SOKOINE UNIVERSITY OF AGRICULTUE MOROGORO, TANZANIA

DEVELOPMENT STUDIES INSTITUTE

TITTLE: CLIMATE CHANGE ADAPTATION MEASURES AMONG SMALLHOLDER FARMERS IN MVOMERO DISTRICT, TANZANIA.

STUDENT: Mussa Kabele Kabele

(MASTER OF ARTS IN RURAL DEVEOLPMENT)

SUPERVISOR: DR. C. P. I. MAHONGE

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ABSTRACT

Climate change in Tanzania is emerging as one of the most important challenges among smallholder farmers who depend largely, if not solely, on rain-fed agriculture. Weather forecast and prediction indicate that drought and flood will be more frequent and inconsistent rainfall will be experienced. These changes will affect smallholder farmers, due to the fact that these farmers are more vulnerable because of limited resources and low knowledge on how to adapt to climate change impacts in agricultural productivity. Currently, there is limited understanding in Tanzania on how smallholder farmers cope with climate change. This study assessed climate change adaptation techniques among smallholder farmers in Mvomero District. Specifically, this study analyzed how household characteristics influence the adoption of climate change adaptation measures, determined smallholder farmers' awareness on climate change adaptation measures, and identified climate change adaptation practices. Data for this study were collected using questionnaires, focus group discussion, observation and key informants' interview. Informal talks were used to confirm and complement information collected using the above mentioned methods. Secondary data were obtained from published and unpublished documents including reading books and journal articles. Quantitative data were analyzed using SPSS and content analytical procedures were used to analyze qualitative data. Results indicated that the adoption of climate change adaptation measures varied by household characteristics, knowledge and climate change adaptation practice. In other words, household characteristics and awareness on climate change adaptation measures influenced the adoption of climate change

adaptation measures among smallholder farmers. The findings further showed that climate change adaptation among smallholder farmers is still limited, because of low knowledge, inadequate information and lack of financial capital. In order to improve adaptability to climate change impacts, awareness rising among farmers is recommended through training, seminars and information transfer through mass media.

DECLARATION

I, MUSSA KABELE KABELE, do hereby declare to the Senate of the Sokoine University of Agriculture that this dissertation is my own original work and that it has not been submitted for a degree at any other University.

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MUSSA KABELE KABELE **Date**

(M.A Rural Development)

The above declaration confirmed

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DR. CHRISTOPHER P. I. MAHONGE **Date**

(Supervisor)

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DEDICATION

This dissertation is dedicated to my beloved mother Neema Mussa Kabele who paved the way of my academic career.

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AU	-	Africa Union
CCEE	-	Collaborating Centre on Energy and Environment
COP	-	Conference of Parties
FAO	-	Food and Agriculture Organization
UNFCCC	-	United Nations framework convention on climate change
GCOS	-	The Global Climate Observing System
GHGs	-	Greenhouse Gases
HBS	-	Household Budget Survey
IPCC	-	The Intergovernmental Panel on Climate Change

NAFCO	-	National Agriculture and Food Corporation
NRC	-	National Research Council
NSGRP	-	-National Strategy for Growth and Reduction of Poverty
REDD	-	Reduced Emissions from Deforestation and Degradation
SADC	-	Southern Africa Development Community
SUA	-	Sokoine University of Agriculture
UN	-	United Nations
UNEP	-	United Nation Environmental Programme
URT	-	United Republic of Tanzania
WMO	-	The World Meteorological Organization
NGOs	-	-Non Government Organization

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background Introduction

Cli**m**ate change is emerging as one of the most important challenges of the 21st century among smallholder farmers. The current statistics show that the earth's average temperature has risen by 0.74°C since 1990 (Stern *et al.*, 2006). Following this statistics, scientists envision that the global average temperatures will rise by the average from 1.4°C to 5.6°C by 2080s (Eriksen and O'brien, 2008) which will tremendously affect smallholder farmers' crops productivity because of their high dependence on rain-fed agriculture. The study done by Mwanubi (2008) shows that inconsistent rainfall, and frequent drought and floods have been affecting smallholder farmers' household crops production in Mvomero District. The scholar's further show that maize production will be reduced by 30 % and other staples crops like millet and rice by at least 10% in the next 20 years, because of overdependence of smallholder farmers on rain-fed agriculture. Decline of crops production led to the increase level of poverty and food insecurity among smallholder farmers' households in the study area (McLeman and Smit, 2006).

Reilly and Schimmelpfennig, (2000) state that, in order to deal with drought, floods and inconsistent rainfall in the community level, smallholder farmers should choose appropriate climate change adaptation measures for the sake of increasing farm productivity. Climate change adaptation measures is a action in a system (household, community, group, sector, region and country) which allow a system to better cope with, manage or adjust to some changing conditions, stress, hazards, risk or

opportunity (Smit and Wandel, 2006). Climate change adaptation measures imply reducing present and future vulnerability to climate change and include adaptation measures or changes in practices and processes in light of the perceived climatic change negative impacts among smallholder farmers. The capacity to adapt among smallholder farmers depends largely on the assets (natural, human and social, physical and financial capital resources) that one has or can access and how well these are utilized (Reilly and Schimmelpfennig, 2000). Some of the climate change adaptation measures that smallholder farmers can apply include water storage, introduce and establishment of irrigation techniques, management of water resources, crop insurances, traditional insurance schemes (e.g. labour migration, part time farming, as well as family and clan networks etc.), early warning systems, capacity development to strengthening local institutions the resilience of communities against disaster and knowledge management (access to information and the establishment of local data pools) (McLeman and Smit, 2006; Grothmann *et al.*, 2005).

There have been national efforts towards climate change adaptation measures among smallholder farmers in many areas in Tanzania including Mvomero District. For instance, the government of Tanzania has ratified the UN framework convention on climate change (UNFCCC) in April 1996 (Athumani, 2009). The UNFCCC requires member countries to communicate to the conference of the parties (CoP) on different issues regarding climate change adaptation measures in local communities. In other words, the UNFCCC commits parties of the convention to develop national programme and measures on coping as well as adaptation (Athumani, 2009; Khalif,

2008). As part of arrangement to empower the national programmes and measures on adaptations, DANIDA has provided financial assistance to Tanzania for development of methodologies and capacity building in Greenhouse Gases (GHGs) mitigation, and for development of coping strategies and assessment of adaptation measures. The project is being managed by the United Nation Environmental Programme (UNEP) Collaborating Centre on Energy and Environment (CCEE) and is being funded by DANIDA as a part of a large effort to support coping strategies, adaptation and mitigation studies in developing countries (Athumani, 2009).

Like in many parts of Tanzania the climate change adaptation measures is likely to be limited specifically to smallholder farmers in Mvomero District because of poverty to afford some of the adaptation measures such as use of improved irrigation systems, improved seeds and the like. Smallholder farmers are vulnerable to drought, rain inconsistent and heavier torrential downpours. All these phenomena surely affect agricultural production among smallholder farmers in Mvomero District. The economies of many rural people including Mvomero District who depend on rain-fed agriculture are now vulnerable because of climate change (Collier *et al.*, 2010; URT, 2007). Although several studies have been done on effects of climate change on smallholder farmers in Tanzania, a gap of knowledge exists on adaptation measures taken by smallholder farmers in Mvomero District. Therefore, this study aimed to assess climate change adaptation measures among smallholder farmers in light of climate change impacts.

1.2 Problem Statement

Mvomero District's smallholder farmers are in great danger of climate change. Climate change contributes to inconsistent rainfall, droughts and floods which consequently affect smallholder farmers' activities in the study area where majority depend solely on rain-fed agriculture. However, little is known on how smallholder farmers adapt to climate change. To reduce climate change negative impacts to smallholder farmers in Tanzania including Mvomero District, the Tanzanian government has launched adaptation measures programme and the national Reduced Emissions for Deforestation and Degradation (REDD) wherein the Norwegian government has allocated 100 billion Tsh for rectifying damage to the forest through a programme that will run for over 5 years (Athuman, 2009).

To address the existing challenges due to climate change, a number of studies concerning climate change adaptation measures have been done. According to Ziad and Jamous (2010) although negative effects of climate change are being evident at a global scale, these effects are more severely felt in poor communities. This is true for Mvomero District where communities are highly dependent on natural resources and with limited capacity of financial and knowledge on how to adapt to climate variability and extremities. Study done by Ayers (2009) confirms this further by stating that climate change increases the vulnerability of poor people by adversely affecting their health and livelihoods, thus undermining economic growth opportunities and livelihood assets. Besides, poor financial and adaptive knowledge capacity among smallholder producers makes national and local level poverty reduction efforts directed towards them difficult to operationalise. While

information on climate change and climate change adaptations are well documented little empirical evidence is known on the climate change adaptation measures adopted at farm level by smallholder farmers to increase agricultural production. Therefore this study intended to assess climate change adaptation measures adopted by smallholder farmers at farm level to reduce vulnerability to climate change in Mvomero District in Morogoro Region.

1.3 Justification

The findings of this study will provide knowledge on good and bad agricultural management practices undertaken by smallholder farmers in the light of climate change influences. From these findings, measures will be recommended for enhancing the capacity of smallholder farmers to adopt appropriate practices for climate change adaptation and improved livelihoods. The study will also provide insights that will make policy and decisions makers understand the local area better and therefore be in position to design relevant and appropriate policies and measures for addressing negative impacts due to climate change and improving livelihoods.

1.4 Objectives

1.4.1 Main objective

The main objective of the study was to assess climate change adaptation measures among smallholder farmers in Mvomero District.

