PERCEPTION OF FARMERS ON CASSAVA AS A POTENTIAL CROP FOR CLIMATE CHANGE ADAPTATION IN KIGOMA REGION, TANZANIA

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A DISSERTATION SUBMITTED IN PARTIAL FULFILLMENT 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

Perceptions guides decision making and eventually determines the actions to be made by farmers on climate change adaptation. This study analyzed how farmers perceive cassava as climate change crop, determinants of farmer's perception and also estimated the share of cassava to total household income in Kigoma Region. A multistage random sampling procedure was used to select a total of 140 household heads for analysis. Data were collected using structured questionnaire and key informants interview. Descriptive statistics, Likert scale items and Chi-square tests were employed to analyze data. The Heckman's two step model was used to identify the determinants of perceptions of the sampled households. The results show that 72.7% to 98.3% of the household farmers perceived cassava as a suitable crop for climate change adaptation. Accordingly, most of the respondents considered cassava as a food security crop in the face of changing climatic conditions. Age, gender, marital status and availability of climate information were found to be basic determinants of farmer's perception on cassava as climate change crop. The profitability of various crops produced in the study area was estimated using gross margin analysis. Among food crops grown in the study area, cassava was noted to constitute a significant share of household income, suggesting that is not only an important food crop but also a major source of income. This study concluded that, farmers perceive cassava as a climate change mitigation crop, hence recommends that the efforts by policy marker towards climate change adaptation while improving food security should target at improving and promoting cassava production.

DECLARATION

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

James Peter   Date

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The above declaration is confirmed

Prof. R. M. J. Kadigi   Date

(Supervisor)

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DEDICATION

This work is dedicated to my beloved family, my wife Getrude and my sons (Sweetbert, Peter and Moses) for their patience and assistance during the entire period of my study.

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LIST OF ABBREVIATIONS AND ACRONYMS

AERC	African Economic Research Consortium
EARRNET	East Africa Root crop Research Network
FAO	Food and Agriculture Organization of the United Nations
GDP	Gross Domestic Product
GM	Gross Margin
IIED	International Institution for Environment and Development
IITA	International Institute of Tropical Agriculture
IPCC	Intergovernmental Panel on Climate Change
MNL	Multinomial logit
MNP	Multinomial probit
NARS	National Root and Tuber Research
NBS	National Bureau of Statistics
OCGS	Office of Chief Government Statistician
PHC	Population and Housing Census
SNAL	Sokoine National of Agricultural Library
SSA	Sub-Saharan Africa
SUA	Sokoine University of Agriculture
Tshs	Tanzanian shillings
URT	United Republic of Tanzania

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background Information

Agriculture development in most parts of developing countries is mainly challenged by climate change. High temperature, reduced rainfall and increased rainfall variability due to climate change reduce crop yield and threaten food security in low income and agricultural-based economies. In view of the fact that it relies heavily on rainfall with only 2% of arable land equipped with irrigation facilities; agricultural sector in Tanzania has been worst affected by climate change (Shemsanga *et al*., 2010). Rainfall in about 75% of the country is erratic and only 21% of the country can expect an annual rainfall of more than 750mm (Mbilinyi *et al.*, 2013). However, the role of agriculture in economy of Tanzania is unquestionably vital. The sector contributes around 26% to 27.7% of the total national Gross Domestic Product (GDP) and comprises up to 85% of export earnings employing about 80% of the work force (URT, 2012).

According to Shemsanga *et al*. (2010) and Mbilinyi *et al*. (2013) the impacts of climate change to agriculture have and will continue to have devastating effects on the economy, food security and thus threaten the stability of the country. This call for adaptation as it is the most efficient and friendly way for farmers to reduce the negative effects due to climate change. Under a warmer and drier climate, sustainable agriculture requires plants with high water-use efficiency and the capacity to maintain production at high ambient carbon dioxide concentrations.

Cassava *(Manihot esculenta*) is documented to be highly drought-tolerant crop and thus poses a number of physiological adaptations that allow it to tolerate extended periods of water stress (Ravi *et al.,* 2011; Lal *et al*., 2014). In Tanzania cassava is one of the major subsistence food crops grown and is renowned for its drought tolerance and hardness in stressful environments. As noted by Bennett *et al*. (2012) cassava is the second most important food crop after maize in terms of production volume and per capita consumption, supporting the livelihood of 37% of farmers in rural areas in the country. Essentially, the crop contributes to an average of 15% in the national food production basket (Sewando, 2012). Cassava also serves as source of raw material for industrial applications, including food, animal feed and starch. Cassava production is concentrated in Southeast and Western Tanzania with the proportion of farmers growing cassava being high in Mtwara (74%) and over 50% in Kigoma, Mara, Ruvuma, and Lindi (Minot, 2010).

1.2 Problem Statement and Justification of the Study

Raising agricultural production at the national level will improve overall economic growth and development and at most ensuring staple food security. Nevertheless, the ability to achieve this goal is multifaceted by climate change which its impacts on agriculture are highly uncertain. The major portion of western regions of Tanzania for instance has experienced an increase in temperature of between 1°C and 2°C and the rest of the country between 0.2°C to 1°C from 1974 to 2005 (IPCC, 2007). Moreover, climate projections for Tanzania show a warmer future climate (IPCC, 2007; IIED, 2009) as cited by Mongi *et al*. (2010) over the Western parts of the country.

The forecast show the rise in temperature between 2°C and 4°C and a decline in rainfall of between 5% and 15% (Davies and Thornton, 2011). This signifies that all food components including food security in Tanzania will be more negatively affected. Moreover the impacts on Tanzania's agriculture sector will reduce the nation’s total

GDP by 0.6-1% by 2030 and or rise to 5-68% by 2085 if no meaningful adaptation (Davies and Thornton, 2011). Essentially, the reductions in productivity will affect staple crops with maize expected to decline by 33% across the country. To this effect, adaptation to the effects of climate change becomes very important if the goal of staple food security and better life for rural people will be ever achieved.

In the context of food security, the climate impacts and adaptation debate have largely focused on yields. Cassava is increasingly seen as a climate change adaptation crop experiencing less instances of crop failure (Ravi *et al.,* 2011; Lal *et al*., 2014). Perceptions guide decision making and eventually determine the actions to be made by farmers on climate change adaptation. However, little is known about the perceptions of farmers on cassava as a climate change mitigation crop. Importantly, cassava is already the second and major staple source of calories in Tanzania after maize (Minot, 2010). It is therefore evident that cassava is the most rapidly growing crop in the country due to its adaptable nature, hence warrants special consideration to propel it.

Studies on climate change in Tanzania are numerous, but most of them have focused largely on farmers understanding of climate change and adaptation strategies (Mongi *et al.* 2010; Komba and Muchaponda, 2012; Mbilinyi *et al.* 2013) have reported farmer observations of climate change and existing adaptation strategies for managing climate risks. Their findings can generally be viewed as interesting, especially in informing policy making and interventions both at micro and macro levels. Nevertheless, the recommendations that emerge from these previous studies may be quite misleading and inappropriate as they are broadly generated based on farmers' perceptions but not narrowed down to specific crops.

Kigoma is among of the potential regions for cassava production in Tanzania which is found in western part of the country where the studies show the existence and future warmer climate hence vulnerable to climate change. As to the best of my knowledge, no earlier study was conducted to hear farmers voice on cassava as potential crop for climate change adaptation at household levels in the region. This study has addressed this bottleneck by investigating farmers' perceptions on cassava as a potential crop for climate change adaptation. The knowledge generated from the study will help to inform decision makers (e.g., farmers, policy makers and other stakeholders) about the potential of cassava to serve as a climate change adaptation crop. Accordingly, this knowledge provides a key in the efforts to enhance agricultural production, food security and alleviate poverty in the face of changing climatic conditions.

1.3 Research Objectives

1.3.1 Overall objective

The overall objective of the study was to investigate the potential of cassava to serve as a food security crop in the face of changing climatic conditions and inform adaptation policies and strategies in Tanzania.

1.3.2 Specific objectives

The specific objectives of the study were:

i. To evaluate perceptions of farmers on cassava as a potential crop for climate change adaptation
ii. To assess factors that influence the perceptions of farmers on cassava as a crop for climate change adaptation
iii. To estimate the contribution of cassava to total household income

1.4 Research Hypotheses

i. Farmers do not perceive cassava as a potential crop for climate change adaptation

ii. Famers' perceptions on cassava as a climate change crop do not depend on their socio-economic characteristics

iii. Share of income from cassava constitutes a small proportion to total household income

1.5 Organization of the Dissertation

The present study has five chapters. The first Chapter provides a general background to the study, where among other things; it presents the problem statement, study objectives and hypotheses. The second Chapter presents a critical review of literature relevant to the study. A detailed description of the methodology employed, study area and the data used by the present study is provided in Chapter three. The fourth Chapter presents results and discussion. Main policy recommendations and conclusion are provided in Chapter five of this dissertation.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Definitions of Key Concepts

2.1.1 Climate change

Climate change implies the change in the statistical distribution of weather patterns when that change lasts for an extended period of time (decades to millions of years) regardless the cause. It is a natural phenomenon which influences agricultural production and negatively affects the social and economic activities resulting to food insecurity. IPCC (2007) defines climate change as a change in the state of the climate that can be identified by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer. Changes in the variance and frequency of extremes of climatic variables such as temperature and precipitation, altogether can contribute to climatic variability.

2.1.2 Adaptation

According to Lambrou and Piana (2006), adaptation refers to changes in the processes or structures to moderate or offset potential dangers or take advantage of opportunity associated with changes in climate. It is an adjustment in natural or human systems in response to actual or expected climatic change impacts to moderate damage or make use of beneficial opportunities. The fundamental goal of adaptation strategies is the reduction of the vulnerabilities to climate-induced change in order to protect and enhance the livelihood of poor people.

