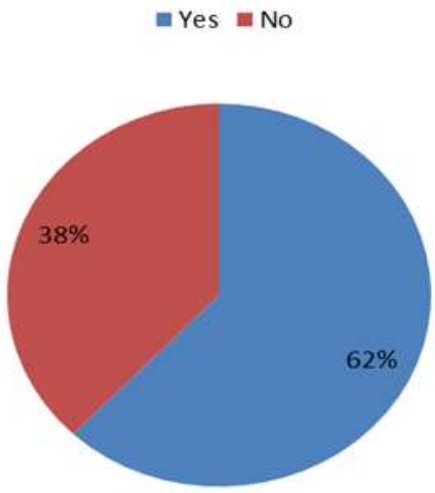

Figure 5: Farmers' willingness to pay

Further analysis was done to observe the willingness to pay by villages as shown in Table. 8. The aim was to observe the pattern between villages. The WTP implies that farmers are willing to adopt the varieties.

Table 8: Willingness to pay by villages

Village	Farmers' Willingness to Pay		Total
	Yes	No	
Mahenje	25	8	33
Chimbuya	20	13	33
Nanyala	18	15	33
Ihanda	14	11	25
Total	**77**	**47**	**124**

Results presented in Table 8 shows that farmers from Mahenje will be willing to pay for the varieties compared to other villages and this may probably due to the location of the village which belong to the agricultural ecological area with unpredictable rainfall. On the other hand Ihanda which is found in the Northern part is characterized by sufficient rainfall hence farmer's willingness to pay for the varieties is low.

In determining the motive behind willing and not willing to pay for the varieties, different reasons were reported as summarized in Table 9. To reduce the consequence of the severity of drought was the key reason for the willingness to pay which was mentioned by 35.5% of all respondents. Other reasons for the willingness to pay was because the local varieties can't give high yield under drought circumstance which was mentioned by 19.4% while 16.9% said the reason for their willingness to pay is because of the high yielding characteristics of the varieties. Disease resistance and high economic return were also mentioned as the reason for the willingness to pay as shown in the Table 9.

Table 9: Reasons for the willingness to pay

Reasons from respondents	**Villages**				
	Mahenje	**Nanyala**	**Ihanda**	**Chimbuya**	**Total**
Reasons for the willingness to pay					
To reduce the severity of the consequence of drought	16	8	8	12	44(35.5)
Low yield from local varieties	9	6	3	6	24(19.4)
They are disease resistant	0	0	2	1	3(2.4)
High economic return	4	0	0	1	5(4.0)
Because of its high yielding	3	10	2	6	21(16.9)
Reasons for not willing to pay					
High price of the seeds	0	3	0	1	4(3.2)
Prefer local over improved	0	0	1	1	2(1.6)
Lack of knowledge about the varieties	0	0	1	0	1(0.8)
No market for the crop	0	3	2	1	6(4.8)
Because of the cost of other inputs	1	3	6	5	14(11.3)

(Note: Numbers in brackets are percentages)

For those who are not willing to pay the study found that the main reason was due to the cost of other key inputs which was mentioned by about 11.3% of all respondents. Farmers reported that without other necessary key inputs it is unlikely to get enough yield. It was followed by a lack of market for the crop which was reported by 4.8% of the respondents. Other reasons included high price for the varieties preference of local varieties over improved and lack of knowledge about the varieties.

4.4 Mean willingness to pay (WTP) estimates

In this study apart from respondents being required to show their willingness to pay for the varieties, each respondent was required to state exactly the monetary value that he or she will be willing to pay for the DTM seed varieties. The purpose of asking the monetary value was to find out the price that they will be willing to pay per unit of DTM variety. The mean willingness to pays shows the ability that an individual is willing to pay for the varieties. The initial price that was used in the study was 12 000 TZS for the package of 2kg because that is the package that is used for most of the maize seed varieties. Then if the respondent was ready to pay at that price then the enumerator had to raise the price by 1000 TZS until 'NO' response. The price before the 'NO' response was considered as the maximum amount that a farmer is willing to pay for the varieties. If the respondent was not ready to pay the stated price then the enumerator had to lower the price by 1000 TZS until 'YES' response.

The information on the willingness to pay in monetary value for the DTM seed varieties from each response was collected and the binary logistic regression was used to get the value of alpha (α) and rho (ρ). The restricted equation (vi) without farmers' characteristics was estimated and the mean WTP was obtained from the ratio (-α/ ρ) whereby α is the

coefficient of the intercept term and ρ is the coefficient of the price stated by the respondent. Table 10 below shows the estimated Mean WTP for the DTM seed varieties.

