



**INFORMATION DISSEMINATION FOR ADAPTATION TO CLIMATE CHANGE
AND VARIABILITY IN THE AGRICULTURE SECTOR: THE CASE OF MALUGA
AND CHIBELELA VILLAGES, CENTRAL TANZANIA**

by

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Submitted in fulfilment of the requirements for the degree of Doctor of Philosophy in the Information Studies Programme, School of Social Sciences, College of Humanities, University of KwaZulu-Natal, Pietermaritzburg, South Africa.

2013

DECLARATION

Submitted in fulfilment of the requirements for the degree of Doctor of Philosophy in the Graduate Programme in Information Studies, University of KwaZulu-Natal, Pietermaritzburg, South Africa.

I, Emmanuel Frank Elia, declare that:

1. The research reported in this thesis, except where otherwise indicated, is my original research.
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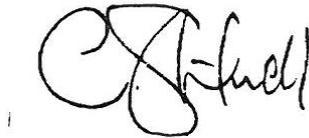
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Signature

Date

12 March 2014

ABSTRACT

This study investigated how access to and use of agricultural information contributed to farmers' adaptation to climate change and variability in the semi-arid Maluga and Chibelela villages of central Tanzania. The major research problem this study sought to address was how information on adaptation to climate change and variability is packaged and disseminated to farmers.

Specifically, the study 1) identified the Climate Change Adaptation in Africa project goals of disseminating information to farmers on climate change and variability; 2) assessed the status of knowledge adaptation to climate change and variability by farmers; 3) determined farmers' access to, and use of, information on climate change and variability, and 4) investigated factors affecting access to, and use of, information on adaptation to climate change and variability by farmers.

The study was underpinned by Rogers' Diffusion of Innovations Model. A post-positivist approach was used, with a predominantly qualitative and lesser quantitative approach, respectively. Interviews and focus group discussions were used to collect data. The study population was made up of farmers, agricultural extension officers and the Climate Change Adaptation in Africa project manager. Quantitative data was analysed using descriptive statistics and the SPSS, while qualitative data was analysed using content analysis. Reliability and validity were ensured by methodological triangulation, pretesting the interview guides and careful transcription of the data.

The key findings showed that farmers' training is crucial in mitigating the impacts of climate change and variability for agricultural development. The study found farmers had a problem with accessing and using climate information. Farmers perceived scientific information on weather as unreliable and untimely and were turning to indigenous knowledge (IK) to predict weather patterns. Repackaging of timely and accurate information on climate change and variability, education and training for farmers and collaboration between researchers, meteorology experts, extension officers and farmers are recommended for implementation to mitigate the adverse effect of climate change and variability on farmers. A clear policy framework for the dissemination of information related to climate change and variability is needed.

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DEDICATION

I dedicate this work to my wife, Brenda Joshua Kileo, my son Elkan, my daughter Briette and my late father, Dr. Frank Martin Elia.

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LIST OF ABBREVIATIONS AND ACRONYMS

AIACC	-	Assessment of Impact and Adaptation to Climate Change
ASDP	-	Agricultural Sector Development Programme
ASDS	-	Agricultural Sector Development Strategy
ASK	-	Anomalous State of Knowledge
CBD	-	United Nations Convention on Biological Diversity
CCAA	-	Climate Change Adaptation in Africa
CCIAM	-	Climate Change, Impacts, Adaptation and Mitigation in Tanzania
CCV	-	Climate Change and Variability
CIA	-	Central Intelligence Agency
DOI	-	Diffusion of Innovations
ERP	-	Economic Recovery Programme
FAO	-	Food and Agriculture Organization
FFS	-	Farmer Field School
FGD	-	Focus Group Discussion
GHG	-	Green House Gases
GM	-	Genetically Modified
HDI	-	Human Development Index
HDR	-	Human Development Report
HYV	-	High Yield Varieties
ICRISAT	-	International Crops Research Institute for the Semi-Arid Tropics
ICT	-	Information and Communication Technology
DFID	-	Department for International Development
IDRC	-	International Development Research Centre