1.4.2 Specific objectives

To achieve the main objective, the following specific objectives were covered.

i. To analyze how household characteristics influence the adoption of climate change adaptation measures

ii. To examine smallholder farmers' awareness on climate change adaptation measures.

iii. To investigate climate change adaptation practices undertaken at farm level

1.5 Research Questions

i. How do household characteristics influence the adoption of climate change adaptation measures?

ii. What awareness smallholder farmers have regarding climate change adaptation measures?

iii. What are the climate change adaptation measures adopted by smallholder farmers at farm level?

1.6 Conceptual Framework

A conceptual framework adopted in this study depicts linkages among household characteristics, climate change, and climate change adaptation measures which influence agricultural productivity among smallholder farmers (Figure 1). Interactions among the aforementioned variables are complex as elaborated below.

Households possess differential powers of diverse social, natural, physical, financial, cognitive and capital assets in this study collectively called household

characteristics, which facilitate or constrain their interactions with the environment around them in the course and process of securing livelihood interests. The cognitive capital that accumulates over time through experiential learning of environmental indicators enables household to notice changes in climatic phenomenon and conditions. By using their social capital resources in combination with financial, physical, and natural resources at their disposal, households respond to the climate change influences.

The adaptation and/or coping measures adopted by the household have mixed outcomes to both livelihood productivity and climate change. On the one hand, these adaptation measures/strategies may positively impact on both smallholder farm productivity and to the climate change by contributing to the reduction of adverse climatic impacts. On the other hand, the adaptation measures implemented may worsen the existing or introduce new problems to both climatic and the livelihood dimensions by enhancing adverse climatic situation and reducing agricultural productivity consequently making households more vulnerable to climate change. So far two potential impacts of coping strategies/adaptation measures on livelihoods and environmental dimensions have been introduced. However, various combinations of diverse degrees of the foregoing two scenarios may be experienced. The focus of this study nonetheless is on how interactions between climate change, climate change adaptation measures and household characteristics impact on agricultural productivity at household level.

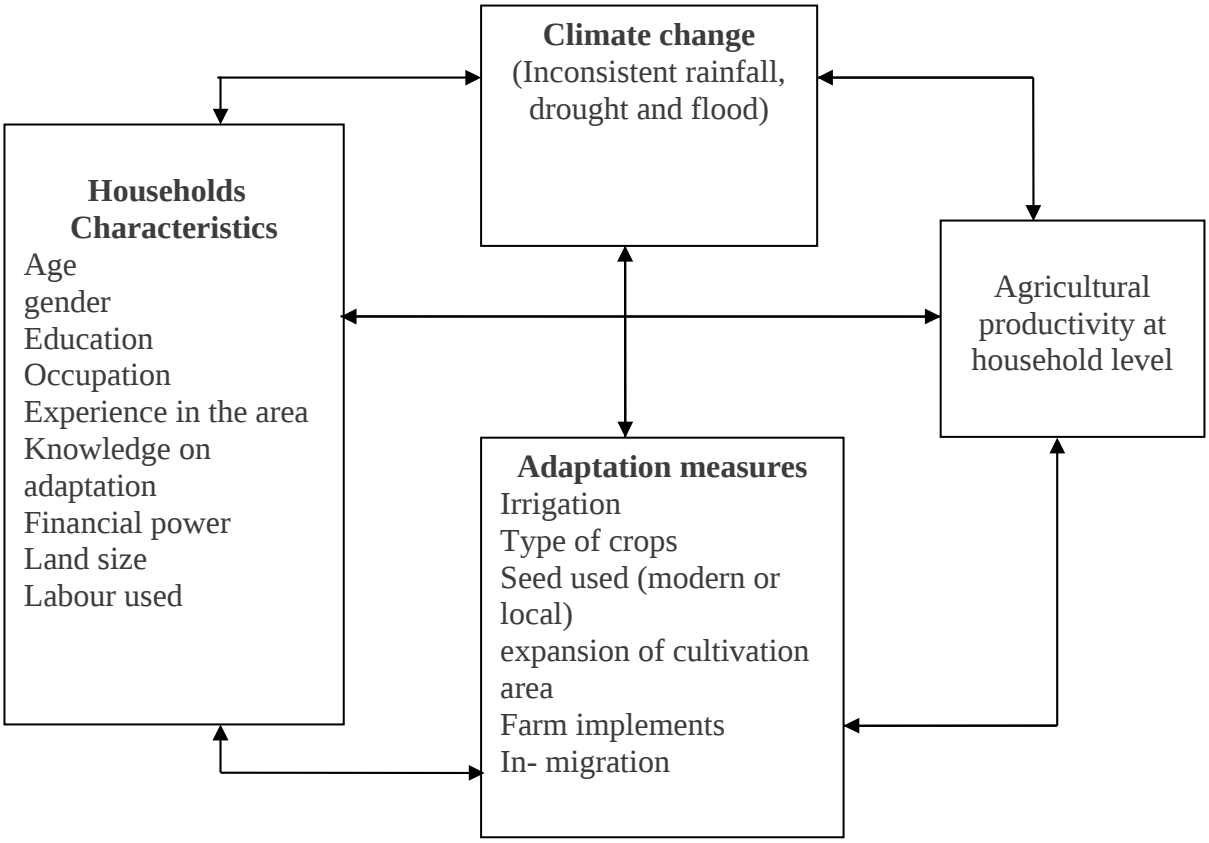

Figure 1: Interactions among climate change, household characteristics, climate change adaptation measures and agricultural productivity at household level.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Introduction

Climate change is a change in the statistical distribution of weather over periods of time that range from decades to millions of years. It can be a change in the average weather or a change in the distribution of weather events around an average (for example, greater or fewer extreme weather events). Climate change may be limited to a specific region, or may occur across the whole earth. It can be caused by recurring, often cyclical climate patterns such as El Niño-Southern Oscillation, or come in the form of more singular events such as the Dust Bowl. It is a natural process that takes place simultaneously on various time scales astronomical, geological, and decadal. It refers to the variation over time in the earth's global climate or in regional climates, and it can be caused by both natural forces and human activities (Jarvis *et al.*, 2011; Ziad and Jamous, 2010). According to IPCC (2007) and Fazey *et al.*, (2010) most of the observed increase in globally averaged temperatures since the mid 20th century, the phenomenon known as global warming, is very likely caused by human activity, principally the burning of fossil fuels and deforestation, which have increased the amount of greenhouse gases in the atmosphere. Some of those greenhouse gases include water vapor, carbon dioxide (CO2), methane (CH4), and nitrous oxide (N2O).

This chapter presents relationship presented in various literature, on climate change and agriculture, characteristics of small-scale farming in Tanzania, adaptation and adaptation processes, motivation of smallholder producers to respond to negative

climate change impacts, types of adaptation options in agriculture, climate change adaptation characteristics, methods of climate change adaptation, climate change adaptation among smallholder farmers and the role of social construction to climate change adaptation measures.

2.2 Relationship between Climate Change and Agriculture

Extreme meteorological events, such as spells of high temperature, heavy storms, and droughts disrupt agricultural production. A recent study done by Pant (2009) has found that changes in the variability as well as in the mean values of climatic variables have negative impacts on crops. Where certain varieties of crops are grown near their limits of maximum temperature tolerance, such as rice, heat spells can be particularly detrimental. Similarly, frequent droughts not only reduce water supplies but also increase the amount of water needed for plant transpiration. Climate change can impact agricultural sustainability in two interrelated ways: first, by diminishing the long-term ability of agro-ecosystems to provide food and fiber for the world's population, and second, by inducing shifts in agricultural regions that may encroach upon natural habitats, at the expense of floral and faunal diversity. Virtanen *et al.*, (2011) argued that climate change may encourage the expansion of agricultural activities into regions now occupied by natural ecosystems such as forests, particularly at mid and high latitudes. Forced encroachments of this sort may thwart the processes of natural selection of climatically adapted native crops and other species.

Agricultural systems are vulnerable to climate variability, whether naturally occurrence, or due to human activities. Vulnerability can be viewed as a function of the sensitivity of agricultural system to changes in climate, the adaptive capacity of the system, and the degree of exposure to climate hazards (Nibleus and Lundin, 2010). The productivity of food crops, from year to year, for example, is inherently sensitive to variability in climate. Smallholder producers in many parts of the developing world including Tanzania have less physical, agricultural, economic and social resources to adapt the impacts of climate variability on food production systems (Gabbers and Adamchuk, 2010)).

2.3 Characteristics of Small-scale Farming in Tanzania

Small scale farming takes various forms in Tanzania. Normally farms are small, food and cash crops including livestock are raised with little capital and low knowledge (Lupatu and Matee, 2001). The farm household is self-sufficient, home consumption oriented production unit, which internally decides on production and consumption without relating to any external market. Farmers would like to meet their subsistence food requirements before any production for sale is affected. A surplus, if any, is sold for the purpose of earning income, which is used to purchase other essential items.

The foregoing scholars also found that a peasant farmer uses resources at his/her disposal, normally family labour and land to work on the farm. Producers often lacks technical know how in production instead they depend largely on local experience accumulated over many generations. Higher dependence on local

experience only means that knowledge on production is not sufficient. Modern farming techniques such as the use of improved farm implements e.g. ox-plough, tractor, chemical fertilizer; insecticides and harvesting machines, where applicable, are seldom used (Mkai, 2005). Shifting cultivation, where land is abundant, and fallow system are the main dependable forms of farming. As most farmers depend on family labour for farm work, surplus produce after meeting food needs is generally small. Even if farmers cultivate cash crops, labour becomes limited in most cases. Thus, crop sales are usually low leading to low total income (Mkai, 2005).