2.1.3 Food security

Food security describes a condition in which all people at all time have both physical and economic access to the basic food they need. There are two essentially and joint determinants of food security; availability and access to food. Availability does not guarantee access to food but access to food is conditional on there being food available at market as the poor usually lack adequate means to secure access to food.

2.2 Overview of Climate Change in Tanzania

Evidence from most literature indicates that the climate has changed and continues to change. The study by Davies and Thornton (2011) noted that; Tanzania is already experiencing an increase in extreme weather conditions with higher incidences and more prolonged periods of flooding and drought resulting from climate change. Referring to farmers opinions, Mbilinyi *et al.* (2013) noted farmers' observation to changes in rainfall seasons and patterns of temperature in some areas than it was before with incidences of extreme events such as floods and drought being increased. Generally, declining agricultural productivity due to climate change are no longer potential threats but rather threats that have already struck and caused Tanzanian repeated misery (Shemsanga *et al.,* 2010). Tanzania is expected to have a decrease in rainfall by between 0 to 20% in the inner part of the land with most of the literature showing that the associated extreme weather events namely floods, draughts, cyclones and tropical storms are projected to be more intense, frequent and unpredictable affecting mostly weather sensitive activities.

2.3 Agriculture and Food Security in the Face of Climate Change

Climate change and agriculture are interrelated processes, both of which take place on a global level. The consequences of climate change for agriculture and food security in developing countries are of serious concern. From a food security perspective, IPCC

(2007) argued that Sub-Saharan Africa (SSA) is the most vulnerable region to many adverse effects of climate change due to high reliance on rain-fed agriculture for basic food security and economic growth. Climate change is certain to amplify these vulnerabilities given projections of warming temperatures. All current quantitative assessment show that climate change will severely affect food security and thus potential adaptation remain the only means to be secured and improve the outcome. The IPCC (2007) underpinned that, the biophysical changes that resulted from a global warming of more than 3^{o}C will trigger increasingly negative impacts in all climate sensitive sectors in all regions of the world.

Agriculture is the most climate sensitive sector hence expected the diminishing role in nearly all value chain due to climate change impacts. Climate change influence agricultural decision making, affecting what crops farmers grows, when and where they grow them with the actual amount of food produced in a given year. In Tanzania, the climate change impacts and adaptation debate largely has focused on yield and thus, the major pressing issues such as food security, poverty and water availability within the country are both interconnected with climate change. In line to this, Shemsanga *et al.* (2010) added global climate change and population growth as a two major problems facing the world today linked by food quality and quantity.

Estimating the impacts of climate change on food security in Tanzania, Arndt *et al*. (2011) asserted that, relative to a no climate change baseline and considering domestic agricultural production as the principal channel of impact, food security in Tanzania appears likely to deteriorate as a result of climate change. This relative decline comes about through reductions in agricultural production, principally food production, due to increases in temperature and changes in rainfall patterns (URT, 2007). Generally, Climate change in the form of higher temperature, reduced rainfall and increased rainfall variability reduces crop yield and threatens food security in low income and agriculture-based economies like Tanzania.

2.4 Cassava Production Trends in Tanzania

The available data indicate that Africa produces more cassava than the rest of the world combined. According to IITA (1997), cited by Chipeta and Bokosi (2013); Nigeria is the leading producer (35% of total African production and 19% of world production), Democratic Republic of Congo (19% of African production), Ghana (8%), Tanzania (7%) and Mozambique (6%).With exception to Mozambique, Tanzania's contribution to world and Africa production is very low compared to the rest of the mentioned countries. Tanzania however, is mentioned as one of the largest cassava producers in Africa. In recent years, cassava production has been around 6.0 million tons of fresh roots. Referring to FAO statistics, Minot (2010) commented the growth of more than 20% in cassava production although accurate production statistics for cassava are difficult to obtain because of its irregular harvesting pattern.

The increase in cassava production was at most due to increase in area under cassava cultivation. Accordingly, there was also increased reliance on cassava for food security, especially in maize deficit (drought) years and increased institutional support such as research and extension on development of high yielding varieties and good management practices from the National Root and Tuber Research (NARS) Program in collaboration with IITA/EARRNET. Cassava production is mainly done by smallholder farmers in Tanzania. As indicated by Bennett *et al.* (2012), the majority of the poorest farmers (59%) are reported to grow the crop for food. Because it can be stored in the ground and is drought-tolerant, farmers in almost all regions of Tanzania plant cassava as a back-up in case other crops fail.

2.5 Farmers' Perception on Climate Change and Adaptation

Agriculture is one of the main sources of livelihoods for vulnerable poor smallholder farmers. Nevertheless, smallholder's farmers continue to face more changes that impede agricultural productivity with climate change being acknowledged as a major challenge to agriculture. The literature on adaptations makes it clear that perception is a necessary prerequisite for adaptation. As part of targeting smallholders and solutions for climate change and variability, Ogalleh *et al*. (2012) found farmers' perceptions as very important to enhance their adaptive capacity. Perception describes the beliefs or opinions often held by many people based on how things seem to them. It is the process by which we receive information or stimuli from our environment and transform it into psychological awareness that influences the way we act.

As shown by Kisauzi *et al*. (2012), both perception and knowledge guide decision making and consequently, farmer's action on climate change adaptation. The adoption and successful implementation of new technology and farmers' adaptation to changes in their system depends on their tendency to perceive and react favorably towards changes in climate and environment. According to Maddison (2007), adaptation to climate change requires first perceiving that climate change has occurred and then deciding whether or not to adopt a particular measure. Yet, climate change and adaptation are perceived differently at different levels of conceptualization depending mostly on the level of education, livelihood activity, location, gender and age of the farmers.

Generally, farmers perceive and associate the increase in drought, temperature and dry spell to climate change (Mongi *et al.,* 2010). Adaptation strategies that have been recommended to lessen the negative impacts of climate change include; encouraging livestock ownership, planting early-maturing and drought tolerant crop varieties, investment in irrigation and strengthening research institutions (Deressa and Hassan, 2009; Okonya *et al*., 2013). Some societies in Tanzania and to their capacities have been perceiving the change and impacts due to climate change and eventually coping with the effect using their indigenous skills as most of them find hard to cope using modern technology. In Tanzania, Mongi *et al.* (2010) and Shemsanga *et al.* (2013) identified expansion of areas under cultivation, reducing fallow, switching to more drought-resistant crops such as cassava and sorghum as common adaptation strategies used by farmers.

2.6 Factors Influencing Perceptions of Farmers

As indicated earlier, perception describes the beliefs or opinions often held by many people based on how things seem to them. Among others, perceptions determine and guide decision making and eventually the actions to be made by farmers on climate change adaptation. A certain situation or phenomenon can be inferred differently by most people using the same or different sets of information. Study by Komba and Muchaponda (2012) indicates that successful adaptation measures and implementation requires better understanding of opportunities for adaptation and the most key drivers toward voluntary adaptation by vulnerable smallholder farmers or lack off. As previous authors have found, perception and coping strategies to climate change are influenced by a number of socioeconomic and environmental factors (Nhemachana and Hassan, 2007; Komba and Muchaponda, 2012) namely as: education, household size, livestock ownership, agro-ecological zone, farm size and access to credit among others.

A scoping study by Deressa *et al*. (2008) to analyze the determinants of farmers' choice of adaptation methods and perception of climate change in the Nile Basin of Ethiopia reported that age, wealth, information on climate change and farmer to farmer extension service to influence farmers' perceptions of climate changes in climatic attributes. Consequently, education of the household head, Contact with extension agent and farming experience were identified by Deseret (2014) as factors influencing perception of farmers of soil conservation practices.

2.7 Contribution of Agriculture to Total Household Income

Agriculture remains a dominant source of income for most of the smallholder farmers in Sub-Saharan African countries. In Tanzania, agriculture is a dominant source of income for almost 90% of the smallholder farmers (Mbilinyi *et al.,* 2013). This implicates that the farmers' source of income are less diversified hence more vulnerable if any bad event such as drought happen to agriculture. Mbilinyi *et al.* (2013) further contend that climate change affects small scale subsistence farmers in terms of productivity, food security and family income.

Smallholder farmers mainly depend on crop and livestock output for their income and livelihoods. Accordingly, the occurrence for bad seasons due to lack of rainfall, floods or drought means the farmers' income will be compromised. The changes in climate which affect agriculture negatively lead to neither producing enough for sale nor for the farmers own food. Considering this effect to farmer's welfare, Mbilinyi *et al.* (2013) concluded that the income earning capacity of the farmers is impaired hence limiting their access to social services which are nowadays literally not free.

2.8 Theoretical Framework

The present study is based on the theory of technology adoption. The adoption theory posits that social, economic, ecological and institutional systems as well as individuals can and do adapt to changing environment. Accordingly, the level of sustainable adaptation depends on the adaptive capacity, knowledge, skills, robustness of livelihoods and alternatives, resources and institutions accessible to enable undertaking effective adaptation (IPCC, 2007).

Technology adoption has been guided mainly by innovation-diffusion paradigm, economic constraint paradigm and adopter perception paradigm (Kalinda, 2011). Innovation-diffusion paradigm identifies information dissemination as a key factor in influencing adoption decision while the economic constraint paradigm argue that technology adoption is influenced by utility maximization behaviour and economic constraints due to asymmetric distribution of resources. On the other hand, the adopter perceptions paradigm posits that the adoption process starts with the adopters' perception of the problem and technology proposed. The adopter perception paradigm argues that perceptions of adopters are important in influencing adoption decisions.

2.9 Review of Analytical Tools

2.9.1 Farmers perception on climate change Adaptation

The analysis of farmers' perceptions towards climate change uses several techniques but many scientist use descriptive statistics. Various studies have been done on farmers' perception on climate change adaptations. Okonya *et al*. (2013) used descriptive statistics to analyze and assess how farmers perceive the effects of climate change and variability and how they have adjusted their farming practices to cope with the changes in climate from six agro-ecological zones of Uganda. Kalinda (2011) also used descriptive statistics to document Smallholder Farmers' Perceptions of Climate Change and Conservation Agriculture in Zambia. Results revealed that, gender of the household head and size of land owned in Uganda significantly affect adaptation while the extent to which smallholder farmers perceived conservation agriculture as a climate change adaptation strategy in Zambia was very low.