IIED	-	International Institute for Environment and Development
IK	-	Indigenous Knowledge
IPCC	-	Intergovernmental Panel on Climate Change
IPM	-	Integrated Pest Management
IRA	-	Institute of Resource Assessment
MDG	-	Millennium Development Goals
MOA	-	Ministry of Agriculture
NAPA	-	National Action Programme for Adaptation
NGO	-	Non-Governmental Organisations
NSGRP	-	National Strategy for Growth and Reduction of Poverty
PELUM	-	Participatory Ecological Land Use Management
PHDR	-	Poverty and Human Development Report
POPs	-	Persistent Organic Pollutants
PRSP	-	Poverty Reduction Strategy Programme
PVS	-	Participatory variety selection
RDS	-	Rural Development Strategy
REDD	-	Reducing Emissions from Deforestation and Forest Degradation
RLDC	-	Rural Livelihood Development Company
RRSU	-	Regional Remote Sensing Unit
RWHT	-	Rain Water Harvesting Technologies
SADC	-	Southern African Development Community
SAP	-	Sustainable Agriculture Practices
SCF	-	Seasonal Climate Forecast

SK	-	Scientific Knowledge
SLF	-	Sustainable Livelihood Framework
TMA	-	Tanzania Meteorological Agency
TMV1	-	Tanzania Maize Variety 1
TV	-	Television
UNCCD	-	United Nations Convention to Combat Desertification
UNDP	-	United Nations Development Programme
UNFCC	-	United Nations Framework Convention on Climate Change
URT	-	United Republic of Tanzania
USA	-	United States of America

CHAPTER ONE

INTRODUCTION

1.1 Background to the Research Problem and Rationale for the Study

Globally, it is estimated that one third of the population live in multidimensional poverty and on less than US\$1.25 a day. The United Nations Development Programme (UNDP) determines multidimensional poverty using the multidimensional poverty index, which assesses people's poverty level by analysing factors such as health, education and standard of living (UNDP 2010). The 2010 Human Development Report estimates that more than a quarter (458 million people) of the poor live in Africa and that sub-Saharan Africa has the highest incidence of multidimensional, poverty with the level ranging from a low of 3% in South Africa to a massive 93% in Niger. Tanzania, the site of the current study, depends heavily on agriculture as the backbone of the economy (Fair 2000). The sector produces about half the Gross Domestic Product (GDP), provides 85% of exports and employs 80% of the workforce. It is estimated that about 85% of Tanzania's labour force lives in rural areas, where agriculture is the major economic activity (Fair 2000). Lema and Majule (2009) found that over 70% of Tanzania's population depend on subsistence agriculture, which accounts, on average, for about 50% of the Gross Net Product and about 66% of total export earnings. These statistics show the important contribution of agriculture to the national economy, with most people in rural areas still engaged in agricultural production.

The Tanzanian Government has, since the collapse of the Arusha Declaration (Clarke and Pitelis 1993; Fair 2000), taken a number of initiatives to promote agricultural development in Tanzania. The Arusha Declaration committed the country to a policy of Socialism and Self-reliance, translated in Kiswahili as "Ujamaa na Kujitegemea". In a nutshell, the policy of Socialism and Self-reliance described in the Arusha Declaration had a number of resolutions. These included an increase in agricultural production, improving health, education, public ownership of the means of production, ownership of resources by the poor and pioneering the freedom of Africans. In this regard, peasant agriculture was described as a pre-requisite tool for enhancing agricultural production to ensure food for every Tanzanian. Surplus food and cash crops were to be exported to enhance economic growth and development. Besides the Arusha Declaration, other measures government has taken to promote agriculture development include the formulation of the Economic Recovery Programme (ERP) of 1986,

Economic and Social Action Plan of 1990, the Agricultural Sector Development Strategy (ASDS) of 2001, the Poverty Reduction Strategy Programme (PRSP) of 2001; Rural Development Strategy (RDS) of 2002 and Agricultural Sector Development Programme (ASDP) of 2006 of the United Republic of Tanzania (URT 2006). Other initiatives include the Tanzania's Development Vision 2025 of 1998; the National Strategy for Growth and Reduction of Poverty (NSGRP) of 2005 and, currently, 'Kilimo Kwanza', native words meaning agriculture is a priority (URT 1998; URT 2005; URT 2009a).