2.4 Adaptation and Adaptation Processes

2.4.1 Adaptation

Adaptation can be defined as adjustments of a system to reduce vulnerability and increase the resilience of the system to change. Adaptation occurs at a range of inter-linking scales, and can either occur in anticipation of change, or be a response to those changes. Most adaptation being implemented at present is responding to current climate change and variability, these include diversification of livelihood activities, shift from one livelihood option to another, and modification of the existing technology or adopting new ones, the phenomenon or process that can collectively be referred to as technology adaptation (e.g. the development of new drought resistant crop varieties or improved information systems, irrigation system and other technology adaptation process) (Fussel, 2007).

Technology adaptation process can be defined as a mental process an individual passes from first hearing about an innovation to final adoption (Feder *et al.,* 1985). The scholar further defines final adoption as the degree of the use of a new technology in the long-run equilibrium when the farmer has full information about the new technology and it's potential. The dynamic nature of adaptation decisions involves a change as information is progressively collected. Adaptation is conceptualized as a multi- stage decision process involving information acquisition and learning by doing by people who vary in their risk preferences and their perceptions of risk characteristic of an innovation (Feder *et al.*, 1985).

2.4.2 Adaptation Processes

The agricultural adaptation options available to households and individual farmers to reduce vulnerability to climate change risks are very essential for smallholder agricultural production. There are many kinds of technological, public policy and farm management options with potential to moderate adverse climate change effects or to realize opportunities (Smit, 2001). Yet the process of adaptation in agriculture itself is rarely researched. There has been very little research on the likelihood that such adaptation measures would actually be adopted, or on the conditions under which such adaptations might be employed in the agriculture sector (Wall and Smit, 2007). Humankinds limited knowledge on actual adaptation decision making (corroborated by findings from research on innovation adoption and agricultural risk management) indicates, among other things, that (1) there are distinctive (although inter-related) roles in adaptation for individual farm operators, agri-business (industry), and governments; (2) decisions to adopt or modify measures or practices

are rarely made relative to one risk alone, but in light of the mix of conditions and risks (climate, social norms, etc.) that influence decision-making; and (3) decisions to adopt or modify measures or practices are usually made not in a static manner, but in a dynamic, on-going 'trial-by-error' process (Wall and Smit, 2006; Enete and Amusa, 2010; Smit, 2001).

Adaptation in agriculture involves various stakeholders with different, yet often inter-related points of view. In order to evaluate and promote practically the adoption of adaptations such as the development of new crops or irrigation, it is necessary to recognize which players are involved and what their roles are with respect to adaptation. The significant distinctions exist between adaptation options that are employed by private decision makers, including individual producers (farmers), and public decision makers (government and public agencies). However, private and public adaptation options are not necessarily independent of each another, and often have inter-related roles in the adaptation process. While for example, it is the farmer's decision to buy water from irrigation scheme and to invest in the on-farm equipment to irrigate, this option is dependent on some public agency establishing the regional infrastructure and managing the allocation system (Grothmann and Patt, 2005).

Understanding the relationships between adaptation options and the existing processes in place to ameliorate the impacts of climate change is a key component of any evaluation of adaptation options and of analyses of the likelihood of adaptation options actually being implemented. Ultimately, adaptations in agriculture occur via

decisions of producers (to employ a technology, to choose a crop, to change a practice, to alter timing and to modify inputs). These decisions are made in the context of prevailing economic conditions, institutional and regulatory arrangements, and of existing technology, policy, financial systems, and social norms (Wall and Smit, 2006). Adaptation processes are articulated through the institutional and regulatory mechanisms of prevailing agricultural, economic, financial, management, political and technological systems (Wall and Smit, 2007). The mechanisms through which adaptation occurs are widespread and include public research and extension programs, resource management legislation and regulations, agricultural support programs, and economic policies (Mutekwa, 2009). Adaptation options in agriculture are adopted relative to these mechanisms, which have the potential to modify the significance of climate related stresses experienced in agriculture and are important constraints in the farm decision making process (Fusel, 2007).

The connections between adaptation options and existing adaptation processes and mechanisms involve primarily relationships between farm production practices and financial management, and public sector decision making processes. For example, the adoption of irrigation as a farm production practice adaptation may be constrained by the existence of water management regulations such as the legislation of water use rights (Chuku and Okoye, 2006). Investment on research programs promoting resource management innovations may also influence the adoption of farm production practice options through education and incentives. In terms of farm financial management, agricultural support programs and macro-economic policies often influence the adoption of adaptation options. Decisions regarding the

diversification of household income in light of climate change may be influenced by government policies encouraging a general move away from agricultural production in some areas (Lewandrowski and Brazee, 1993; Pollock**,** 2011; Ayers, 2009).

Agricultural decision making with respect to adaptation to climate change is not likely to be considered as separate from other agricultural decisions. At both the farmers and government levels, decisions are made continuously, in an on-going incremental fashion, in light of multiple stimuli and conditions. For example, the decision to diversify farm production or household income is not considered with respect to climate risks alone. Market risks, personal preferences, capital and labour costs associated with changing production or enterprises are likely to overshadow the climatic stimuli for adaptation. Similarly, government decisions regarding irrigation, crop insurance, subsidy and support programs, and resource management are made with respect to various economic, social, environmental and political conditions of which climatic conditions may play a very small role. In identifying and evaluating which adaptations are attractive, considerations must be given to how they relate to on-going decision making processes, constraints, stimuli and decision criteria. Further consideration of the connection between adaptation processes and decision mechanisms is necessary to usefully evaluate options, to fully address the likelihood that adaptation options will be implemented, and to identify the conditions and constraints under which they might be employed (Meehl and Coauthors, 2006; Fussel, 2007; Osbahr *et al.,* 2008).

2.5 Motivation to Respond to Negative Climate Change Impacts

Motivation is seen as important factor in shaping people's response to a perceived risk. Exploring motivation is relevant for understanding reasons for some people to

adopt adaptive practices to address climate risk while other people do not (Grothmann and Patt, 2005). Motivation depends on a complex interplay between an individual or group's value, knowledge, aims, personality traits and the characteristics of a physical and social environment. A person's motivation to adopt climate change adaptive practices such as irrigation, drought resistant crops (e.g. millet and cassava) and type of seeds is guided by goals, value and other personal and social characteristics and is reflected in the reasons they give for taking certain actions. The reasons that people offer in support of their actions represent conscious rationalization of their motivation. Three main factors namely perceived threat, sense of a challenge and attribution of moral responsibility drive people's motivation at individual level. These elements can be used in understanding what generates the motivations to address climate change impacts at farm level (Fussel, 2007).

Climate change adaptation motivation is closely influenced by factors like perception of risk, causal knowledge, augments about causes and the perceived consequences of a particular risk in agriculture within the light of climate change. For example, drought is typical seen as being caused by a natural event which lies outside human moral responsibility. However, climate change may generate more sense of social and moral responsibility to respond if people attribute its cause to anthropogenic greenhouse gases emission (Grothmann and Patt, 2005).

In some cases, climate change adaptation measures adoption motivation arises from emergence of new challenges. This may be the case if people are thinking positively or trust is placed in innovative management strategies in contrast to being anxious

about the future. Such perception is usually influenced by person's characteristics as well as situation at hand. An entrepreneurial farmer who, for example, believes that problems can be managed if one plans well, may see drought as an opportunity rather than threats (Deressa *et al.*, 2009).

Motivation can also be driven by sense of the consequences of a risk (sense of threat). If one perceives threat to farming viability, one may be motivated to take action. A sense of threat may also be placed on effects on some valued elements like a particular vulnerable group in society or the environment. Which driver generates more motivation will depend upon what is valued as well as other factors as introduced above such as casual knowledge or the potential consequences of the risk. In reality, motivation to act may arise from any or combination of these three sources of motivation (Grothmann and Patt, 2005).

2.6 Types of Adaptation Options in Agriculture

This section identifies types of agricultural adaptation options to climate change. These agricultural adaptation options are grouped according to two main categories that are not mutually exclusive: (1) government programs and insurance (2) and farm financial management. The typology is based on the scale at which adaptations are undertaken and at which the stakeholders are involved.

2.6.1 Government programs and insurance

Government programs and insurance are institutional responses to the economic risks associated with climate change and have the potential to influence farm level risk management strategies to increase farm production. These include government

agricultural subsidy and support (to decrease the risk of climate-related income loss, and spread exposure to climate-related risks publicly); private insurance (to decrease the risk of climate related income loss, and spread exposure to climate-related risks privately); and resource management programs (to influence resource management in light of changing climate conditions).

Agricultural subsidy and support programs involve modifications to investment in established government programs to deal with climate change negative impacts. These programs can provide compensation for disaster related income loss independent of the support provided by established crop insurance, income stabilization and farm production subsidy, support and incentive programs (Schmitz *et al.*, 1994; Smit, 1994; Challinor *et al.*, 2010). All of these programs greatly influence farm level production and management strategies by transferring risk in agriculture within the light of climate change (Mupenzi *et al.*, 2011). Modifications to the terms of reference for crop insurance or other farm production subsidies, supports and incentives have the potential to encourage or discourage changes in farm level production and management by spreading exposure to climate-related risks (Ye and Yeh, 2009; Wang *et al.*, 1998; Turvey, 2000). Changes to government investment in income stabilization and disaster relief have the potential to alter the funds available to farmers to reduce the risk of income loss as a result of increased incidence, severity and duration of droughts, floods and other climate related events (Romain and Calkins, 2008; Changnon *et al.*, 2007; Love *et al.*, 1997). The success of agricultural subsidy and support programs has been difficult to determine as

government programs seldom address climate related risks independently of other risks to agriculture (Bradshaw *et al.*, 2001).