Daninga (2011) used descriptive analysis approach on farmers' perception concerning indicators affecting agriculture in Tanzania and revealed that, farmers are aware that, the impact of climate change has led to droughts and decline in crop production. Accordingly, Kisauzi *et al*. (2012) used descriptive analysis in analyzing farmers' perception on climate change and chi-square tests to determine the relationship between farmers' perceptions and gender in Teso Sub - Region, Eastern Uganda. The study revealed that, all farmers, men and women were aware of climate change. This study adopted a combined descriptive and Likert scale to assess farmers' perception on cassava as climate change crop.

2.9.2 The Heckman's two-step procedures

Agricultural technology adoption, climate change adaptation methods and other related models involve decisions on whether to adopt or not. Based on the results of several adoption studies, perceptions and attitudes; previous studies have observed that agricultural technology adoption models are based on farmers' utility or profit maximizing behaviors. As Deressa *et al*. (2008) noted; it is assumed that economic agents, including smallholder subsistence farmers, use adaptation methods only when the perceived utility or net benefit from using such a method is significantly greater than is the case without it. Much of the applied adoption research has used a probit or logit analysis of survey data to identify the probability of adoption given socioeconomic and other characteristics of adopters and non adopters. These approaches are found extensively in various literatures some of which include Komba and Muchaponda (2012) and Kadigi (2013).

Nevertheless, binary probit or logit models are employed when the number of choices available is limited to two (whether to adopt or not). When the number of choices available is more than two, Apata (2011) contends that these models are extended to multivariate models. In unordered choices, multinomial logit (MNL) and multinomial probit (MNP) models are the most commonly cited multivariate choice models. The MNL is widely employed in climate change adaptation studies including Nhemachena and Hassan, (2007); Deressa *et al*. (2008) and Komba and Muchaponda (2012). It is employed when the dependent variable has more than two outcomes. On the other hand, these studies revealed that the decision processes of farmers to adopt a new technology require more than one step, hence requires models with the two-step regressions (see also Apata, (2011) and Ndambiri *et al*. (undated)). Models with two-step regressions are employed to correct for the selection bias generated during the decision making processes. This self-selection bias if left uncorrected; results from the analysis of adoption could be biased.

The most common approach used in the literature to account for sample selection is the Heckman two-step estimator. In similar settings such models have been used, for example William and Stan (2003) employed the Heckman's two- step procedure to analyze the factors affecting the awareness and adoption of new agricultural technologies in the United States of America. The first stage was the analysis of factors affecting the awareness of new agricultural technologies and the second stage was the adoption of the new agricultural technologies. Similarly, Deressa *et al*. (2008) also employed the Heckman's probit selection model to analyze the determinants of farmers' choice of adaptation methods and perception of climate change in the Nile Basin of Ethiopia. Accordingly, Apata (2011) uses the Heckman probit model to analyze the two-step process of adaptation measures to climate change in Southwest Nigeria; which initially assess a farmer's perception that climate is changing and followed by an examination of the response to this perception in the form of adaptation.

A similar approach in analysis was also used by Maddison (2007) and Kadigi (2013). In this study, Heckman's two-step procedure is employed to study the factors that influence the perceptions of farmers on cassava as a crop for climate change adaptation in the study area.

2.9.3 Evaluation of share of income to total household income

Gross Margin (GM) is a technique that is used to establish the economic profitability. It is given as the difference between the annual gross income earned and the variable costs directly associated with the enterprise. To define the concept of gross margin, variable costs and fixed costs have to be distinguished. Variable costs are those cost that increase or decrease as output changes. Common examples of variable costs in agricultural production include seeds, fertilizers, and pesticides while the most important fixed costs are owned land, farm buildings, machinery and implements. The key advantages of GM analysis as an economic analytical tool include its easiness to be understood, its ability to draw logical interrelation of economic and technological parameters and its ability of rational variants for the operational structure of an enterprise or individual farmers (Phillip, 2007 cited in Mahoo, 2011).

It is therefore found that although gross margin is not a good measure of profitability, it has remained most satisfactory measure of efficient use of resources available in small scale agriculture. The limitation of the method is that gross margin is not a profit figure since fixed costs has to be covered by gross margin before arriving at the profit figure. Additionally, gross margin can vary widely from one year to the next due to differences in market prices, weather conditions and efficiency which can result from differences in performance levels. Despite those limitations, the Gross Margin Analysis has been employed as a proxy of the profit accrued from a farm enterprise by various scholarly. For instance, Mwema *et al*. (2012) employed GM analysis to evaluate the contribution of selected indigenous fruits on household income and food security in Mwingi, Kenya.

Shimbe *et al*. (2010) used Gross margin to analyze profit and eventually the contribution of urban agriculture among other source to the total household income in Morogoro Municipality. From their study, average annual GM accrued from urban agriculture was compared with that of other income sources. Currently, study by Mangasini *et al*. (2012) employed GM analysis to determine the contribution of groundnut production to the overall household income of smallholder farmers in Urambo District, Tabora Region. This study also adopted the same tool to determine the average annual gross income of each crop and livestock of the respondents and eventually contribution of cassava towards the total household income.

2.10 Conceptual Framework for the Study

Climate change in the form of temperature, rainfall and extreme events induces impacts on agricultural system leading to reduced crop yield. The impacts due climate change force farmers respond by switching to growing drought-resistant crop. However, the adoption of adaptation strategy (growing cassava) is determined by socio-economic, environment and institutional factors as well as the perception of farmers on cassava as an adaptive crop. Accordingly, cassava will serve as a source of income to large numbers of farmers who grow and market it in rural and urban communities hence increase in agricultural income.

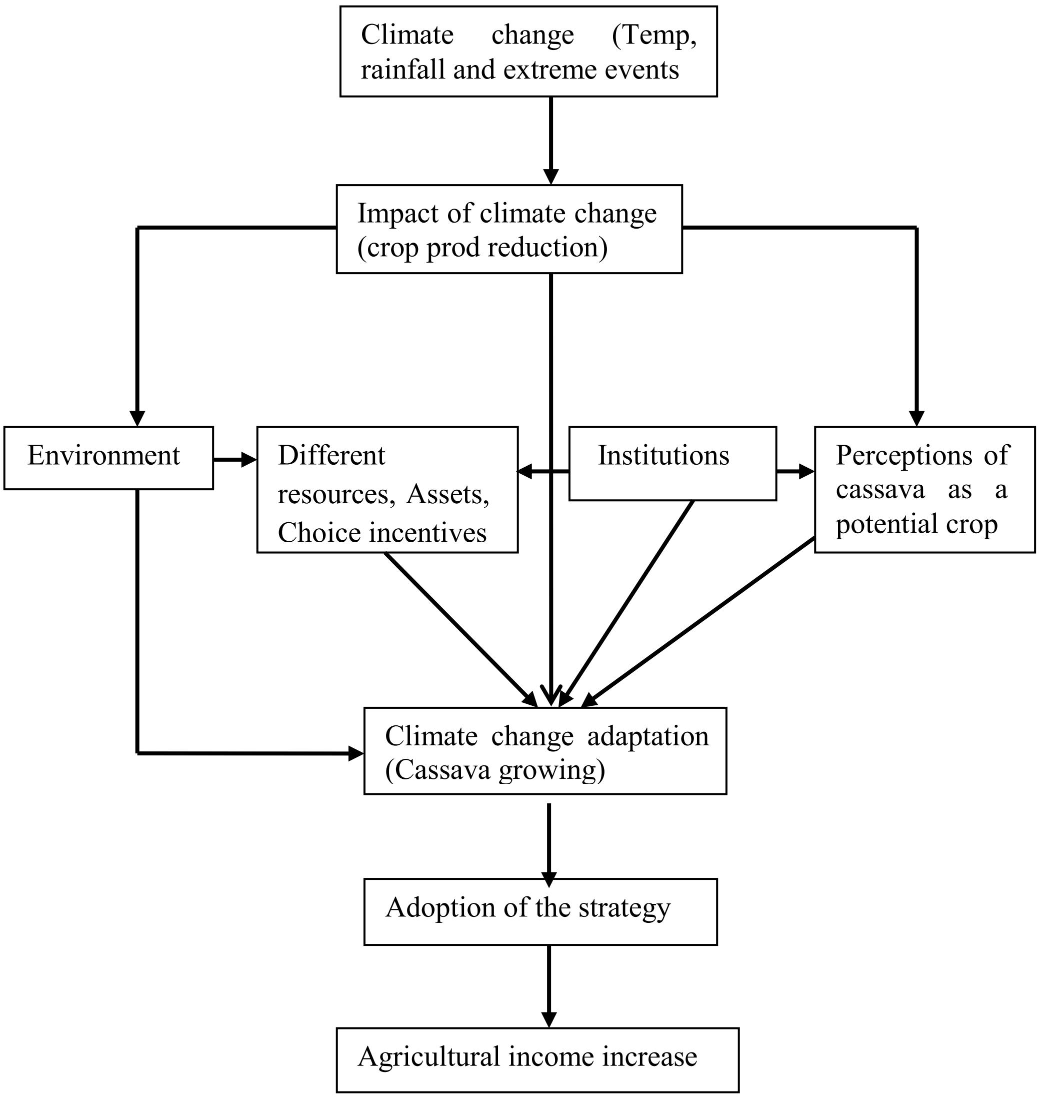

Figure 1: Conceptual framework for the study

Source: Adopted and modified from Legesse *et al.* (2012)

CHAPTER THREE

3.0 METHODOLOGY

3.1 Description of the Study Area

3.1.1 Location

This study was carried out in Buhigwe District of Kigoma region located in the north western corner of Tanzania, on the eastern shore of Lake Tanganyika. The region lies at about 5° south and 30° east of Greenwich. The region's total area is 45 066 square kilometers of which 37037 square kilometers is land and 8029 square kilometers is water. This is equivalent to 4.8% of the total area of Tanzania. It shares boundaries with Burundi and Kagera Region to the North, Shinyanga and Tabora regions to the East, Congo to the West and Rukwa region to the South. Buhigwe is among the six district councils in Kigoma region. Other districts in the region are Kigoma Rural, Kibondo, Kasulu, Uvinza, and Kakonko.