The ERP and Economic and Social Action Plan aimed at liberalising trade policies, improving incentives for agricultural production, reducing the overvaluation of the currency and the implementation of an appropriate monetary and fiscal policy (Pfander and Gold 2000). The Poverty Reduction Strategy Programme (PRSP) aimed at enhancing macroeconomic stability and market efficiency to alleviate poverty (URT 2001b). The PRSP thus focused on uplifting the economy of the country towards a market-based economy in sectors which greatly contribute to the economic growth of the country, the agricultural sector being one of the sectors. The PRSP programme thus envisaged a positive impact for the agricultural sectors by ensuring quality agricultural produce to enhance development. Moreover, Tanzania's Development Vision 2025's main objective is to awaken, co-ordinate and direct the people's efforts, minds and natural resources towards core sectors, which will play a major role for the country to attain its development goals and withstand the expected intensive economic competition (URT 1998). The National Strategy for Growth and Reduction of Poverty (NSGRP) is a five-year strategy to enhance quality of livelihood; high and shared growth; quality education; peace, stability and unity; good governance and international competitiveness (URT 2005).

The ASDS programme aims at attaining better profitability and sustainability through adoption of new technologies and extension of use of existing technologies, efficiency in managing inputs and outputs and improved management of agricultural resources (URT 2001a). The main objectives of the ASDP programme are: (i) to enable farmers to have better access to, and use of, agricultural technologies, knowledge, infrastructure and marketing systems; all of which contribute to higher farm incomes and productivity; and (ii) to promote agricultural private investment based on an improved policy and regulatory environment (URT 2006). The RDS focuses on the development of the entire rural sector, including agriculture, non-farm economic activities, social services and economic and social

infrastructure (URT 2002). These programmes have unlocked the agricultural sector from a government monopoly and opened it to private investment regarding inputs importation and distribution, production and processing and agricultural marketing. The private sector has recently been commissioned by the government to order or produce agricultural equipment for farmers such as fertilizers, tractors, herbicides and insecticides, which before this were overseen by the government. The private/government partnership has been more evident in the newly introduced Kilimo Kwanza initiative, which was launched by the government in 2009, aiming at achieving a green revolution in the agricultural sector (URT 2009a).

The Kilimo Kwanza government initiative has ten pillars which strive towards improving farmers' welfare by modernising agriculture and assimilating more of the private sector in the agricultural sector. The programme aims at eradicating poverty by increasing the agricultural production from 4% to 10% by 2015. The pillars are: (i) National vision on Kilimo Kwanza; (ii) Financing Kilimo Kwanza; (iii) Institutional reorganization of management of Kilimo Kwanza; (iv) A paradigm shift to the strategic framework of Kilimo Kwanza; (v) Land for Kilimo Kwanza; (vi) Incentives for Kilimo Kwanza; (vi) Industrialization for Kilimo Kwanza; (vii) Science, Technology and Human resources for Kilimo Kwanza; (ix) Infrastructure development for Kilimo Kwanza; and Mobilization of Tanzanians for Kilimo Kwanza. The third pillar in the Kilimo Kwanza strategy espouses incorporating and mainstreaming environment issues in all aspects of Kilimo Kwanza (URT 2009a). Despite the tenth pillar emphasising the dissemination of information through awareness and sensitisation of Kilimo Kwanza to farmers and other stakeholders, the first and tenth pillar do not demonstrate the government's commitment to advocate climate change and variability issues to farmers.