The development of private insurance represents an adaptation to climate related risks that is primarily the responsibility of the financial services sector, which, in turn, is usually influenced by government programs. This involves the development of insurance schemes by private companies to address crop and property damage from such climate-related hazards as droughts, floods and other climate-related events. This type of adaptation has the potential to reduce vulnerability at the farm level among poor smallholder farmers who depend on rain-fed agriculture (Agahi and Bahrami, 2008). Resource management programs involve the development of government policies and programs that encourage or discourage changes in land use, water use and management practices. This type of adaptation includes the development of land use regulations and best management practices (Mendelsohn and Ariel, 2009). These policy instruments of governments represent adaptations at an aggregate scale and also influence farm-level adaptation decision making among smallholder farmers in light of climate change.

2.6.2 Farm financial management

Farm financial adaptation options are farm level responses using farm income strategies (both government supported and private) to reduce the risk of climate related income loss. Government agricultural support and incentive programs greatly influence farm financial management decisions. Farm financial adaptations involve decisions with respect to crop insurance, crop shares and futures, income

stabilization programs, and household income. Crop insurance reduces income loss as a result of reduced crop yields from droughts, floods and other climate-related events, and in the case of subsidized programs spreads exposure to climate related risks publicly (Smit 1994; Chuku and Okoye, 2009). Purchasing insurance entails financial decision making aimed at stabilizing income from crop production in light of climate change risks. This type of adaptation includes participation in established village and hamlets subsidized crop insurance programs (Turvey, 2000). At the sector scale, publicly supported crop insurance and disaster relief programs represent an important type of adaptation in countries like Tanzania.

Investment in crop shares and futures has also been proposed to spread exposure to climate-related risks and reduce vulnerability to income loss (Mahul and Vermersch, 2000). This adaptation option involves the use of securities, shares and other financial options developed by government and industry, including banks, as an alternative financial management strategy to crop insurance (Turvey, 2000; Smit and Windel, 2006; Chiotti *et al.*, 1997).

2.7 Climate Change Adaptation Characteristics

There is a huge number and variety of measures or actions that could be undertaken in agriculture to adapt to climate change. There also exist numerous characteristics by which adaptations can be distinguished, and which could serve as bases for a typology of agricultural adaptations. Among the distinguishing characteristics of adaptation are farm management and technology, adaptation on-farm management, adapting new plant varieties, and changed attitudes about weather forecasts, intent

and purposefulness, timing and duration, scale and responsibility, and form (Reilly and Schimmelpfennig, 2000).

2.7.1 Farm management and technology

Changes in farm management include a wide range of adjustments in land use and livelihood strategies that go beyond the usual agricultural practices available for coping with constantly varying biophysical and socioeconomic conditions. In the face of increasing climate variability and gradual changes in average climatic conditions, farmer may reassess the crop and varieties they grow, and they may consider shifting from farming to raising livestock. They may also introduce different livestock breeds that are more resistant to drought. Change in technology includes, for example, the development of new drought resistance crops varieties or improved climate information systems among smallholder farmers (Doppler *et al.*, 2000).

Kurukulasuriya and Mendelsohn (2006) show that crop selection among African farmers vary significantly in cooler, moderately warm, and hot regions. The farmers select sorghum and maize-millet in the cooler regions of Africa, maize-beans, maize-groundnuts, and maize in moderately warm regions; and cowpea, cowpea-sorghum, and millet-groundnuts in hot regions. However, Thomas *et al.* (2007) states that during dry spells farmers tend to reduce their investment in crops or even stop planting and focus on livestock management. Climate change scenarios predict an increase in climate variability in many parts of Africa including Tanzania, which will compel farmers to turn into temporary coping strategies and finally into climate change adaptation, Access to land that gives good yields during times of drought and

irrigation practice also play important role to farmers who depend on rain-fed agriculture. Further, improved crop varieties have considerable potential for strengthening the adaptive capacity for farmers (Janssen, 2007).

2.7.2 Adoption of weather forecasts

Understanding of seasonal rainfall forecasts is very important to farmers, because many farmers think of rainfall as a process rather than in terms of quality, as scientists do. Roncoli *et al.* (2005) argue that farmers will not accept forecasts, unless they are adjusted to their understandings. However, Grothmann and Patt (2005) revealed that farmers' acceptance of seasonal climate forecasts increased when they can be provided a part of local indigenous climate forecasts. Farmers are more likely to adopt external climate forecasts when they can see them in the context of existing practice.

A fundamental factor in farmers' willingness to take up climate forecasts is their appraisal of risk (Janssen, 2007). Grothmann and Patt (2005) observed a link between risk appraisal and farmers' willingness to acceptance and use forecasts. On a conceptual level scholars further developed the socio-cognitive Model of Private Proactive Adaptation to Climate Change in order to address psychological factors that make farmers adapt to climate change. Their model is based on protection motivation theory, which developed in the context of health threats. Both models focus on two major perceptual processes. In risk appraisal, a person assesses the probability that the worst will come to pass and damage potential things the person values. In appraising adaptation, the person judges his or her ability to avert harm from the threat and considers the costs of taking a certain action.

2.7.3 Intent and purposefulness

Intent and purposefulness are undertaken spontaneously, or autonomously, as a regular part of on-going farm management from those that are consciously and specifically planned in light of a climate change related risks (Enete and Amusa, 2010; Mupenzi *et al.,* 2011). Within socio-economic systems, public sector adaptations are usually consciously planned strategies, such as investments in government programs to adopt climate change adaptation measures among farmers, but private sector and individual adaptations can be autonomously planned or a combination of the two.

2.7.4 Time and duration target on crops planting

Time target and type of crops are among appropriate climate change techniques since a producer who has experienced several droughts for many years, and expects drought frequency to remain similar or increase in the future, may adjust certain crops production practices to manage drought risks. However, duration of adaptation distinguishes responses according to the time frame over which they apply, such as tactical (shorter-term) versus strategic (longer-term). In agriculture, tactical adaptations might include adjustments made within a season, which involves dealing with a climatic condition, such as drought, in the short term. Tactical adaptations might include selling of livestock, purchasing feed, plowing down a crop or taking out a bank loan. Strategic adaptations refer to structural changes in the farm operation or changes in enterprises or management that would apply for a subsequent season, or a longer term. Thus, strategic adaptations might include

changes in land use, enterprise mix, crop type or use of insurance (Patt and Gwata, 2002).

2.7.5 Scale and responsibility

Adaptations can be distinguished according to the scale at which they occur and the agent responsible for their development and employment. In agriculture, adaptations occur at a variety of spatial scales, including plant, plot, field, farm, region etc. At the same time, responsibility can be differentiated among the various actors that undertake or facilitate adaptations in agriculture including individual producers (farmers), agri-business (private industries), and governments (public agencies) (Mupenzi *et al.,* 2011). However, most discussions of adaptation do not distinguish the roles of different decision makers. For example, a commonly espoused adaptation in agriculture is the use of crop development for changed climatic conditions. Such an adaptation would likely involve government agencies (encouraging this focus in breeding research), corporations (developing and marketing new crop varieties), and also farmer (selecting and growing new crops). Any realistic assessment of adaptation options needs to systematically consider the roles of the various stakeholders.

2.7.6 Form

Adaptation in agriculture occurs via a variety of processes and can take many different forms at any given scale or with respect to any given stakeholder. Distinctions among adaptations based on form have been suggested by, among

others, Ford *et al.*, (2010), Carter *et al.* (1994) and Challinor *et al.*, (2010). These studies consider adaptations according to their administrative, financial, institutional, legal, managerial, organizational, political, practical, structural, and technological characteristics. For example, Wall and Smit (2006) identify forms of adaptation at the farm level, including modification of resource management, purchasing crop insurance, and diversification. The scholars also identify different forms of policy level adaptations including aid for research and development, incentive strategies and infrastructure measures. Differentiating responses to climate change according to form provides a useful framework for understanding adaptation in agriculture.

2.8 *Methods of Adaptation*

This sub-section intends to discuss several adaptation methods which can be used by smallholder farmers to minimize the degree of risk caused by climate change in the agricultural production. Adaptation methods discussed in this sub-section are agricultural production, drought tolerant crops varieties and irrigation (Van Herk, 2001).

2.8.1 Agriculture production

A significant effect of global climate change is the altering of global rainfall patterns, with certain effects on agriculture. Extended drought can cause the failure of small and marginal farms with resultant economic, political and social disruption. However, such events have previously occurred in human history independent of global climate change. In recent decades, global trade has created distribution

networks capable of delivering surplus food to where it is needed, thus reducing local impact (Janssen, 2007).

2.8.2 Drought tolerant crops

The development of new crop varieties including types, cultivars and hybrids, has the potential to provide crop choices better suited to temperature, moisture and other conditions associated with climate change. This involves the development of plant varieties that are more tolerant to such climatic conditions as heat or drought through conventional breeding, cloning and genetic engineering. On the other hand, van Herk (2001) has noted that not only is climatic variability not a target for crop breeding (although it could be), but also that an anomalous climatic season (e.g. drought) is seen as an inconvenience in field testing, with its results discarded, rather than as an opportunity to develop and retain the robustness features of the crop variety that does well under such anomalous conditions. Furthermore, there already exist a very wide range of crops and varieties, with differing climatic requirements, yet farmers still have to make management choices when selecting among these with only probabilistic knowledge of the growing season conditions (Smit *et al.*, 1996; Janssen, 2007).