Buhigwe District is explicitly situated to the north-western part of the region between latitude 3°45′ and 3°55′ to the south of the equator and longitude 29°45′ to 30°45′to the East of Greenwich meridian covering an area of 1503.25 square kilometers. The District is bordered to the west by both Burundi, to the east and northern part by Kasulu District. In the south-eastern part is bordered by Democratic Republic of Congo and with Kigoma District in the southern part.

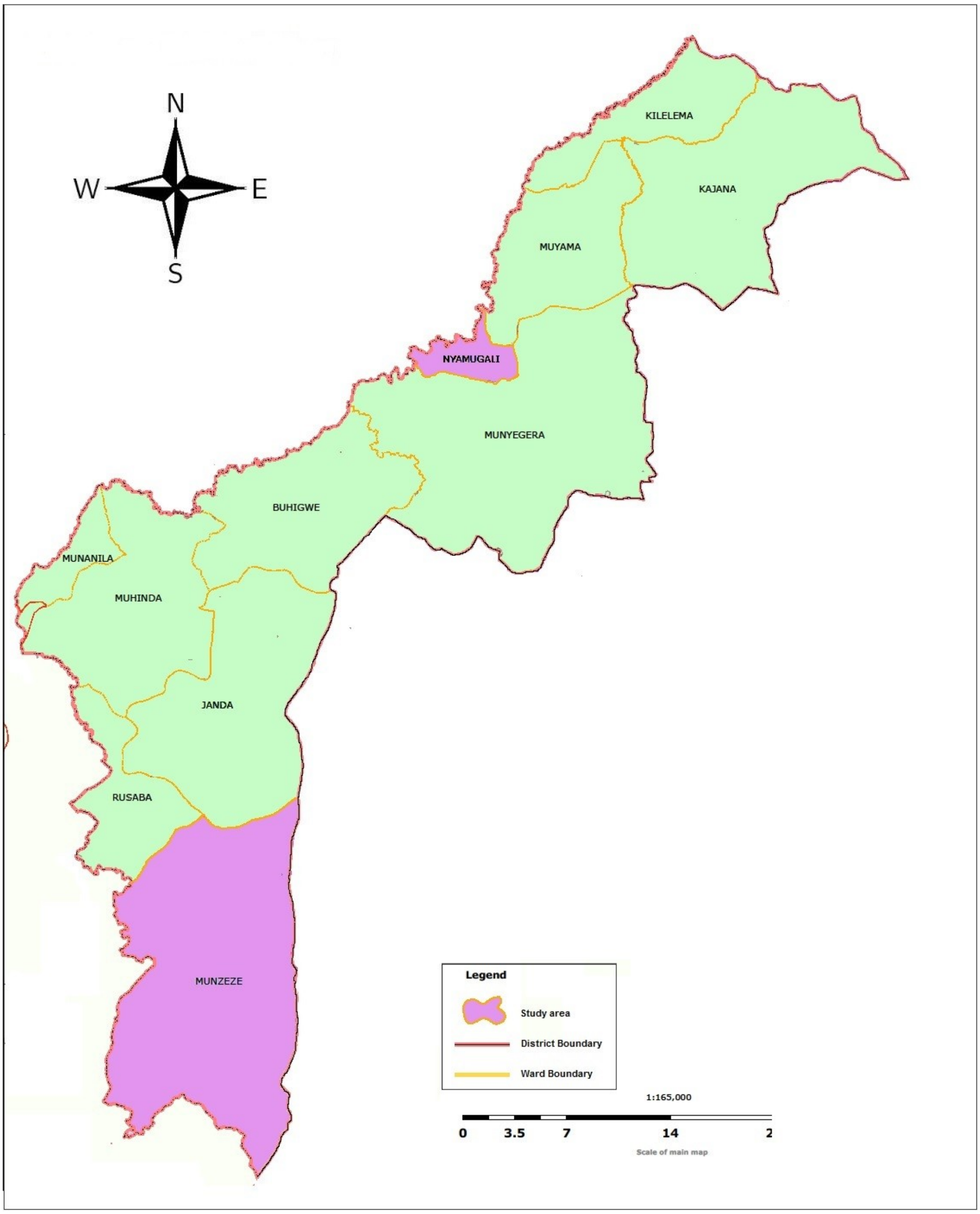

Figure 2: The location of the study areas

3.1.2 Population

According to the 2012 Population and Housing Census (PHC), the population of Kigoma Region was 2 127 930 (5.3% of the national population). The region had 2.4 percent average annual population growth rate as compared to national growth rate of 2.7 percent. Kigoma Region is most densely populated with population density of 57 people per km square (NBS and OCGS-Zanzibar, 2013). Based on the 2012 Population and Housing Census, the population of Buhigwe District is 254 342 people (120 690 males and 133 652 females) and average size of the household is 5.7 persons. The main indigenous ethnic group for Kigoma region is the Waha who are dominant in all the six districts of the region.

3.1.3 Climate and Vegetation

The climate of Kigoma Region is characteristically tropical with a distinct long wet rainy season beginning from late October to May with short dry spell of 2-3 weeks in January or February followed by a prolonged dry season. The region has two types of rain season; long rainfall season (*Masika*), which starts from March to May and short rainfall season (*Vuli*) which starts from October to December. The average rainfall is over 1000mm. Mean daily temperatures which varies inversely with altitude range between 25^{o}C in December, January to 28^{o}C in September. The vegetation in Kigoma Region comprises closed and open woodland which cover about 70% the land area, bushy grassland and swamps. Explicitly, Buhigwe district has climatic and ecological extremes with altitudes varying from 914 and 1800 above sea level. The mean annual temperature ranges from 16°C to 30°C.

3.1.4 Economic activities

The main economic activity in Kigoma Region is subsistence farming and small and medium scale businesses. Over 85% of the total population of the Region depends on agriculture for its livelihood. The bulk of agricultural productions come from smallholders who employ very little capital. The major crops grown in the region include maize, beans, cassava, rice, bananas, groundnuts, oil palm, coffee, fruits, cotton, tobacco and various vegetable which are distributed across three agro ecological zones. In Buhigwe District, agriculture is also the main source of livelihood for the majority. Farming is mainly rain-fed and cultivation is under subsistence.

3.2 Research Design

The study adopted a cross-sectional design whereby data were collected only once. Cross sectional design is useful because it is cost-effective, less time consuming and much information is obtained in a relatively short period of time and allows data to be collected at one point in time from different individuals or groups of respondents (Bailey, 1998). This design also collects data which enable to measure prevalence of all factors under investigation.

3.3 Study Population

The study population for the study was all household farmers both male and female heads living in the selected locations. Household heads were targeted because were believed to be a good source of information and possessed varied experience in the village. The unit of study therefore was a rural household farmer.

3.4 Data Types and Sources

3.4.1 Primary data

The household survey was used to collect primary data using a structured questionnaire comprising of both open and closed questions. To supplement quantitative data, a checklist of items for an in-depth interview with key informants was used to collect the qualitative data. Primary data were collected on a number of variables including socioeconomic variables, farmers' perception on climate change and its effect to crop yield, attitudes and perception on cassava as climate change crop, the household livelihood strategies and options with the income derived from each strategies, access to credit and household assets.

3.4.2 Secondary data

Due to the fact that additional information from different perspectives was needed to enrich the study. This study used the secondary data which included socio-demographic profile of the region and district. The major sources of secondary data included, internet, thesis and unpublished reports at Sokoine National Agricultural Library (SNAL), region and district offices, and other resource persons.

3.5 Sampling Procedures and Sample Size

Multi-stage sampling technique was adopted to select respondents for the study. In the first stage, one district out of 6 districts in the region was first selected randomly. Considering the production of cassava; two divisions, one ward from each division were purposively selected in the second stage. In the next stage, two villages from each ward were randomly selected. Finally and basing to the share of each village in the overall population of the four villages and also to ensure catching both male and female household head; a sample respondents of household farmers used for this study were purposively selected. The sample size was determined using the formula in Equation 1 below as presented by Kothari (2004).

$$n=\frac{Z^2.N.p.q}{e^2.(N-1)+Z^2.p.q} \quad \text{..} (1)$$

Where; Z = Standard normal deviation set at 1.96 corresponding to 95% confidence level; N= the study population equal to 4431, n = sample size; p = Sample proportion, for maximum n, p = 0.5; q = 1-p that is: 1-0.5 = 0.5; and e = Degree of accuracy desired set at 0.05 (5%) at 95% confidence level. Substituting the values in equation 1 above we get n = 354 as shown below.

$$n=\frac{(1.96)^2 * 4431 * (0.5 * 0.5)}{(0.05)^2 * (4431-1) + (1.96)^2 ** (0.5 * 0.5)} = 353.58 \approx 354$$

However, due to limitation of time and cost of the research work, the sample size used was 140 for this study. The sample size is found to be convenient for statistics analysis, well beyond the recommended bare minimum sample size of 30 to allow meaningful statistical analysis (Bailey, 1994). Based on the total number of households in each village, the number of households chosen (Table 1) was estimated using the following formula.

$$n=\frac{P_1 * N}{P_2} \quad \text{..} (2)$$

Where; N=Total sample 140, n= expected sub-sample, P_1 = Estimated population of the village and P_2 = Total households of all 4 sampled villages.