The literature shows that, despite the various initiatives the government of Tanzania has undertaken in the agricultural sector, including the private/government partnerships, little has been achieved towards freeing the people of Tanzania from the cycle of extreme poverty and hunger in line with the first goal of the Millennium Development Goals (MDGs). The first MDG aims at eliminating poverty and hunger by 2015 (URT 2009b). This is evident from the statement issued by the government of Tanzania in September 2012 at the UN General Assembly and the progress report by the United Nations Development Programme (UNDP 2010; URT 2012a). In a recent statement (URT 2012a), the government of Tanzania

indicated that it had made significant progress in two of the eight millennium development goals.

The goals mentioned are:

- goal 2, which is universal primary education
- goal 3, which aimed at promoting gender equality and empowerment of women
- goal 6, which is combating HIV/AIDS, malaria and other diseases.

The reasons for the failure to meet the first MDG and eradicate poverty and reduce hunger in Tanzania could be attributed to factors including:

- low agricultural production caused by dependence on rain-fed agriculture, poor agricultural mechanisation
- heavy reliance on donor funding
- inadequate policy implementation and institutional framework
- poor innovative technologies and skills
- lack of information
- inadequate funding of agricultural research and technology
- poor access to markets, finance
- poor road infrastructure (Economic Report on Africa 2009; Mongi, Majule and Lyimo 2010).

One of the major setbacks likely to affect achieving the first MDG in Tanzania, according to Salinger, Sivakumar and Motha (2005) and the National Action Programme for Adaptation (URT 2007), is climate change and variability. These changes have adverse impacts on agricultural production as a result of prolonged droughts, floods and increased incidence of pests and disease (Lema and Majule 2009; Mongi, Majule and Lyimo 2010). Additionally, the seventh MDG, which is ensuring environment sustainability, is indirectly affected by climate change and variability as prolonged droughts increase aridity which exacerbates land degradation, desertification and loss of biological diversity in arid and semi-arid areas (Kandji and Verchot 2007). Thus, climate change and variability is a major risk to sustainable growth and development and in poverty alleviation in developing countries (Devereux and Edward 2004; Mertz, Halsnas, Olesen and Rasmussen 2009).

Climate change has been described by the Intergovernmental Panel on Climate Change (IPCC) as the state of the climate that can be identified using statistical tests by changes in the mean and/or the variability of its properties and that persists for an extended period of time such as decades or longer (IPCC 2007). Climate change denotes a process in which greenhouse gases are released into the atmosphere due to industrialization which then results in global warming. Climate variability, in contrast, refers to variations in the mean state and other statistics such as standard deviations of the climate on all spatial and temporal scales beyond that of individual weather events (IPCC 2007). As a result of climate change and variability, mean global temperatures are expected to increase by from 1.4 to 5.8 degrees Celsius by 2100 (IPCC 2001). These increases have and will result in erratic changes in rainfall, temperature, frequency and intensity of extreme weather events and rising sea levels. These changes will also affect human systems such as agriculture, water resources, industry and human health (Orindi and Murray 2005). Over the past 25 years there has been an increase in heavy precipitation in many parts of the northern hemisphere, over land in the mid- and high latitudes, leading to an enhanced hydrological cycle. There has also been an increase in the intensity and frequency of El Niño and La Niña phenomena, which are characterised by heavy rainfall leading to floods and droughts, respectively. There has been a decline in the extent of Arctic sea ice, particularly in spring and summer, with an approximate 40% decrease in the average thickness of summer Arctic sea ice over the last three decades of the 20th Century (Folland and Karl 2001; IPCC 2001c).