2.8.3 Irrigation

The development of technological innovations in water resource management has the potential to address climate-related stimuli. Broad scale water resource management innovations address the risk of water (moisture) deficiencies or surpluses associated with shifting precipitation patterns and the probability of more

frequent floods and/or droughts (Thomas *et al.*, 2007). At a regional scale, involving public agencies, these innovations include the development or modification of irrigation systems, water transfers, water diversions, and desalinization technologies (Chuku and Okoye, 2009). Farm level resource management innovations have also been proposed. These adaptations include mechanical innovations such as the development of integrated drainage systems, land contouring, reservoirs and recharge areas, and alternative tillage systems (Spaling, 1995). Water resource management innovations assume adequate supplies of water and are often constrained by prevailing economic and institutional arrangements. The lead actors for developing technological adaptations are generally governments and agri-business whereas the employment or adoption of these technologies is a farm-level decision. The scholar further notes that when acknowledging that research will yield many new technologies for expanding food production while preserving land, water and genetic diversity, the real trick will be getting farmers to use them.

2.9 Climate Change Adaptation among Smallholder Farmers

Adaptive capacity and vulnerability are important concepts for understanding adaptation. Vulnerability can be seen as the context in which adaptation takes place, and adaptive capacity is the ability or potential of a system to respond successfully to climate variability, in order to reduce adverse impacts and take advantage of new opportunities. Farmers that can respond to climate change quickly have a high adaptive capacity than those who are not. It is important to note however, that high adaptive capacity does not necessarily translate into successful adaptation (Rivington *et al.*, 2005).

Adaptive capacity is driven by factors operating at many different interlinked scales, and it is important to understand the ways in which the different drivers of adaptive capacity interact for the purpose of increase farm production. The social drivers of adaptive capacity are varied but may include broad structures such as economic and political processes, as well as those which operate at a very local scale, such as access to decision making and the structure of social networks and relationships within a community. Adaptive capacity at a local scale is constrained by broader scale processes, for example, a farmer's adaptive capacity will not only depend on access to resources such as physical and social within the community but also knowledge which allow a crop to be grown successfully (Spaling, 1995).

It is clear from the literature (Khalif, 2008) that people have always adapted to a changing climate and that coping strategies already exist in many communities, for example changing sowing times or adopting new water saving techniques. Traditional knowledge and coping strategies must be maintained and strengthened, otherwise adaptive capacity may be weakened as local knowledge of the environment is lost. Strengthening these indigenous techniques and building upon them also makes it more likely that adaptation strategies will be adopted, as it creates more community ownership and involvement in the process. In some cases however, traditional knowledge will not be enough to adapt to new conditions which are outside the range of those previously experienced, and new techniques will be needed.

2.10 The role of Social Construction to Climate Change Adaptation

The social construction of adaptive capacity is very important when thinking about the risks and impacts of a changing climate. It is not just the change in climate which will affect vulnerability and livelihoods, but also the way that these changes are negotiated through complex social systems. A 10% decrease in rainfall may be tolerable and manageable to members of a community who have access to improved agricultural techniques, or whose livelihoods are in some way diversified, whereas marginalized members of the community may not be able to cope with these changes. Adaptation can be seen as a social and institutional process that involves reflecting on and responding to current trends and projected changes in climate (Rivington *et al.*, 2005).

2.11 Conclusion

This chapter describes the negative impacts of climate change (inconsistent rainfall, floods and drought) among smallholder farmers' in relation to agricultural productivity. The chapter has further; analyze how agricultural production can be decline and threaten households' livelihoods and food security. It also shows different climate change adaptation measures such as improved seeds, various drought resistant crops (millet, cassava, etc) and river which can be used as a source of agriculture irrigation practice by smallholder farmers' to increase agricultural production in light of climate change. While information on smallholder farmers are well documented, little empirical evidence is known on measures taken by smallholder farmers to minimize the negative impacts (unpredictable rainfall, drought and floods) of climate change on farm productivity. Therefore this study

intends to assess climate change adaptation measures adopted by smallholder farmers in Mvomero District.

CHAPTER THREE

3.0 RESEARCH METHODOLOGY

3.1 Introduction

This chapter presents a short description of Mvomero District, the study area. It highlights on its location, climatic conditions, relief features, human population, economic activities, and provides a justification for selecting this study area. The research design and sampling as well as sample size are also given. Additionally, data collection methodology is highlighted and the methods, instruments and tools used under this methodology are revealed. This entails the use of a combination of methods for complementing and confirming the data collected using individual methods. Methods for analyzing the collected data are ultimately covered in this chapter.

3.2 The Study Area

3.2.1 Location of the study area

As introduced above, this study was carried out in Mvomero District which was formerly a part of Morogoro District. Mvomero district is among the six councils of Morogoro Region. This district is located in the North-east of Morogoro Region between 5º 58′ and 10º 0′ latitudes south of equator and between longitudes 35º 25′ and 35º 58′ to the east of the Greenwich Meridian. The District has the total area of 7325 square kilometers and its boundaries are as follows: to the north is Handeni District, to the east is Bagamoyo District, to the south is Morogoro Municipal and Morogoro District, and to the west there is Kilosa District (URT, 2003).

3.2.2 Climatic conditions and relief features

The district has temperatures ranging from 18°C to 30°C and rainfall varies from 600 mm to 1000 mm per year. The area experiences bi-modal rainfall pattern. Long rains are experienced from March to the end of May while short rains occur from October to December. The dry seasons are from June to August and January to March. The land is generally plain surrounded by the Nguru Mountains. The district is characterized by different types of soil namely sandy, clay, and loamy soil which is unevenly/sparsely distributed (URT, 2005).

3.2.3 Human population and economic activities

Mvomero District has total population of 260 525 people of whom 131 159 are male and 129 376 are female. According to the Tanzanian Population Census of 2002, the population density in this district is 31 people per square kilometer (URT, 2003). The estimated per capital income of the people of Mvomero in 2001 was about Tshs 182 500 per year. Climatic condition is conducive for human settlement and agriculture. URT (2005) reported that more than 85% of the population in this district is engaged in agriculture, producing maize, beans, cassava, sugarcane, rice, fruits and sunflower. The majority of farmers depend on livestock keeping and subsistence crops production and most of the farming activities are done manually for which human labour accounts for 64%, tractor 35%, and Ox-cultivation 1%. The main tribes are the Luguru, Kutu, Kwere, Maasai, Zigua, Gogo and Sukuma**.**

3.2.4 Justification for selection of the study area

The study area was chosen based on the fact that, it is among the areas in Tanzania which are highly affected by climate change. The area frequently faces drought and

floods which affect the production of crops such as maize and rice which are among the main crops grown in the area. As a result, a decrease in farm productivity threatens people's life and makes them more vulnerable to food insecurity. While the majority (85%) of inhabitants in the study area depends on agricultural production, they are financially incapable to invest in irrigation infrastructures and therefore 82% of the respondents depend solely on rain-fed agriculture.

3.3 Research Design

A cross-sectional research design was used in this study. According to Bailey (1998) this design allows data to be collected at a single point in time since it employs a survey method and can be used for descriptive studies as well as for determination of relationships between variables. The limited time for fieldwork justifies the use of the selected design.

3.4 Sampling and Sample Size

A multi-stage sampling was employed in which one division (Mvomero), one ward (Mvomero) and two villages (Wami-dakawa and Luhindo) were randomly selected from village registry book. In keeping with Grinnel (2001), 10% of household were interviewed of which 64 were male while 36 were female headed. As such, 100 households were involved in the household survey. The selection criteria for this population were purposive that is, smallholder farmers who depend on rain-fed agriculture were the target. Also, 20 key informants including village extension officers and village leaders were interviewed for administrative and technical issues regarding climate change adaptations.

3.5 Data Collection

3.5.1 Primary Data

Primary data for this study were collected using a structured questionnaire with both close and open-ended questions. Using this tool, variable such as age, sex, education, occupation, and experience of households were collected. The principal focus of data collection was household heads but other members in the household complimented the information given by household heads. Other information on climate change adaptation was collected using focus group discussion (FGD) and observation. Also, checklist of questions was administered to village leaders and extension officers as key informants. Besides questionnaire, focus group discussion, observation and checklist of questions as formal interview arrangements, informal talks were used to confirm and complement information collected using questionnaire and interview methods. These talks were useful in generating more information which could not be obtained during formal discussions, possibly because the respondents regarded the talks as causal. In some cases, when respondents are formally questioned, they tend to give answers which sieve information they think lead them to a risk in one way or another. As such, data collection exercise required some flexibility. For some households, the members of the households were busy with farm operations during data collection exercise and therefore it was obliged to interview these respondents while working in their farms.

3.2.2 Secondary data

Secondary data were obtained from published and unpublished documents including books, Journals, National Library, Sokoine National Agricultural Library (SNAL)

and relevant documents from Mvomero District office. Also, internet was used for collecting data under this category.

3.6 Data processing and Analysis

After being collected, the data were coded and summarized. Then, the process of data entry into a computer was undertaken. Quantitative data were analyzed using the Statistical Package for Social Sciences (SPSS) computer software; using this tool descriptive statistics including frequencies, percentages and means were calculated. Qualitative data collected from village leaders and extension officers were analyzed using content analytical procedures. Using this method, qualitative information was categorized into meaningful units and themes in line with the objectives of the study.

3.7 Limitation of the Study

During data collection, the study encountered a number of limitations which in one way or another have affected the accomplishment of scheduled tasks. The following are some of the problems encountered:

i. Some respondents were interviewed while working. This was considered as the problem to this research due to the fact that it reduced the possibility of getting more clarification from respondents. Therefore researcher decided to participate in their work so as to get information required.

ii. Some respondents were reluctant to give answers during questionnaire administration and/or escaped from interviews. Therefore researcher conducted focused group discussion and informal talks to get more information.

iii. Some areas where respondents resided were far from the center of the village. Therefore, the researcher had to walk long distances to collect information from such distant residences. Yet, in other areas the study households were scattered, and therefore the researcher had to spend a lot of time to collect data from these households.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Introduction

This chapter presents and discusses the findings of the study. Section 4.2 analyzes the relationship between household characteristics and adoption of climate change adaptation measures. Section 4.3 describes the awareness on climate change adaptation, for the aim of gaining insights on whether smallholder farmers are aware about climate change adaptation measures or not. Section 4.4 investigates adaptation techniques adopted by smallholder farmers at farm level in light of climate change and variability.