Table 1: The number of selected households in each village

S/no	Village	Households	Sample
1	Munzeze	1 104	35
2	Kishanga	1 192	38
3	Nyamugali	1 218	38
4	Bulimanyi	917	29
	Total	**4 431**	**140**

3.6 Data Collection

3.6.1 Questionnaire design

A structured household questionnaire with both closed and open-ended questions was used to obtain information on stated objectives and was designed to collect both qualitative and quantitative data from farmers.

3.6.2 Questionnaire administration

Prior to the data collection exercise three enumerators with experience were recruited and trained on the study tools and questionnaire. As part of the training, the enumerators were familiarized with the survey by explaining the objective of the survey, its relevance to local and national development level. Accordingly, each question of the questionnaire was discussed in detail regarding its reason, measurement, concept, coverage and the reference period. Both English and Swahili questionnaire version were prepared but face to face interviews were conducted with household heads in Swahili language. To ensure high quality of the data, close supervision of enumerators was undertaken by the researcher during the process of data collection.

3.6.3 Key informants' interview guide

Key informant interviews were used to gather great in-depth of knowledge and additional information from knowledgeable and informed people on the subject matter under study in the study area. They included agricultural and livestock extension officers from the region district and ward levels and also the village chairpersons and other influential and knowledgeable persons in the study village. Using key informants' interview schedule, information gathered included perception on cassava as climate change crop, if government should put more effort in cassava production and suggestions on what should be done by the government to support the crop.

3.7 Data Analysis

3.7.1 The perceptions of farmers on cassava as climate change crop

Apata *et al*. (2013) asserted that local perceptions cannot be estimated by models, this study, therefore used a Likert scale to measure farmers' perceptions on cassava as a potential crop for climate change adaptation. This was done by scale ranging from strongly agree, agree, undecided, disagree and strongly disagree to fit respondent feelings. According to Bernard (1994), Likert scale type of interview items results in a single score that represents the degree to which a person is favourable or unfavourable responding with respect to question asked. However, perception of farmers on cassava as climate change crop was done by looking on perceived ability of cassava to withstand extended drought, instance of crop failure and incidence of disease and pests as compared to other crops. So to say, the different aspects related to attributes that make cassava attractive as a crop to promote under any climate change adaptation in the study area was focused.

Descriptive statistical tools (percentages and frequencies) were used to summarize the information gathered and show respondents perception. In order to verify the farmer's perception toward cassava as a potential crop for climate change adaptation, Chi-square ($\chi 2$) test was applied to test the proportions of farmers with positive perception to those with negative perception for cassava as an adaptation crop.

3.7.2 Factors influencing the farmers' perceptions on cassava as climate change crop

According to Maddison (2007), adaptation to climate change is a two-stage process involving perception and adaptation stages. Certainly, the use of cassava as a climate change adaptation strategy is not likely to be possible if the household farmers do not perceive it as a climate change crop. Hence, the perception on cassava as climate change crop and adaptation can be described as a two- stage process. For this study; farmers required first to perceive cassava as crop for climate change adaptation and then opt for whether or not to adopt by growing the crop conditional on the first stage. Although the study would be primarily be interested by cassava farmers and as the second stage of adaptation is a sub-sample of the first stage, it is therefore likely that the second stage subsample is non-random and different from those who could perceive cassava as a climate change crop but failed to adopt due to some reasons. This leads to a sample selectivity problem, since only those who perceive cassava as potential crop will adapt, where as it requires inferring about the perception made by the agricultural population as whole.

Following Maddison (2007), this study employed the Heckman's two-step procedure to analyze the factors that influence the perceptions of farmers on cassava as potential crop for climate change adaptation. The model has two equations of interest that are modeled, namely: the selection (perception) equation and the outcome (adaptation) equation.

For empirical purpose, let us consider the following two-equation latent dependent variable model given by

$$u_i^* = w_i^{'} \alpha + \mu_i \qquad (3)$$

$$v_i^* = y_i^{'} \beta + \varepsilon_i \qquad (4)$$

The selection equation is (3), while (4) is the adaptation equation.

Where; w_i and y_i are k and j row vectors of exogenous explanatory variable that are assumed to be determinants of u_i and v_i and α and β are k and j column vectors of parameters to be estimated for the model. In this simplistic model, it is assumed that,

$$u_i = \{ {}^{1}_{0} \; if \; {}^{u_i^* > 0}_{v_i^* \leq 0} \quad and \quad v_i = \begin{cases} v_i^* \\ 0 \end{cases} if \; {}^{u_i = 1}_{v_i = 0} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (5)$$

Thus, we observe u_i a dummy variable, which is the realization of an observed (or latent) variable u^*_i with the error term μ_1. For values of u_i =1, we observe v_i, which is the realization of a second latent variable v^*_i with error ε_i. The joint normal distribution of (u_i, ε_i) is assumed to be bivariate normal with zero means, variances equal to 1 and correlation ρ.

Model variables

The independent variables hypothesized and included by this study are age, gender, marital status, education level, household size, availability of extension services and access to climate change information. More precisely, the findings of past studies on the farmer's perception and its determinations were used to select explanatory variables. The definitions and units of measurements of the dependent and explanatory variable used in the Heckman selection model are presented in Tables 2 and 3.

Table 2: Description of model variables of the selection equation for Heckman's probit selection model

• **Dependant variable**	Perception on cassava (dummy: takes the value of 1 if farmer has perceived cassava as climate change crop and 0 otherwise)
Description	**Expected sign**
Age of the farm household head in years (Continuous)	+/-
Gender (dummy: takes the value of 1 if male and 0 otherwise)	+
Education of household head in years (continuous)	+
Marital status (dummy: takes the value of 1 if married and 0 otherwise	+/-
Access to information on climate (dummy: 1 if access and 0 otherwise)	+
Access to extension services (dummy: 1 if access and 0 otherwise	+
Household size (continuous)	+/-

Table 3: Description of model variables for the outcome of Heckman's probit selection model

• **Dependant variable**	Adaptation to climate change (dummy: takes the value of 1 if farmer has adapted by growing cassava and 0 otherwise)
Description	**Expected sign**
Gender (dummy: takes the value of 1 if male and 0 otherwise)	+
Education of household head in years (continuous)	+
Marital status (dummy: takes the value of 1 if married and 0 otherwise	+/-
Access to information on climate (dummy: 1 if access and 0 otherwise)	+
Access to extension services (dummy: 1 if access and 0 otherwise	+
Household size (continuous)	+/-

Explanatory Variables for the Selection Equation

For the selection equation, it is hypothesized that, age of the head of household, gender, and marital status, education, access to information on climate, extension services and household size influence farmers' perception on cassava as climate change crop. Age of the head of household is assumed to represent farming experience. Age and farming experience increase the likelihood of perceiving cassava as potential crop for climate change adaptation, as experienced farmer have much knowledge and also information on climate change and best adaptive measures. Moreover, the gender of the heads of household is associated with the male and female social ascribed roles and thus they have different set of knowledge and needs, hence hypothesized to increase the likelihood to perceive cassava as potential crop for climate change adaptation. It was hypothesized as household size and marital status of the household head increases the pressure to grow food from climatically stressed environment also increases because the food and income needs of large household will be higher. Eventually, the household will get to a point where adaptive responses become the only solution available to enhance food security to the family. This may entail perceiving and adapting drought resistant crops.

More education broadens the outlook and horizontally expansion of knowledge. A literacy level is expected to increase farmers' ability to obtain, understand, analyze and perceive different issues in a positive ways. Contact with extension gives access to climate change information and eventually advices on adaptive measures to reduce negative impacts. The availability of extension agent assists the farmers to make favourable perception on crops that yield better under climate change. Likewise, increasing factors which are believed to create awareness to climate change such as information on climate is hypothesized to increase the likelihood of perceiving cassava as a climate change crop.

Explanatory Variables for the Outcome Equation

The variables hypothesized to influence adaptation include gender of the head of household, marital status, education of the head of household, size of household, access to climate information and extension on crop and livestock production. The justification for the inclusion of these variables along with the hypothesized direction of relationship with adaptation has been explained under the section describing the explanatory variables for the selection equation and omitted here to avoid redundancy.

3.7.3 To estimate the contribution of cassava to total household income

In assessing the contribution of cassava to total household income, the gross margin for the crops and livestock mostly produced in the study area were determined (Appendices 1and 2) . The gross revenue was calculated using the stated price of the commodity along with the quantity of production reported by the household farmers. In case the farmer reported that the quantity produced was not sold, the value of the yields of the crop was estimated using the market price of the production season. Total variable costs were obtained directly from the respondents during the interviews. The costs of the input were calculated as the product of the unit input cost and the quantity of each input used in production. The use of GM can be criticized for ignoring fixed costs within and or among enterprises. However, GM remains useful where the value of the fixed cost is negligible, as it is the case with agricultural enterprises which are operated mostly at small scale level (Arene and Mbata, 2008).

The GM was computed using the following formula;

$$GM_i = R_i - VC_i \qquad (6)$$

Where: GM_i= Gross Margin accrued from the i^{th} activity;

R_i= Revenue from the i^{th} activity;

VC_i = Variable Cost from i^{th} activity.

Accordingly, major sources of income other than agriculture were identified and respondents were asked to state the amount they earned per month or per year from each source. Income from cassava for each household was expressed as percentage of the total household income. The average percentage for all respondents was taken to be the proportion by which income from cassava contributes to total household income in the study area.