In Africa, climate change and variability is likely to exacerbate existing problems for farmers and create new risks if it is not mitigated timeously. The reasons for the greater vulnerability of Africa to climate change and variability lie in widespread poverty; limited access to information on climate change and variability; dependence on the natural environment and agriculture for the majority of people; complex governance and institutional systems; limited access to capital including markets, infrastructure, technology, ecosystem degradation; and complex disasters and conflicts (IPCC 2007; Mertz, Halsnas, Olesen and Rasmussen 2009; Ziervogel and Zermoglio 2009). Salinger, Sivakumar and Motha (2005) and Gwambene (2007) pointed out that the adverse impacts of climate change and variability in developing countries is caused by the low levels of adaptive capacity, and limited use of technology and innovation. Hence, vulnerability to climate change and variability exacerbates poverty in the agricultural sector of many sub-Saharan African countries, including Tanzania, and cannot be

eliminated without proper packaging and dissemination of appropriate information to farmers. In this study, information packaging and repackaging are terms which will be used interchangeably, depending on the context. Sturges and Chimseu (1996b) use the terms to refer to organising the information content in an efficient and effective way to make it useful so that it can reach a wider community in a format which is understandable.

A number of scholars have observed the association between development and climate change and variability. The Intergovernmental Panel on Climate Change (2001) and Assessment of Impact and Adaptation to Climate Change (2005) observed that, climate change and variability has and will adversely affect water resources, agriculture, forestry, fisheries, human settlements, ecological systems and human health in many parts of the world. Devereux and Edward (2004) observed that countries in East Africa are already among the most food insecure in the world. They further stated that, climate change and variability will exacerbate falling harvests through widespread climatic changes such as increase in drought and floods which have already been observed in the region. Devereux and Edward (2004) point out that climate change and variability will have both direct and indirect impact on the development of climate-dependent activities such as infrastructure, agricultural poverty, conflict, health and education. As a result, climate change and variability will undermine, and even undo, socio-economic development in East Africa. It is evident that an urgent response from East African governments and institutions is necessary in order to formulate long-term adaptation strategies.

Several studies have shown a positive relationship between an increased flow of information and agricultural development (Raju 2000; Cash 2001; Manda 2002; Kalusopa 2005). In Tanzania and Malawi, rural information provision has been demonstrated to have had a positive impact on agricultural practices (Mchombu 2001; 2003; Muyepa 2002). Notwithstanding their potential for agricultural development, the majority of African countries have failed in informing the population in the rural areas about agricultural practices (Adomi, Ogbomo and Inoni 2003). Despite the agricultural information generated by research institutions, government agencies, Non-governmental Organisations (NGOs) and Community-Based Organisations (CBOs), only a limited information on various innovations is known to the majority of smallholder farmers (Laizer 1999). Tarhule (2007) observed that, despite notable advances in climate research and climate forecasting, many African countries have not experienced the benefits of climate research for mitigating the adverse impacts of

climate change and variability. As a result, most African countries continue to suffer the highest level of climate change and variability impacts. This has severe implications for economic growth and development.

It is evident that access to timely information on climate change and variability is of paramount importance, if adaptation and development are to be sustained (Chikozho 2010). A number of studies have revealed that, despite other factors which influence adaptation to climate change and variability, information heavily triggers and enhances farmers' ability to adapt. Some studies, including that of Mengistu (2011) in Ethiopia, which found that accessibility and availability of timely information on climate change and variability was a prerequisite to adaptation and mitigation of the adverse impact of climate change and variability. Kandji and Verchot (2007) in East Africa found out that information on climate change and variability was a critical factor for local communities in making the right decisions in agriculture and other socio-economic activities including adaptation to climate change and variability. In Tanzania, Chang'a, Yanda and Ngana (2010) and Mongi, Majule and Lyimo (2010) have shown importance of indigenous knowledge possessed by farmers. They recommended the urgent need for scientists to recognise and incorporate indigenous knowledge into more mainstream scientific practices for effective adaptation strategies.