4.2 Relationship between Household Characteristics and Climate Change Adaptation Measures

4.2.1 Age

The findings from this study show that the average age of respondents was 41 years and age of respondents ranged from 20-71 years, with the majority being in age group 20-40 years (49.2%) and age group 41-60 years (48.3%). Few respondents were above 61 years (2.5%) (Table 1). The focus group discussions showed that older farmers aged between 41 and above 61 years (50.8%) were able to take risk (for instance, investing more financial and human resources in farming activities) associated with new technologies to adapt to climate change impacts. As such, older age group was more empowered to find appropriate measures against climate change impacts compared to the young age (49.2%). This is because, older farmers have more resources like livestock, permanent crops, land and labour that offer them the

capability to relatively afford labour and capital-intensive technologies to increase farm production in light of climate change. These findings are in agreement with those presented by Shiferaw and Holder (1998) who found that older people above 45 years had more experiences on climate change that enable them to access improved technologies such as drought resistant crops (e.g. millet), irrigation infrastructures and to undertake off-farm activities to face climate change impacts on agricultural production.

Table 1: Average age (Years) and distribution of heads of households by age group

Age group	Frequency	Percent
20 - 40	59	49.1
41 - 60	58	48.1
> 61	3	2.5

4.2.2 Gender

The selected total sample size for the study comprised of 100 respondent households. The results in Table 2 show that 53.3% male headed and 46.7% female headed households were interviewed. This implies that many studied households were headed by men. According to Narayan (2001) conventionally in African families' men are household heads and therefore controllers of households' economy. However, generally the results indicate that a significant number of households were headed by women. The reason for this was that some men who are heads of their households were not at home during data collection while other women were widows and/or divorced. This study learnt that many interviewed women (46.7%) in the study area were engaged in some agricultural innovations related to climate change adaptation, including water harvesting in their farm plots

and mulching. However, observation from study shows that women were quick to respond to questions and preferred to ask the researcher about appropriate practices to adapt to climate change at farm level. Furthermore, women were more interested in knowing new climate change techniques than men. Commenting on the role of female farmers in agricultural production, Swanson *et al.* (1984) assert that although women make a major contribution to world food production, they seldom benefit from agricultural extension services. These scholars asserted further that most extension meetings and demonstrations are scheduled for the convenience of men at times and places that are inconvenient to women. Lionberger and Guin (1991) observed that because of personal and life style characteristics, women seem to prefer communication strategies on climate change adaptation that provide for group participation than men.

Table 2: Gender of the respondents

Gender	Frequency	Percentage
Male	64	53.3
Female	56	46.7

4.2.3 Education

The research findings in Table 3 show that the majority (74.2%) of the studied smallholder farmers had formal primary education and few (19.8%) had not attained any formal education while a smaller number (6%) attained secondary education. These findings imply that most of smallholder farmers in the study area are more vulnerable to climate change because of low formal knowledge important for improving agricultural production in light of climate change constraints. Smallholder farmers who participated in focus group discussion revealed that lack of

enough formal education is among the constraints on climate change adaptation. Smallholder farmers further recommended that education on climate change adaptation should be provided from primary to high learning institutions. Saito (1994) reported that formal agricultural knowledge contributes 50% of the variation in total agricultural output due to the fact that the knowledgeable households can find appropriate ways for climate change adaptation. The more the farmers are educated about climate change the more their knowledge increases on climate change adaptation measures. Anandajayasekeram *et al.* (1996) also emphasizes that education may make a farmer more perceptive to an advice provided by an extension agency or more able to deal with technical recommendations that require certain level of literacy to cope against climate change in crop farming. Instead of developing negative attitudes towards new innovations on climate change adaptation, educated farmers will apply rational criteria in the choice of technologies. These scholars further argued that farmers with better education are early adopters of modern technologies and apply inputs more efficiently throughout the adaptation process such as irrigation and use of seeds which are drought resistant. The more complex the technology, the scholars contend, the more likely education will play a key role in enhancing the adoption of that technology to increase farm production. Farmers with low education have limited capacity to find techniques to adapt to climate change because of limited knowledge on climate change adaptation.

Table 3: Education of the head of households in terms of years spent in school

Years spent in of school	Frequency	Percent
< 1	20	19.8
1- 8	93	74.2
9- 12	7	6.0

4.2.4 Occupation

Main occupation of the respondent provides an explanation on the type of labour force availability in a given locality. The findings presented in Table 4 show that the majority (70%) were peasants, while one-sixth (16.7%) were engaged in casual activities such as selling of local brew, tailoring, tree planting programs, welding, security guard, day workers in large scale farms, and burning charcoal. Smaller numbers of respondents were pastoralists (6.7%) and engaged in business (6.7%). Like in many other rural areas in developing countries, farming is the main occupation of people in the study areas. The study learnt that majority (70%) of smallholder farmers still depend on farm activities which make more vulnerable to climate change, instead of adopting off farm activities such as business and keeping drought resistant animals like goats and sheep.

Table 4: Main occupation of respondents

Main activity of the respondent	Frequency	Percent
Peasants	84	70.0
Business person	8	6.7
Pastoralists	8	6.7
Other activities	20	16.6

These findings are contrary to those reported by Pouliotte *et al.,* (2009) as cited by Khalif (2008) which showed that increase in drought and rainfall variability made farmers switch from crop cultivation to livestock keeping of especially drought resistant animals such as goats and sheep. However, based on the findings from this study, training should be given to smallholder farmers so as to enhance their power to engage in off-farm activities to reduce the degree of vulnerability and poverty at household level as from field observation from this study currently knowledge on off-farm activities is low.

4.2.5 Duration of living in the study area

The results in Table 5 show that the average period (years) of respondents' stay in the study area was 23.7 years. While about a third (30%) of respondents has lived in the study area for a more than 30 years, another significant number of respondents (29.2%) have lived in the study area for less than 10 years. This implies that farmers who lived in the study area for many years (>20 years) have acquired more experience than those who have lived in this area for a few years (< 10 years). The focus group discussions have found that experience of the household members is an important factor since such experience contributes to the adoption of new technology at household level in light of climate change. The longer the members of household live in particular area, the more experience they gain about impacts of

climate change and hence they can apply this experience to make decision on how to increase farm production in light of climate change than those who have lived in the area for few years. Living for many years in the study area enables smallholder farmers to have accumulated knowledge about climate change and enhance their knowledge in finding appropriate techniques to deal with negative climate change impacts in agricultural production. These findings are similar with those presented by Roncoli *et al*. (2006) and Roncoli *et al*. (2004, 2005) who found that cognitive factor such as experience, influence farmers' perception of the probability of occurrence of climate events and application of climate forecasts. It can be generally be concluded in this study that people who have lived in the study area for many years have more experiences on climate variability which they use as input to develop appropriate techniques and strategies for mitigating negative climate change impacts.

Table 5: Duration of living in the study area

Experience category	Frequency	Percent
< 10	35	29.2
11- 20	31	25.8
21- 30	18	15.0
> 30	36	30.0

4.2.6 Land size

Land size is the one of the important factors influencing agricultural production especially in light of climate change and variability. Access to land as a means of production is a key to ensuring food security at the household level. Adequate land size may enable the farmer to produce sufficiently for food security and selling the surplus to get an income. Farm plot owned by respondents in the study area ranged

from 0.5 to 31 acres. The findings in Table 6 show that the majority of the respondents (78.4%) own farms of less than 5 acres, while some (16.7%) own between 6-10 acres and a smaller number of respondents (2.5%) own between 11-20 acres and more than 21 acres farming land (2.5%). In terms of harvest, smallholder farmers harvested average of 10 bags (rice) per acre; the harvests increased as the size of land increased. The majority of smallholder farmers own small pieces of land and these owners are more vulnerable to climate change compared to those who own large farm plots. During the drought, crops are affected to large extent leading to decreased farm production especially for those who own small farm plots. As such, the degree of vulnerability differs between small and large farm plot owners.

Table 6: The size of farm plots owned by respondents

Farm size category	Frequency	Percent
< 5	94	78.4
6- 10	20	16.6
11- 20	3	2.5
> 21	3	2.5

4.2.7 Farm labour

Agriculture involves a lot of activities including farm preparation, sowing seeds, managing planted crops and harvesting. Therefore, the organization of household labour is an important factor that affects potential harvests to be obtained. Results in Table 7 show that majority of the respondents (56.4%) used their own household labour in farming activities while others (22.8%) used both household and hired labour, and hired labour only (20.8%). Observation from the study area showed that, farm labour has direct link with the adoption of climate change adaptation measures since households with abundant own household and hired labour have more power

to adapt to climate change than those with less labour. The amount of labour can determine the farm size and farm operations efficiency which is among the measures to adapt to climate change. Farmers with adequate labour are likely to cultivate large land and hence produce more than households with limited labour. These findings are similar with those presented by Lin *et al.*, (2008*)* in his analysis of socio-economic aspects of small scale irrigation in Ethiopia. According to this scholar, labour power of the individual household often limits the size of the land that can be cultivated. The scholar asserted further that, labour size positively influence the adoptation climate change adaptation measures. As such, large sizes with more labour supply are expected to adopt labour intensive technologies. On the other side, nonetheless, large household size is likely to face lower per capital land availability and high dependency ratios for food requirements. To cope with this limitation, all the available land can be put to constant cultivation rather than practicing fallow.