3.8 Limitations of this Study

In conducting this study, several limitations were faced. Listed below are some of the constraints which were faced during this study;

i. Research regarding farmers' perception on cassava as a crop for climate change has almost not been done in Tanzania, particularly in Kigoma Region. It was therefore very difficult to access recent and relevant materials concerning the study. To overcome this problem; various information from secondary data, literature and internet were used to insure reliable research results.

ii. Record keeping regarding production, selling prices and inputs was a limiting factor for this study. The data provided from the household head were basically based on their memory and, hence sometimes difficult to them to memorize the actual quantities they produced and or the actual price they sold their produce. So in some cases, respondents used estimation. To mitigate the problem, information regarding production, marketing and price were supplemented from ward agricultural and livestock officer and district offices.

iii. During data collection, it was a season for growing beans, an activity that makes majority of the farmers leaving their home early in the morning and returning back also late in the evening as the farm are situated a bit far from their home place. This process therefore took quite some time than it was planned. This problem was resolved by having an appointment with village leader and ward agricultural and livestock extension officers on dates and time to conduct interviews with farmers and the procedures was successful.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Demographic and Socio-Economic Characteristics of the Respondents

The mean age of the households interviewed was found to be 45.5 with oldest being 76.0 years and youngest being 21 years. This implies that, many of the households heads involved in the study were old enough to have been able to experience the changes in climate and as such able to give liable response to the questions in the research. Age can equally affect farmer's perception about climate change indicators, coping and adaptation strategies (Daninga, 2011). From the results in Table 4 the average household size seems to be high (6.0), the figure which exceeds the national and even region average household size which is between 4.8 and 5.7 people respectively (NBS and OCGS-Zanzibar, 2013). Household size has an implication in the agricultural production and consumption after production.

Table 4: Households size and age of respondents

Variable	Minimum	Maximum	Mean
Age of respondent	21.0	76.0	45.51
Household size	1.0	12.0	6.0

The study as presented in Table 5 shows that 78.6% of the household head in the study area have attained primary education. This implies that majority of the household head are relative literate and thus they can understand and digest the potential and future role of cassava as climate change crop. Likewise, about 75.7% of the household head interviewed were married. This indicates that married respondents are the most participants in agricultural production in the study area. This could be attributed to the necessity of the married counterparts to meet family basic needs such as food self-sufficiency.

Table 5: Distribution of respondents by education and marital status (n=140)

Variable	Percentage
Educational level	
None formal	19.3
Primary	78.6
Secondary	1.4
College/university	0.7
Marital status	
Married	75.7
Single	6.4
Divorced	8.6
Widowed	9.3

4.2 Technical Services and Farming Experience

Table 6 shows that high proportion (67.9%) of the household head interviewed in the studied villages reported to have had no access to extension services. This implies that the study area is not yet tuned to extension services. The low exposure to extension services may be as results of inadequate extension staff which may hinder the perception and adoption of cassava as a climate change crop. With regard to the farming experience, the study found out that the majority (91.4%) of the household heads interviewed had high farming experience (above 10 years). Farming experience enables the household farmer to consider about pros and cone of different crops grown in the face climate change and adaptation.

Table 6: Technical services and farming experience (n=140)

Variable	Percentage
Extension services	
Yes	32.1
No	67.9
Farming experience	
Low farming experience (1-10 years)	8.6
High farming experience (10+ years)	91.4

4.3 Farmers' Perception on Cassava as a Climate Crop

The study targeted to evaluate how cassava is perceived by farmers to be potential for climate change adaptation. Out of the 140 total of household heads interviewed and shown in table 7, nearly 86.4% reported that cassava is potential for climate change adaptation. This implicates that events of climate change affect less cassava plant, hence pointing out to the resilience of cassava crop towards drought.

Table 7: Distribution by farmers' perceptions regarding cassava as a climate change crop of sample households (yes or no type question)

Survey question	Frequency	Percentage	χ^2 value
Perceive cassava as potential crop			
Yes	121	86.4	140.00***
No	19	3.6	
Total	140	100	

***Indicate significant levels at 1%

To achieve more insight of farmers' perception on cassava as a climate change crop, the Likert scale of interview were used. Set of questions were asked to farmers household to find out whether they are aware with the variables that describes the ability of cassava to sustain under changing climate especially during drought such as tolerant to drought, less instance of crop failure, as an important component of food security in the future and if as a consequence of climate change farmers have adapted growing the crop. Respondents were requested to indicate whether they strongly agreed, agreed, were neutral, disagreed and or strongly disagreed with each perceptual statement. Strongly agreed and agreed were treated as positive perception towards perception on cassava as potential crop for climate change adaptation and strongly disagreed and disagreed were treated as negative perception while undecided items showed farmers knew nothing.

Table 8 shows that 72.7% to 98.3% of the farmers' household interviewed in the study area agreed that cassava can tolerate extended period of water stress, show less incidence of crop failure and help to meet national food security on the face of climate change in the future. This implicates that most of the household farmers view climate change in form of drought as an external force against which they find themselves engaging in cassava growing contrary to 3.3% to 18.2% of the interviewed household heads. The study findings indicate that majority of households are aware that cassava is a climate change crop. This suggests that over 72.7% of the household farmers in the study area have positive perception on cassava as potential for climate change adaptation. This fact could have been attributed by the sensitive nature of other staple food crops towards the climate change as compared to cassava plant.

Further, Table 8 shows that perception of famers on cassava as a potential crop for climate change adaptation is statistically significant at $p<0.05$ and $p<0.01$. Hence the null hypothesis is rejected and it can be concluded that farmers perceive cassava as a potential crop for climate change adaptation. This research finding correspond to Lal *et al*. (2014) who reported and concluded farmers being satisfied in cultivating cassava under climate change scenarios owing to its innate capacity to cope with the events related to changing weather and climate.

Accordingly, the perception of high incidences of disease and pests to cassava being less as compared to other crops stand at 45.5% of the headed households are in agreement to it while 44.6% were against. The result therefore, reveals a divide within the respondents regarding those who thought that disease and pests incidences to cassava are less compared to other crops. This implicates that disease and pests' problem in the study area could be more similar to other crops that are grown by farmers. Ifeanyi-Obi and Issa (2013) also noted that cassava is affected by various diseases and insect pests including African cassava mosaic diseases, bacterial blight and mealy bug.

Table 8: Distribution of farmers' perceptions on cassava as a climate change crop of sample households (5-point Likert type scale measure)

Statement	Percentage score on the scale			χ^2 value
	Agree	Undecided	Disagree	
Cassava is highly drought tolerant	98.3	1.7	0	11.498**
Cassava show less incidence of crop failure	97.5	2.5	0	6.443***
Drought a motivation to growing cassava	72.7	9.1	18.2	44.172***
Cassava can meet national food security	90.9	5.8	3.3	15.098***
Cassava tolerate disease and pests	45.5	9.9	44.6	56.881***

***, ** Indicate significant levels at 1% and 5% respectively

Outcomes of the key informants' interview also concurred with the results obtained from the survey data. 80% of the key informant interviewed declared the crop as a potential for climate change adaptation and thus government should put more effort in cassava production. Respondents who indicated to perceive cassava as climate change crop were asked a subsequent open-ended question demanding the reasons for their perception.

Majority of the respondents both female and male headed household attributed their perception to

a) Cassava is drought-resistant crop, in the sense that once established the crop is not easily affected by dry spells and drought.
b) The crop can still yield better in poor soil compared to other crops. This is due to the reason that, cassava has extensive root system that enables it to grow in soils too impoverished to support other crops.
c) Cassava requires little inputs use when compared with other crops.

However, some respondents were found to perceive but failed to give the reason for their perception.

4.3 Factors Influencing the Perceptions of Farmers on Cassava as a Climate Change Crop

Despite the fact that majority of the farmers interviewed claimed that they perceive cassava as a climate change crop, some of the farmers who perceived cassava as potential for climate change adaptation did not respond by growing the crop. It fall out that both farmers who perceive and responded and also those not responded share some common characteristics, which assist in better understanding the reasons underlying their perception as captured by the Heckman selection model. From the Heckman's probit model results, a positive estimated coefficient implies increase in the farmers' perception on cassava as the crop for climate change adaptation with increased value of the explanatory variable. Whereas negative estimated coefficient in the model implies decreasing perception with increase in the value of the explanatory variable.

The results from the Heckman two step selection model analyses of the sampled households are presented in Table 9**.** Age, gender, marital status and information on climate change significantly influence the perception of farmers on cassava as a potential crop for climate change adaptation.

Positive determinants of the perception on cassava as climate change crop included only marital status and access to climate change information by household head among others. Level of education of the household head, access to extension services and household size were nearly insignificant.

Table 9: Results of the Heckman probit selection model (two-step)

Independent variable	Regression values for adaptation model		Regression values for perception model	
	Coeff.	**P-value**	**Coeff.**	**P-value**
Age			-0.0290398**	0.042
Gender	-0.1002596	0.452	-0.9305632*	0.034
Marital status	0.5182943***	0.001	1.34156***	0.015
Education level	0.021936	0.115	-0.0181754	0.750
Information on climate	0.3309272**	0.083	0.7693463**	0.077
Extension services	-0.1373581	0.162	0.460739	0.164
Household size	-0.0126582	0.582	-0.0753174	0.409
Lambda	0.383676	0.406		
Number of observations	140			
Censored observations	19			
Uncensored observations	121			
Wald chi-square	29.83, p=0.0000			

***, **, * = Significant at 1%, 5% and 10% probability level, respectively

As for the age of the household head, the results came out as expected as the age of the household head would be negatively and significantly related to the farmers' perception on cassava as a climate change crop. The survey finding reveals that the probability of perceiving cassava as potential for climate change adaptation was less for younger farmers than it is for older farmer's heads of household. Ndambiri *et al*. (undated) attest to this finding when in their respective study, they observed positive relationship between age of the household head and perception on climate change and adaptation. Further research by Meseret (2014) also found that a unit increase in age of the household head decreases the farmers' perception of being involved in conservation activity.

As hypothesized, gender of the household head was a significant factor and had the predicted negative relationship with the probability to perceive cassava as climate change crop. The study found out that the likelihood to perceive of the male headed household was lower than that of the female headed households ($\beta = - 0.9305632$, $p < 0.010$). Hence, in the present analysis, gender of the household head is negatively associated with the perception of farmers. This could be attributed by the reason that, in adapting female normally devote to adaptation practice that enable them to reduce hunger while male devote to practices that reduce effects of climate change on cash crops and livestock. Nandi *et al*. (2011) reported that most of the cassava farmers are females indicating that cassava production is however not gender exclusive.