Table 10: Mean willingness to pay by the farmers

Variable	Coefficient	P-Value
Constant(α)	67.839	0.000***
Bid(ρ)	-0.0141	0.002***
Mean WTP(TZS)	4 790	
Number of observations	124	
log-likelihood	79.08	

Note: *** significant at 1%

The estimated mean WTP was found to be 4 790 TZS per Kg. Therefore these findings respond to the question on the amount that farmers are willing to pay per unit for the varieties. When making a comparison between the estimated mean willingness to pay for the farmers and the set initial market price per kilogram for the DTM market price which is 6 000 TZS there is a difference of 1 210 TZS. This amount is higher than what farmers will be willing to pay. The amount that farmers stated they are willing to pay represented their ability to pay. The results imply that farmer's ability to pay for the varieties is lower than the price per kilogram for the varieties. It requires additional 1 210 TZS for a farmer to be able to purchase 1Kg of the varieties. Therefore this result suggests that farmers cannot manage to use the varieties as an adaptation technique to climate change since they are not able to pay the stated initial price for the varieties.

4.5 Socio-economic Factors Affecting WTP

A logistic regression model equation (viii) in the methodology was used to analyse the social-economic factors that affect farmers' willingness to pay. The model was significant ($P<0.005$).

Table 11: Socio-economic factors affecting WTP

Variable	Marginal effect	Coefficient	P value
Constant	-	7.68	0.1
Price	-1.08	-0.1955	0.002***
Sex	0.0367	0.1993	0.666
Age	0.0024	0.1312	0.089*
Income	0.004	0.2304	0.024**
Household size	-0.040	-0.0433	0.05**
Credit	0.134	0.1588	0.143
Marital	-0.105	-0.6467	0.238
Education	0.023	0.8188	0.076*
Farm size	0.034	0.9232	0.059*
DTM knowledge	0.103	0.4764	0.031**
W-info	0.201	0.4798	0.064*
Extension services	0.071	0.5060	0.179

Note: ***, ** and * Means significance level at 1%, 5% and 10% respectively

The results are shown in Table 11. Age, bid price, household income, household size, education level, farm size, knowledge on the DTM, access to weather forecasting information and the extension services were found to be significant in influencing farmer's WTP. Therefore the results reject the null hypothesis that socio-economic characteristics do not influence willingness to pay for the DTM varieties.

The coefficient of price was found to be negative as expected because farmers are more likely to pay for the DTM seeds if the seeds were offered at a low price. The results from the marginal effects show that a unit increases in price the probability of Willingness to pay decreases by 1.08 keeping other factors constant. The results are consistent with the findings of Ahmed and Masud (2015) who conducted a study to estimate a willingness to pay for the adaptation program in Pakistan where the price was found to have a negative

relationship with the willingness to pay. Age also influences the WTP positively; the marginal effect showed that one year increase in age increases the probability of willingness to pay by 0.002 keeping other factors constant. Age in the model was used as a proxy to the farming experience.

The income of a farmer influences the WTP for the DTM seed varieties positively at 5% Significance level. The result is also in line with the basic economic theory, which states that an individuals' demand for commodities or services is positively related to income level. Keeping other factors constant, the result of the marginal effect shows that unit increase in the monthly income of a farmer increases the probability of willingness to pay for the DTM variety by 0.004. This result conforms with the studies done by Alemaw and Simalenga (2015) who used the total income. This study also used the total income of a household by aggregating the income from farming activities and off-farm activities.

Farm size of the household affects the willingness to pay for DTM seed varieties at 10% significance level. This result conforms with the results of Alemu *et al.* (2013). The marginal effect showed that a unit increase in farm size of the household increases the probability of being willing to pay for the DTM seed varieties by 0.034 keeping other factors constant. It is also possible that the increase in the size of the land gives farmer freedom to diversify that is planting DTM seeds in one piece of land and non-DTM seeds in another plot especially for those who are not completely aware of the characteristics of the DTM seeds.

Access to credit and to extension services was found to be insignificant in the model which is contrary to the prior prediction. This may be the case because in the study area there was only one common source for the farmers to access credit however despite the

presence of the source many reported that conditions for obtaining the credit are high that makes them fail to access the credit for farming activities.

Knowledge of the DTM seed varieties especially the characteristics of the seeds and the Education level of a farmer were also found to influence positively the willingness to pay both coefficients were significant at 10% and 5% respectively. Education is known to facilitate farmers' understanding and use of different agricultural technology. Household size has a negative relationship with the WTP, the results show that farmers' willingness to pay decreases with the increase in the number of the household. The marginal effect showed that unit increase (individual) in the household decreases the probability of the WTP by 0.04 keeping other factors constant. This could be because as household size increases the household expenditure increases hence minimizing the probability to pay for some agricultural technologies including the DTM seed varieties.