Table 7 Distribution of the respondents according to source of farm labour

Source of labour	Frequency	Percent
Family labour	68	56.4
Hired laour	25	20.8
Family and hired labour	27	22.8

4.3 Awareness on Climate Change and Climate Change Adaptation

4.3.1 Awareness on climate change adaptation measures

The results in Table 8 show the awareness of the respondents on climate change adaptation in the study area. More than a third (39.2%) of the respondents are aware about climate change adaptation measures while most (60.8%) had no such knowledge. Table 9 shows that most (60.0%) of the respondents in study area had not heard about any information on climate change adaptation techniques, while

some (15.0%) became aware on climate change adaptation through media which include radios, televisions and newspapers. Yet, some respondents have become aware on climate change adaptation through village meetings (10.0%), from the street talks (9.2%), through their own experiences and political leaders (5.8%). Since majority (60.8%) of the respondents are not aware on climate change adaptation measures as shown in Table 8, this implies that there is poor farmer to farmer communication which hinders the spread of climate change adaptation measures. Awareness on adaptation measures is important for enhancing farmers' adaptive capacity to climate change and to improve their agricultural production. This awareness can be channeled through radio, television, village meetings and seminars.

These findings are similar with those presented by Siedenburg (2008) who observed that many farmers in developing countries including Tanzania are not aware on climate change adaptation techniques at macro and micro level. This scholar contended that knowledge on climate change adaptation can play a very important role to smallholder farmers. A farmer who knows what to do in light of climate change can find appropriate climate change adaptation measures to increase farm production through the application of different techniques. Siedenburg further asserted that adaptation to climate change through awareness management practices such as practical training of farmers and agricultural extension officers are very important for climate change adaptation. Practices that can be employed at micro level include the use of decision support systems and weather forecasts, wild plants and animals as bellwethers of ecosystem variability or change (Siedenburg, 2008)).

Table 8: Awareness on climate change adaptation

Climate change adaptation	Frequency	Percent
Have awareness	47	39.2
Lack awareness	73	60.8

Table 9: Source of information on climate change adaptation

Source	Frequency	Percent
Never heard	72	60.0
Media	18	15.0
Street	11	9.2
Village meetings	12	10.0
Other	7	5.8

4.4 Adaptation Techniques Adopted at Farm Level

Climate change adaptation measures are important to smallholder farmers especially in increasing farm productivity after the drought or flood has stricken household livelihoods. In the study area, change of crop types, use of drought resistant seeds and irrigation were used as climate change adaptation measures among smallholder farmers. In this section, these adaptive measures are analyzed.

4.4.1 Type of crop

The findings in Table 10 show that about half (48.3%) of respondents in study area grow rice, another significant number of respondents (45.8%) grow maize while a small number of respondents grow millet (4.5%) and other crops including cassava and sunflowers (1.7%). Fewer smallholder farmers grew drought resistance crops because they did not have enough knowledge on crops such as millet, sorghum and cassava as appropriate crops in light of climate change. These arguments can be substantiated by the fact that many households keep on growing crops such as maize and rice which are vulnerable to climate change, instead of drought resistant crops including millet, sorghum and cassava.

Table 10 Main crops grown in the study area

Crop	Frequency	Percent
Millet	5	4.2
Maize	55	45.8
Rice	58	48.3
Other	2	1.7

Kurukulasuriya and Mendelsohn (2006) attribute the poor crops selection among the farmers to the lack of awareness. These scholars suggested that crop selection among farmers is important in the light of rainfall variability and unpredictability, because drought resistant crops such as sorghum, millet and cassava are better than planting crops such as maize and rice which cannot resist drought. Such wrong choice increases vulnerability of smallholder farmers who solely depend on rain-fed agriculture to climate change.

4.4.2 Source of water for agriculture

The evidence in Table 11 shows that the majority (82.5%) of households depend on rain-fed agriculture while fewer households depend on both rain-fed and irrigation farming (9.2%) and solely on irrigation farming (8.3%). This over-dependence on rain-fed agriculture among smallholder farmers led to the decline of farm productivity in light of climate change. The study through focus group discussions revealed that although there are farmers who are near rivers, irrigation farming practice is limited. While, smallholder farmers are willing to adopt irrigation agriculture this willingness can be operationalized if they can get access to credits which will enable them to buy water pump machines and improve water drainage systems to ensure reliable water availability instead of largely depending on the

unpredictable rainfall. Currently irrigation seems to be very expensive for poor smallholder farmers to afford. It was observed that smallholder farmers who practice irrigation farming depend on water from National Agriculture and Food Cooperation (NAFCO) (*"maplotini"*) where they pay Tsh 50 000 per season to enable distribution of water in their rice farm plots. Yet, competition for water in the study area has resulted into conflicts. Smallholder farmers blamed village leaders for being corrupt by allocating plots where irrigated farming can be practiced to non-residents, despite the fact that one of the criteria for accessing these plots is residency to this area. Findings from this study are similar with those presented by Makundi (1996) who stated that many farmers in Tanzania depend on rain-fed agriculture which makes them more vulnerable to climate change (drought), weather changes, especially uneven distribution of rainfall and hence these farmers attain low agricultural production. Over-dependence on rains has been a major constraint to higher production. While some farmers may have farms close to rivers, there is very limited application of irrigated agriculture due to lack of enough knowledge and/or capital (World Bank, 1996). Through irrigation, farmers can be assured of maximum and consistent production throughout the year. Irrigation minimizes the degree of climate change vulnerability due to the fact that irrigation is among the best solution for mitigating negative impacts of climate change on agricultural production. Farmers need to be advised and empowered to use irrigation in their agricultural activities in light of climate change because high dependence on rainfall which is both unreliable and inconsistent is too risk to their livelihoods (Vogel, 2007).

Table 11: Source of water for agriculture

Water	Frequency	Percent

Rainfall	99	82.5
Irrigation	10	8.3
Rainfall an irrigation	11	9.2

4.4.3 Type of seeds

The findings from this study as presented in Table 12 show that the majority (75.8%) of farmers who were interviewed used locally available maize and rice seeds. While local maize varieties could not be named, local rice varieties included *shingo ya mwali, mbawa mbili, supa ya kawaida and kahogo* from farmers' own handling while some farmers used improved rice seeds, named *supa ya shinyanga and saro* (13.3%) from local available shops (Agro-vet). The improved seeds take very short time to mature. Others farmers (10.8%) used both improved and local seeds.

The majority of the respondents used locally available seeds because of financial incapacity, lack awareness on the improved seeds and availability of those seeds. For example, 2 kg of improved maize seeds was sold at Tsh 7000; Smallholder farmers who own 1 acre should have at least 10kg of maize seeds which is too expensive for farmers to afford. Therefore, financial credits and awareness seminars are imperative to local people to enhance their power of accessing and understanding on appropriate and quality seeds so as to ensure they make appropriate choices on this aspect.

Improved and short term seeds are important especially during drought. Makundi (1996) observed that improved seeds are a critical requirement in any modern agriculture. According to this scholar, about 80% of Tanzanian farmers do not plant improved and certified seeds but rely on their own local cultivars. The scholar

further contended that the problem of planting local cultivars by the majority of the farmers is caused by unavailability of improved and certified seeds due to low supplies, which relate to poor funding for seed production by the government and limited private sector investment. Smallholder Farming (2006) revealed that the collapse of co-operatives, make it very difficult for smallholder farmers to obtain improved seeds and other agricultural inputs in rural areas, because these inputs are only available in major trading centers which in other words means that it is expensive to access such inputs.

Table 12 Seed used by Respondents

Seeds	Frequency	Percent
Improved seeds	16	13.3
Local seeds	91	75.8
Both improved and local seeds	13	10.8

4.4.4 Farm implements

Farm implements used in land preparation and cultivation in the study area were tractors, a hand hoe and oxen. The results in Table 13 show that half (50.8%) of all respondents used a tractor for farm preparation, while about a third (31.7%) of the respondents used hand a hoe, and some (17.5%) used oxen. The use of tractor by many farmers in the study area is due to the capacity of tractors to fast till the land, and easy of sowing seeds and removing weeds in the tractor-ploughed fields. Farmers who used hand hoes said that they have no enough money to hire tractor because of higher costs for them to afford although they view a tractor as the best farm implement. On the other hand however, farmers with small sized farms (78.4%) as indicated in Table 6 reported that, the limited size of land per individual household makes it cost effective and feasible to use a hand hoe than tractors. This

study observed that farmers with improved tools for farm preparation tend to participate more in farming (e.g. cultivating more land) and are likely to obtain better harvests in light of climate change. Farmers who use tractor (50.8%) can easily adapt to climate change by enhancing food security than those who use hand hoe because the use of tractors enables farmers to expand farm size to increase the chance of obtaining better harvest. These findings are similar with those presented by Adesia and Baidu-Forson (1995) who unfolded that accessibility to improved farm implements play an important role in the adoption of new technology because it helps farmers to till and manage their farms easily and hence increase farm production.

Table 13: Type of farm implement used in agricultural production

Farm implements	Frequency	Percent
Hand hoe	38	31.6
Tractor	61	50.8
Oxen	21	17.5

4.4.5 Migration

Migration is one of the important factors that diversified climate change adaptation measures in the study area. People who have migrated from different parts of Tanzania to Mvomero District, the study area, came with new climate change adaptation techniques and technologies such as drought resistant crops, knowledge on how to conserve soil and appropriate ways for mitigating climate change impacts in their farming activities. The findings in Table 14 show that most (65%) of the respondents in the study area are in-migrants from different parts of Tanzania including Mwanza, Tanga and Dodoma while the rest (35%) were natives. These in-migrants introduced drought resistant crops such as cassava, millet and new farm

management techniques such as *matandazo* (mulching) which are used to conserve soil moisture especially during dry season.