Also established by the study finding was a positive and significant association between marital status of the household head and the perception on cassava as a crop for climate change adaptation. The result signifies that the married household heads were more likely to perceive cassava as a potential crop for climate change adaptation in the study area. This can be attributed to the necessity of the married counterparts to meet family basic needs such as food self-sufficiency even under changing environment. Study findings by Lal *et al*. (2014) showed also that larger percentage (84.6%) of tuber cultivating farmers is married.

As expected, the likelihood of perception of cassava as a crop for climate change adaptation is positively related to availability of climatic information to household farmers. The study findings revealed that the accessibility of climate information by household farmer through from either extension agents or any other source had higher chances of influencing farmers to perceive cassava as a climate change crop. This result suggests that household farmers with access to information on climate are more likely to perceive cassava as a climate change crop. The corresponding findings by Deressa *et al*. (2008) also reported a positive relationship between the likelihood of perception of climate change and information on climate.

4.4 Share of Income from Cassava to Overall Household Income

4.5.1 Sources of household income

Figure 3 summarizes the results on source of income to household in the study area. The study findings showed that cattle (25.07%), Ginger (12.28%) and salaried employment (10.86%) were the most three important sources of income for the household head. Other sources included cassava (9.87%), maize (7.47%), Groundnuts (6.5%), beans (5.79%) and goats (5.5%). Income from other sources like artisan work, natural resources based products, business, chicken and sheep contributed less than 5% of total household income. The results imply that farming is the major income-earning activity in the study area.

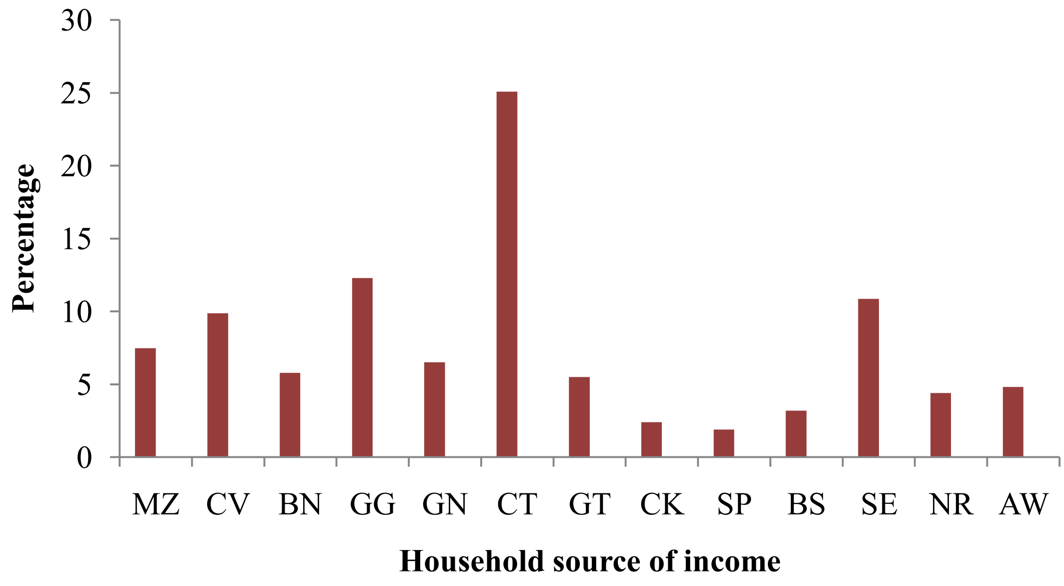

Figure 3: Sources of household income in Buhigwe District

Note: MZ= Maize; CV= Cassava; BN= Beans; GG= Ginger; GN= Groundnuts; CT= Cattle; GT= Goats; CK= Chicken; SP= Sheep; BS= Business; SE= Salaried employment; NR= Natural resources based product and AW= Artisan works

4.5.2 Contribution of different sources of income to total household income

In Table 10, income from agriculture for the sampled household was considered to include the income earned from all major types of crops grown and livestock kept. Generally, the survey findings indicate that agriculture is a major source of income contributing about 76.75% to total household's income. This suggested that, agricultural production is the major livelihood activity in the study area. Farming and livestock keeping are the livelihood activities which are climate sensitive. This assert that household livelihoods are more likely to be affected by the impacts of climate change in the absence of appropriate strategies to overcome the future impacts of climate change in the study area.

Table 10: Household income per source

Source of income	Average income per year (Tsh)	Income share (%)
Agriculture	742 195.23	76.75
Business	30 714.30	3.18
Wage/salary	105 000.00	10.86
NR* Based products	42 500.00	4.39
Artisan works	46 666.70	4.82
Total	**967 076.23**	**100**

4.5.3 Gross margin analysis

Table 11 presents results on the gross margin for major crops and livestock produced in the study area. All gross margin figures are reported per acre for crops and per livestock unit for livestock enterprises. Cattle were the most profitable enterprise with a share of 25.07%, while ginger ranked second contributing about 12.28% to total household income. The proportions of each agricultural activity gross margin out of the total income indicate that cassava was ranked third with a share of 9.87%.

Among other food crops grown in the study area, this empirical evidence proves that cassava production contribute significantly to the overall household income. The similar findings was observed by FAO (2002) cited in Akajuobi *et al*. (2010) who reported cassava to have advantage over other crops when compared as it generates income for the largest numbering household. Also the corresponding findings was noted by Fermont *et al*. (2010) who identified cassava as the most important staple food in 67% of the poorer household surveyed in Western Kenya, with further notification that the crop contribute more than any other single crop to household income.

Table 11: Income share of the income sources to total household income

Enterprise	Average income earned (Tsh)	Income share (%)
Maize	72 259.00	7.47
Cassava	95 420.48	9.87
Beans	55 956.80	5.79
Ginger	118 747.70	12.28
Groundnuts	62 905.00	6.50
Cattle	242 499.00	25.07
Goats	53 207.25	5.50
Chickens	23 000.00	2.39
Sheep	18 200.00	1.88
Total	742 195.23	76.75

Appendices 1 and 2 provides a more conceptual look into the components of the gross margin analysis showing the breakdown of revenue and variable costs as it pertains to the most crops and livestock produced in the study area.

CHAPTER FIVE

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

Owing to the role of cassava and its importance, this study targeted to find out if farmers perceive it as climate change crop and eventually serving as a food security crop in the face of changing climatic conditions. Using the data collected from 140 household farmers, it was found out that majority of the farmers perceive that cassava is potential for climate change adaptation. Majority of the farmers reported that cassava can tolerate extended period of water stress and of important reducing the negative impacts of climate change. Accordingly, cassava is considered by the majority in the study area as food security crop due to its ability to sustain under changing climate conditions.

Furthermore, the results indicates that age, gender, marital status and availability of climate information were crucial factors in influencing the likelihood of heads of household to perceive cassava as a potential crop for climate change adaptation. Any policy aimed at enhancing food security in the study area in the face of climate change should implement strategies and programmes that will influence farmers' perception towards cassava as a climate change mitigation crop. It was also discovered that cassava in the study area is important, not just as a food crop but even more as a major source of income. This was due to the reason that most of farmers earn considerable portion of their income from cassava as compared to other food crops grown. This has important policy implication in that promoting cassava production in Tanzania is of very important if the goal of food security under climate change scenarios has to be achieved.

5.2 Recommendations

As discussed and concluded in this study, majority of the farmers in the study area perceive cassava as one of the most suitable crop for climate change adaptation. In view of this; this study recommends as follows:

a) The findings make a strong case for farmer's perceptions consideration in climate change response policies and programmes. In the design and implementation of projects on planned adaptations to climate change, there is a need to focus not only on technical aspects but also social dimensions such as perceptions of smallholder farmers. This would facilitate exchange of knowledge between smallholder farmers, donors and government for effective adaptation to climate change.

b) The government should implement strategies and programmes that will influence farmers' perception towards cassava as a climate change mitigation crop. This will enhance the role of cassava production and utilization in achieving food security in the face of climate change. Furthermore, extension services should be improved to facilitate adoption of new technologies that will encourage the production of cassava.

c) The Government, NGOs and other agencies linked to agriculture and food security should collaborate in the establishment of strategies aiming to increase, promote and support the cultivation of cassava through research, raising awareness, advocacy, mobilization and empowerment of most vulnerable communities.

5.3 Areas for Further Research

Different varieties of cassava could also show differences in strength to tolerate drought. These differences in strength merit particular attention in future research.

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APPENDICES

Appendix 1: Summary of gross margin across different crops heads of household in Buhigwe District

Item	Maize	Cassava	Beans	Ginger	Groundnuts
Average total output*	159.58	5.75	66.8	493.58	161.5
Average price (Tsh)	800	27 156.8	1300	1140	1232
Average total revenue (Tsh)	127 664	156 151.6	86 840	562 681.2	198 968
Average Variable Cost					
Land preparation	28 500	31 350	13 147	173 304.5	42 123
Seeds	3350	2150	4 068.1	63 500	19 850
Planting	8050	3175	6 718.1	48 250	25 300
Weeding	4500	8 445.32	3250	85 779	30 750
Harvesting	11 005	15 610.8	3700	73 100	18 040
Total variable costs (Tsh)	**55 405**	**60 731.12**	**30 883.2**	**443 933.5**	**136 063**
Gross margin	**72 259**	**95 420.48**	**55 956.8**	**118 747.7**	**63 905**
Gross margin for all crops					**405 288.98**

* The measurement units used are as follows:

- Kg- A unit measures for maize, ginger and beans
- Bag- A unit measure for cassava , which is equivalent to 120kg

Appendix 2: Gross margin for livestock enterprises of household head in Buhigwe District

Item	Cattle	Goat	Chicken	Sheep
Total output produced	50	100	295	15
Total quantity sold	6	19	104	2
Average price (Tsh)	416 666	34 882	6000	40 000
Average total revenue (Tsh)	833 332	82 844.75	48 000	40 000
Average Variable Cost				
Labour	500 000	9000	-	-
Feeds	-	-	25 000	-
Vet treatment	90 833	20 637.5	-	21 800
Total variable costs (Tsh)	**590 833**	**29 637.5**	**25 000**	**21 800**
Gross margin	**51,266**	**53 207.25**	**23 000**	**18 200**
Overall gross margins				**336 906.25**

Appendix 3: Household questionnaire

The perception's of farmers on cassava as a potential crop for climate change adaptation

A: QUESTIONAIRRE IDENTIFICATION

Name of interviewer...............................Name of respondent…………………….
Village…………Ward…………… Division…………Date of interview……………..