Weather forecasting information was found to significantly increase the WTP at 10% and it has a positive direction for the WTP. This implies that farmers who have access to weather forecasting information have a higher probability of WTP than those who do not have access. The marginal effect shows that those who have access to weather forecasting information have the probability of WTP is higher than those who are not willing to pay by 0.20, in addition farmers admitted that access to weather forecasting information help them in planning farm activities such as selection of the crop to grow as well as the seeds varieties.

Sex and marital status both variables were found to be insignificant. The findings are consistent with the findings of Nan (2013) who estimated the willingness to pay for the Tank irrigation in Northwestern China. Both variables were found insignificant in

influencing the willingness to pay for the technology. Hence the variables seem to have no influence in the willingness to pay for the varieties.

CHAPTER FIVE

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusion

The main objective of this study was to analyze farmers' willingness to pay for the DTM seed varieties as one of the technology for the farmers' adaptation to climate change in Mbozi District. In achieving this objective the three specific objectives were undertaken; Assessing farmer's awareness of the characteristics of the DTM seed varieties, estimating farmers' willingness to pay for the varieties and assessing the socio-economic factors that affect the willingness to pay for the Varieties. The major findings were as follows;

The majority of the farmers are aware of the DTM seed varieties, about 97% of the respondents have heard about the varieties from different sources such as media, extensions officers, fellow farmers and farmer groups. When assessing farmers' awareness about the DTM characteristics about 46% of the respondents are aware of the Drought tolerant characteristic, 42% were aware that the varieties have high yield while 7.3% were aware that the varieties are also resistant to diseases. None of the respondents mentioned the protein content of the varieties.

Farmers' mean willingness to pay was found to be 4790 TZS per kilogram which is lower than the stated initial market price 6000 TZS per kilogram. Therefore about 62% of those who said they will be willing to pay they are not able to pay the initial stated market price of the varieties while 38% of the respondent cannot completely pay for the varieties. This imply that farmers adaptation to climate change using the DTM seed varieties is not possible since farmers' ability to pay is lower than the stated initial price of the varieties.

The study found out that socio-economic factors such as age, household size, education level, household income, access to weather forecasting information, access to extension services and the bid price significantly influences farmers' willingness to pay for the DTM seed varieties.

5.2 Recommendations

Based on the findings of the study the following are the recommendation towards increasing the farmer willingness to pay for the DTM seed varieties.

It is the recommendation of the study that deliberate decision is taken to create awareness about the varieties especially the characteristics of the varieties. Farmers' knowledge about the characteristics of the varieties is of significant importance as far as willingness to pay is concerned. Use of the media, extension officers, and farmer groups can be used to disseminate information about the varieties characteristics.

Given the critical role of seed in maize production, the government can intervene by subsidizing the price of the seeds. The initial stated price is 20% more than what farmers are able to pay. The results showed that farmers are willing to pay for the varieties but when it comes to the ability none can manage because of the higher initial stated price per kilogram. If such intervention is done farmers will be served from the negative impact of climate change by using these varieties which have proven to perform well under drought circumstance. Subsidization of other key inputs can be considered since high requirement of other key inputs was one among the reasons for the farmers not to be willing to pay because of cost implication.

Lastly when introducing any agricultural technology social economic factors must be taken into account due to their influence on willingness to pay for a given technology. Example the price at which the product is to be sold must take into account the level of peoples' income. Not only that but also awareness of the varieties depends on the different socio-economic factors such as their level of education as well as age.

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APPENDIX

Appendix 1: Farm household's survey questionnaire

Enumerator's Name_____Date (DD/MM/YY)_____

Village Name_____ Ward_____

INTRODUCTION

I am **Elia Hebel Mlagala** MSc. Agricultural and Applied Economics student from Sokoine University of Agriculture. I kindly request about 30 minutes of your time to ask you few questions concerning willingness to pay for the drought tolerant maize seed varieties given their attributes as an adaptation strategy to climate change. The questionnaire has five parts: **Part A** consists of questions on the socio-demographic characteristics of the interviewee. **Part B** consists of occupation, land ownership and income. **Part C** consists of questions on awareness of DTM seed characteristics **Part D** consists of questions on farmers' group, access to credit and weather forecasting information and the last part consist questions on WTP for the DTM seed varieties.