Table 14: Origin of respondents

Origin	Frequency	Percent
Natives	42	35.0
In- migrants	78	65.0

It was also observed that many in-migrants to the study area learnt new climate change adaptation techniques from natives including the use local drainage systems to direct and retain water in the farm especially during low rainfall seasons, use of short term seeds and irrigation. This implies that both in-migrants and natives possess some knowledge for both parties to benefit from. In stressing the role of migration Mbonile *et al.,* (1997) showed that in the southern zone of Usangu plains in-migration has led to new crops and agricultural techniques being introduced, and that the production of vegetables, for example, is increasingly becoming intensive.

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

The general objective of this study was to assess climate change adaptation measures among smallholder farmers in Mvomero District. This chapter provides

conclusions and recommendations from this study. The chapter is organized as follows. First, the conclusions are given from the findings in the study area. Second, the significance of findings from this study to Tanzania and East Africa as a whole is briefly given. Third, the recommendations are given for enhancing smallholder agricultural production and as way forward areas for further research are highlighted.

5.2 Conclusions

Household characteristics such age, gender, education, occupation, labour used and farm size determined climate change adaptation practices in light of climate change. The more the households possessed those characteristics the more they were in a position of adopting climate change adaptation measures.

Although rainfall variability and unpredictability affected smallholder farmers, majority of the farmers lacked awareness on climate change adaptation techniques. Poor climate relevant information coverage and inaccessibility on mass media (e.g. radio, television and newspaper) and limited capacity of village extension officers to provide adequate knowledge on adaptation techniques to smallholder farmers contributed to this limited awareness.

The majority of smallholder farmers grew maize and rice crops which are vulnerable to climate change, while fewer farmers grew cassava, sorghum, sunflowers and millet, the drought resistant crops. These expose smallholder farmers to high vulnerability in terms of food insecurity in the study area because they lack awareness on appropriate crops for adapting to climate change.

Smallholder farmers solely depend on rainfall in their agricultural activities which contributes to uncertain production, because the rainfall is unreliable and insufficient. The main rationale for high dependency on rain-fed agriculture is poverty which hinders farmers from buying water pump machines, and from using improved water drainage systems. Although there is irrigation area which was owned by NAFCO, many smallholder farmers could not afford to pay Tsh 50,000 per annum for water to be distributed to their farms. As such, financial resources were a major constraint to smallholder farmers because climate change adaptation measures such as irrigation is expensive for these farmers to afford. Furthermore, farmers blamed some village leaders for being corrupt especially in the allocation of plots in the NAFCO irrigation scheme to non-residents, despite the fact that one of criteria for accessing these plots is residency to this area.

Majority of smallholder farmers in the study area still depend on locally available seeds from their own handling. The study learnt that the main reasons for using local seeds are financial incapability, unavailability of improved seeds and lack of awareness on the improved seeds among smallholder farmers.

In-migrants from different parts of Tanzania in the study area came with new climate change adaptation techniques and technologies such as knowledge on how to conserve soil. In-migrants also have introduced farm management techniques like *matandazo* (mulching) which are used to conserve soil moisture especially during the dry seasons.

5.3 Implications of Findings from this Study for Climate Change in Tanzania and East Africa

This study has uncovered efforts and practices undertaken by smallholder farmers in the wake of impacts from climate change that seems to compromise and threaten their livelihood security. It has clearly unfolded the way smallholder farmers' blend diverse personal, social, physical and natural resources at their disposal to cope with climate change problems as a way to sustain productivity of their livelihoods. This is a reality experienced by smallholder farmers in diverse spatial and geographic areas of Tanzania and East Africa at large at various temporal points as the climate change is a global concern. However, the ability of smallholder farmers to improve agricultural productivity may depend on the capacity, at various spaces and times, of smallholder farmer to use diverse resources at their disposal, and to cope with influences from diverse policy and legislative environments from macro, regional and local scales. This study contributes to the baseline knowledge by unfolding relevant attributes to consider in devising practical and policy strategies to enhance smallholder farmers resilience to climate change instrumental not only for the study area but also, as already mentioned, to Tanzania, East Africa and even Africa as a whole. Field informed policy and strategic environments may enhance smallholder farmers' awareness, accessibility and adoptability of the existing innovations and technologies and consequently, improve and enhance their livelihood resilience to climate change.

5.4 Recommendations

Since smallholder farmers households characteristics such age, gender, education, occupation, labour used and farm size vary from one household to another, before recommending any climate change adaptation measures, thorough analysis of the smallholder farmers should be done to enhance the adoptability of those measures.

Because, as this study has indicated, currently smallholder farmers do not have enough information on climate change adaptation due to, among others, limited and infrequent coverage and inaccessibility of climate change adaptation information, the government and development partners need to alleviate these deficiencies by, for example, channeling such relevant information through most popular and easily accessible media. Such weather predictions over days or weeks in keeping with timing of operations such as planting, application of inputs (e.g. pesticides, insecticides, fertilizers etc) or harvesting. This information will assist farm level adaptation among smallholder farmers. Also, this information can be instrumental in selecting appropriate crop varieties based on agro-ecological and climatic realities of particular physical environments.

Since majority of respondents grow crops which are vulnerable to climate change such as maize and rice, agricultural extension officers through forums such as village meetings and seminars should advise smallholder farmers to grow crops that are drought resistant including millet, sorghum and cassava which may reduce the problem of crop failure due to rainfall variability and unpredictability.

Because majority of smallholder farmers are poor to afford agricultural inputs such as water for irrigation, and credits are crucial for enhancing the adoption of climate change adaptation measures among smallholder farmers. Credits may enable smallholder farmers to afford irrigation expenses (e.g. purchase of water pump machines and improvement of water drainage system).

The training is imperative to local people to enhance smallholder farmers understanding on appropriate and quality seeds for the purpose of ensuring them make appropriate choices on this aspect. Improved and short term seeds are very important especially during drought. However, the government should re-introduce farmers' cooperatives as the easy way for farmers to obtain improved seeds in the rural areas.

5.5 Suggestion for Further Research

This study has assessed climate change adaptation measures among smallholder farmers. Its focus was on how smallholder farmers adopted climate change adaptation measures to enhance their agricultural production, and hence to reduce smallholder farmers' vulnerability and increase their resilience in the wake of negative impacts from climate change and variability. However, much remains to be done as regards the impacts of the adaptation measures farmers take to adapt to climate change. One of the areas wherein further research can be directed is on impacts of climate change adaptation measures on environmental conservation.

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APPENDICES

Appendix 1: Household Survey Questionnaire

1. Background Information

QUESTIONNAIRE NO.	DATE OF INTERVIEW	TIME OF INTERVIEW
DISTRICT	DIVISION NAME	WARD NAME
VILLAGE NAMES	HAMLET NAME	RESPONDENT'S NAME
	ORIGIN OF HOUSEHOLD 1. Native 2. Immigrant	

1.2 Appropriate Sufficient Background of Respondent and Household Head Characteristics

1. Name of the household head……
2. Age of the household head …… years
3. Gender of the household head 1= male ( ) 2 = female ( )
4. Years of schooling of the household head …….
5. Occupation of the household head 1= peasant 2= business person 3= pastoralist 4= other specify …….
6. Marital status of the household head 1= single ( ) 2=married ( ) 3= separated ( ) 4= divorce ( ) 5 = widow/widower ( )

7. Household size ……

8. Experience on how long the Household head lives the area (number of years) …….

9. Do you know the meaning of climate change

1= Yes 2= No

10. If YES where did you hear it for the first time?

1= Media 2= Street 3= Village meetings 4= other specify …….

11. Did you face any impacts of climate changes?

1=Yes 2=No

12. If Yes, mention……

13. Do you know the meaning of climate change adaptation strategies?

1= Yes 2= No

14. If YES where did you hear it for the first time?

1= Media 2= Street 3= Village meetings 4= other specify …….

16. Have you practiced any climate change adaptation strategies at farm level?

1= Yes 2= No

17. If yes, mention ……..

18. The Household farms details (Only farms in the village)

1= Inheritance 2= Purchase 3= Lease/rent 4= Clean bushes

No. of Farms	Land Size (acres)	Land Cultivated	Crop type	Yield available	Acquiring Land

19. Does climate change force you to increase land size compare to before?

    1 =Yes 2 = No

20. What type of labour are you using?

    1= Family 2= Hired labour 3=other specify ……

21. (a) Have you increase number of labour in your farm activities?

    1=Yes 2=No

22. If yes, how many compare to five years past? .....

23. Why have you decided to increase?

    1= Demand increased 2= Just a matter of decision 3= other specify ……

24. What do you think should be done?

    1. _____

    2. _____

25. What is your main crop do you grow?

    1= Millet 2= Maize 3= other specify ……..

26. (a)Have you changed type of crop in you farm compare to the five years ago?

    1= Yes 2= No

    If yes explain why? .....

27. What type of seeds are you using?

    1= Modern seeds 2= Local available seeds 3= other specify

28. Which tools are you using?

    1= Hand hoe 2= Tractor 3= Other specify……...

29. Do the tools used bring any benefit in your production?

1= No 2= No

30. What type of farming practice do you use?

1= fallowing 2= Shifting cultivation 3= Insittu 4=other specify ……

31. What is the source of water in your farming activities?

1 = Rainfall 2= Irrigation 3= other specify

32. What should be done to improve your tools? …….

32**.** Does the climate change affect your cropping season?

1= Yes 2= No

If yes explain ……

……

33. How did you adopt the situation of shifting cultivation season.