B: RESPONDENT CHARACTEISTICS

1.0 Provide the following information of the respondent (***tick the appropriate box***)

1.1AGE	0-14	15-24	25-34	35-44	45-54	55-64	65+	**1.2 SEX**	*Male*	
									Female	
1.3 Marital Status	Married	Single	Divorced	Widowed	**1.4 Education level**	No formal	Primary	Secondary	College/University	Other (Specify)
1.5 OCCUPATION	Farmer		Civil servant		Business		Other(Specify)			

1.6 How long have you been in farming activities (give years) ……………..
1.7 a) Are there extension services in your area? 1= Yes, 2= No [ ]
1.7 b) If yes, do you get extension services frequently? 1=Yes, 2=No [ ]

C: HOUSEHOLD COMPOSITION AND CHARACTERISTICS

2.1 Size of the household (***Include all family members & dependants***)…….

Family member (Name)	Sex 1=M 2=F	Relationship to the HH Head **CODE 1**	Age	Marital status **CODE 2**	Education (Years) **CODE 3**	Occupation **CODE 4**	Labor contribution to farms cultivated by HH in 2013/14 **CODE 5**

2.2 Number of females & males of the following age group in household size	*Age group*	0-14	15-24	25-34	35-44	45-54	55-64	65+
	Male							
	Female							

CODE 1	**CODE 2**	**CODE 3**	**CODE 4**	**CODE 5**
1.Head 2.Spouse 3.Child 4.Father 5.Mother 6.Other relative	*1.Married 2.Single 3.Dirvoced 4.Widowed 6.Others (Specify)*	*1.None 2.Primary education 3.Secondary education 4.College/University 5. Other (Specify)*	*1.None 2.Farmer 3.Civil servant 4.Business 5.Student 7.Other*	*1.Full time 2.Part time 3.Does not participate in farming*

D: KNOWLEDGE ON CLIMATE CHANGE & ITS IMPACT TO CROPS

3.1 If noticed any climate change occurred in your village in the past 5 years				Yes		No
3.2 Signs indicated in climate change	Increasing	Decreasing	No change	Don't know		
a) Temperature						
b) Rainfall						
3.3 If yes *(from 3)* how did you respond to climate change	1=Early planting	2=Crop diversification	3=Switching to drought-resistant crops	4=Changing to irrigation farming	5=Expansion of area	6=Other (specify)
3.4 Sources ofthe first information about climate change?	1=Family	2=Friends	3=Neighbors	4=Extension agents	5=Experience	6=Other (specify)
3.5 Have you experience any crop failure in the past 5 years				**1**=Yes		**2= No**
3.6 What do you think was the cause?	**1**=drought		**2**=High rainfall		**3**=don't know	

E: ATTITUDES & PERCEPTION ON CASSAVA AS CLIMATE CHANGE CROP

4.1 Do you agree that cassava is a potential for climate change adaptation? 1=Yes; 2= No [ ]

4.2 If you agree cassava as climate change adaptation crop, why perceiving that? a)………………………b)……………………………c)……………………

4.3 If Yes from 4.1 did you respond by growing cassava as an adaptation measure? 1=Yes; 2= No [ ] (***Go to 4.5 and 4.6***)

4.4 If you disagree (***only for those say NO***) which crops do you think as potential for climate change adaptation?

a)……………………b)………………………….. c)…………………………

4.5 Please circle a number from the scale to show how you agree or disagree with each of the following statement (*Strongly Agree=SA, Agree=A, Undecided=U, Disagree=D and Strongly Disagree=SD*)

S/No	Statements	SA	A	U	D	SD
1	Cassava can tolerate extended period of water stress					
2	Cassava reduce negative impacts of climate change by optimizing crop yields and profits					
3	Has drought been your motivation to adapt cassava growing?					
4	Cassava can help to meet national food security on the face of climate change in the future					
5	Disease & pests incidences to cassava is less compared to other crops					

4.6 What are the main constraints of growing cassava? *Please rate them on a scale of 1 to 5 where 1 is the most serious and 5 least*	**Rating**
1. Diseases and insect pests	
2. Thieves	
3. Poor soil fertility	
4. Inadequate technical knowledge	
5. Inadequate extension services	
6. Unreliable market	
7. Lack of credit	
8. Other (Specify)	

F: HOUSEHOLD INCOME ACTIVITIES FOR 2013/14 CROPPING YEAR

5.1 What is the primary source of income/livelihood of your household? (***Tick the appropriate one-can be more than one)***	***Source of income/Livelihood***	***Tick***
	1. Agriculture	
	2. Livestock	
	3. Natural resources product	
	4. Salaries	
	5. Business	
	6. Others (specify)	

5.2 Type of agriculture	*Subsistence*		*Commercial*		*Subsistence & commercial*	

5.3 Revenue from agricultural production during the 2013/14 cropping year

Type of crop	*Unit*	*Quantity consumed*		*Quantity sold*		*Total Quantity produced*	*Unit price (Tsh)*	*Gross income (Tsh)*	*Variable Cost (Tsh)*	*Net total income*	*Net cash income*
		A	B	C	D	E=A+C	F	G=E x F	H	I=G- H	J=I x D
a) Maize											
b)Cassava											
c)Beans											
d)Banana											
e)Ground nuts											
g)Coffee											
h)Ginger											
i)Other											
Total											

5.3.1 In the table below show labor cost in crops grown per acreage (in man days)

Type of crop	***Land preparation***	***Planting***	***Weeding***	***Harvesting***	***Transport***
a) Maize					
b)Cassava					
c)Beans					
d)Banana					
e)Groundnuts					
g)Coffee					
h)Ginger					
i)Other					
Total					

5.3.2 Fill the table below to show the cost of seeds and fertilizer used

Type of crop	**Cost of seeds**			**Cost of fertilizer**		
	Amount in Kg	*Cost per Kg*	*Total cost*	*Amount in 50Kg bag*	*Cost per bag*	*Total cost*
a) Maize						
b)Cassava						
c)Beans						
d)Banana						
e)Groundnuts						
g)Coffee						
h)Ginger						
i)Other						
Total						

5.5 Do you keep livestock? 1= Yes; 2= No [ ]
5.6 If **YES** state income generated from livestockfor the 2013/14 cropping year.

Type of Livestock	***Number***	***Number of livestock sold***	***Average price***	***Total Revenue***
a) Cattle				
b)Goats				
c)Sheep				
d)Pig				
e)Chicken				
g)Other (Specify)				
Total				

5.7 Quantify the income sources for the2013/14 cropping year from the following off-farm activities (***Include the income of all household members mentioned***)

Income source	Who earned income **(CODE 1)**	Amount earned per month (Tsh)
Business		
Remittances		
Wage/Salary		
NR*-based products		
Artisan works		
Pensions		
Other sources (Specify)		
Total		
CODE 1:*1= Self, 2=Spouse, 3= Self and spouse jointly, 4= Other household member(s)(Specify)*		

G: HOUSEHOLD ASSETS AND ACCESS TO CAPITAL

6.1 Household inventory of durable items

Asset type	Does the HH own[…]1=Yes, 0=No	Number	Current value of@ (Tsh/unit)	Who owns most of the […] **CODE 2**	Who can decide to sell […] most of the time? **CODE 2**
Sickle					
Hand hoe					
Axe					
Slasher					
Matchet/Panga					
House					
Bicycle					
Motorbike					
Improved charcoal stove					
Mobile phone					
Radio					
Cassette or CD					
Television set					
Land owned (acres)					
Other (Specify)					
CODE 2: *1=Self, 2=Spouse, 3=Self & Spouse jointly, 4= Whole family, 5= Other household member*					

6.2 Do you have access to credit services in your area? 1=Yes; 2= No [ ]

6.2.1 If **YES** have you ever accessed loans for agricultural activities? 1=Yes; 2= No[ ]

THANK YOU VERY MUCH FOR YOUR TIME AND PATIENCE!

Appendix 4: Key informants' interview guide

The perception's of farmers on cassava as a potential crop for climate change adaptation

1. For your opinion can we call cassava as a potential for climate change adaptation? *(1=Yes 2=No)*	
2. What do you perceive about the importance of cassava? (*1=Always important; 2= Important; 3= Not important)*	
3. What do you perceive about cassava production in terms of profitability? *(1= Profitable; 2= Sometimes profitable; 3= Not profitable)*	

5. What are the reasons for farmers to perceive cassava as climate change crop? a)…………………………b)…………………………c)…………………………

6. Should the government put more effort in cassava production? 1=*Yes;* 2=*No*) [ ]

6 a) If **YES** what do you think the government should do in order to promote cassava production (*Please explain*)

a)………………………….b)…………………………c)…………………………

7. Perception on constraints hindering cassava production *(1= Not a problem; 2= Minor problem; 3= Big problem; 4= Biggest problem; 5=Other (Specify))*

Constraints	***Response***
a) Problem of land acquisition	
b) Pest and vermin attack	
c) Lack of extension services	
d) Lack of credit	
e) Low crop yield	
f) Shortage of labour	
g) Poor soil fertility	
h) Unreliable market	
i) Too much rainfall	

THANK YOU VERY MUCH FOR YOUR TIME AND PATIENCE!