A: **Household characteristics (Circle the appropriate answer)**

QA1.Age (Years)	**QA2.**Sex	**QA3.**Marital Status	**QA4.**Education level	**QA5.**Household Size (Number)_____	
1= less than18 2=18-35 3=36-55 4=Above55	1 = Male 2=Female	1 = Single 2 = Married 3= Separated 4 = Others (Specify)	1 = Primary education 2 = Secondary education 3 = Tertiary education (college/university 4 = Other (Specify)	Below 18	Above 18

B: Occupation, land ownership and income

QB1. Occupation	**QB3**.Land	**QB5.**Main source of income
1. Farming 2. Business 3. Permanent employment 4. Others (specify)…. **QB2**.Farming experience a) Less than 2 years b) 2-5 years c) Above 5 years	Do you own land 1) Yes 2) No Do you lease? _____ **QB4**.Total Land size_____ 1. Less than 1 Acre 2. 1-3 Acres 3. 3.1-7 Acres 4. Above 7 Acres	1 Farming 2 Business 3 Permanent employment 4 Others(specify) **QB6.**Income per month 1) Less than 100 000 2) 100 000-199 999 3) 200 000-399 999 4) Above 400 000

C: Farmers' awareness and use of the DTM varieties

QC1. Are you aware of DTM seed varieties? 1=Yes 2=No ***(if NO go to QC4)***

QC2. Where did you hear about the DTM seed varieties?

a) From the extension officer b) Fellow farmers c) Farmer group d) Seed company dealers e) From media such as radio, television etc. f) Farm Field Schools g) Others(Specify)

QC3. Mention the Varieties you know……..

QC4. In the last season did you use any maize improved seed variety? 1=Yes 2= No

QC5. For how long have you been using improved maize seed varieties? .....

1. Less than 2 years
2. More than 2 years

QC6. Did you use any DTM seed variety in the last season 1=Yes 2=No

QC7. If "No" what was the reason?

a) High price

b) Too much requirement of other key inputs

c) I prefer local over improved seeds

d) Lack of knowledge about the varieties

e) Not easy to obtain

f) Untimely delivery of the seeds g) others (specify)…….

QC8. If "Yes" Mention the variety used…….

QC9. Was the variety easy to obtain 1= Yes 2= No

If "No" what was the reason?	If "Yes" Where did you obtain?
(a) High price of the seeds (b) Distance to the market (c) Shortage of the varieties (d) Untimely delivery of the seeds (e) Others (specify)…..	(a) From the local market (b) Private seed company (c) Middlemen/Traders (d) Roadside (e) Seed Agent Shop (f) Others (specify)…….

QC10.Do you know any characteristic of DTM variety? 1=Yes 2=No

QC11 Mention the characteristic that you know ***(Enumerator circle the appropriate answer)***

1. Drought tolerant
2. 2. Disease resistant
3. 3. High yielding
4. 4. Protein content

D: Farmers' group, access to credit and weather forecasting information

QD1	**QD2**	**QD3**	**QD4**	**QD5**	**QD6**	**QD7**	**QD8**
Are You a member of any Farmer group? 1=Yes 2=No	Do you have any access to credit? 1=Yes 2=No	Did you use credit in the last farming season 1=Yes 2=No	What was the source of the credit 1=From bank 2=Farmer group 3= SACCOS 4=VICOBA Others(specify)	Do you have any access to weather forecast information? 1=Yes 2=No	What is the source of the information? 1=Telephone 2=Radio 3=Television 4=Farmer Group 5=From Peers	Does the weather forecast information help you in planning for your farm activities? 1=Yes 2=No	Do you have any access to extension services? 1=Yes 2=No

E: Farmers' willingness to pay for the DTM seed varieties

NB. Characteristics of DTM seed varieties

1=High yielding 2=Drought resistant 3=Disease resistant 4= Protein content

5=They have high yield of 40% more than Non-DTM seed varieties

6=They can produce up to 30% of its potential after suffering six weeks of drought at grain filling stage

QE1. Would you be willing to pay for the DTM seed varieties? 1=Yes 2=No.

QE2. Would you pay _____TZS for a package of _____KG of DTM Seed varieties?

QE3. If YES: would you pay _____ TZS? (If YES rise price by interval of 1000 TZS till NO)

QE4. If NO: would you pay _____ TZS? (If NO lower price by interval of 1000 TZS till YES)

WTP Follow-Up Questions

Follow up questions, will be asked to the respondents for helping to clarify the motives for and validity of responses, they are also needed to test the credibility of the scenario above.

QE5.What is the reason for your maximum willing to pay the amount stated above?

i. To reduce the severity of the consequence of drought
ii. Low yield from local varieties
iii. They are disease resistant
iv. High economic return
v. Because of its high yielding
vi. High price of the seeds

vii. Prefer local over improved

viii. Lack of knowledge about the varieties

ix. No market for the crop

x. Because of the cost of other inputs

xi. Others _____(specify)

THANK YOU FOR YOUR COPERATION