Despite several studies undertaken in Tanzania (Liwenga 2003; Yanda, Majule, Mwakaje 2005; Liwenga and Kangelawe 2005; Majule 2008), showing that local communities are adapting to climate change and variability, there is a perception that research and training has had little impact, as farmers still experience poor agricultural yields and food insecurity caused by drought and floods (Liwenga and Kangelawe 2005; Liwenga, Kangelawe, Lyimo, Majule and Ngana 2007). Timely access to, and utilisation of scientific information on climate change and variability, is predicated on well-packaged and disseminated information (Chikozho 2010). However, the literature reveals that knowledge generated and disseminated to farmers aimed at improving agricultural production and adaptation to climate change and variability in Tanzania might be having little impact on agricultural production (Tarhule 2007; Kadi, Njau, Mwikya and Kamga 2011).

The scientific information and knowledge generated on climate change and variability is appropriately packaged and disseminated to farmers to enhance crop production in a situation of climate change and variability. IPCC (2007) pointed out that knowledge generated through

research does not often result in the anticipated behaviour change in the target group because of social, cultural, psychological, physiological and financial barriers. These barriers may be well understood in the context of diffusion of innovations (DOI) model. According to DOI (Rogers 2003), complexity, compatibility and heterophily influence the adoption and use of an innovation. The simplicity and appropriateness with which information is packaged and disseminated to farmers and how this information fits with the value system of the recipients determines its acceptance and use. This study therefore postulates that information on adaptation to climate change and variability, appropriately packaged and disseminated to farmers has the potential to enhance crop production (more detailed description on information dissemination, adaptation to climate change and variability and DOI components is presented in Chapter Three in the literature review).

The University of Dar es Salaam's Institute of Resource Assessment (IRA) and other stakeholders took the initiative through the Climate Change Adaptation in Africa (CCAA) research project to strengthen local agricultural innovation systems in an attempt to mitigate the challenges of climate change and variability. Through the research project based in Maluga, Sanjaranda, Laikala and Chibelela villages in the central regions of Tanzania, farmers have been trained and provided with information on agricultural innovation systems to enhance adaptation to climate change and variability (CCAA 2009). However, the extent to which farmers have received and utilised the knowledge disseminated to them is not evident (Liwenga 2003; Kangalawe *et al.* 2005; Yanda, Majule, Mwakaje 2005; Majule 2008). There is paucity of studies on how information generated through research and training on adaptation to climate change and variability is packaged, disseminated to farmers and utilised. This study therefore investigates how information on the adaptation to climate change and variability generated from the Climate Change Adaptation in Africa project (CCAA) is being utilised by farmers in central Tanzania.

The outcome from this study is expected to inform policy and practice, contribute to ongoing debate and dialogue about improving adaptive capacity on climate change and variability in the agriculture sector with respect to crop production. The study is expected to benefit agricultural research institutes in developing appropriate solutions to ensure effective information and knowledge dissemination to farmers about innovative ways on climate change and variability, such as new drought-resistant seed varieties. The findings from this study are expected to further enhance collaboration and partnerships between researchers,

policy-makers and agricultural information users in rural areas in Tanzania and in other developing countries.

1.2 Statement of the Problem

Agriculture plays an important role in the livelihood of rural communities in most developing countries such as Tanzania. According to Slater, Peskett, Ludi and Brown (2007) and the Food and Agriculture Organization (FAO) (2003), agriculture currently accounts for 24% of world output of GDP and uses 40% of the land area the world over. Efforts have been made by both the government and private sector in promoting agricultural research in the country. The importance of agriculture in the national economy is reflected in the large number of research undertaken by institutions. The purpose of these research institutions is to generate information that would improve food production to feed the majority of Tanzanians who live in rural areas. Research undertaken include best farming practices, quality seeds, insecticides, livestock breeding, training of agricultural extension officers and adaptation to climate change and variability.

The role agriculture plays in Tanzania is important to the livelihood of rural communities. However, the 2012 Human Development Report (HDR) ranked Tanzania 152 out of 186 countries with an Human Development Index value (HDI) of 0.476. It is evident that Tanzania is still lagging behind other countries in the world (UNDP 2013). The HDI shows that the country which has achieved the highest human development is Norway, with an index of 0.955 and the lowest is Niger with an index of 0.304. The over-dependence on rain-fed agriculture by the majority of people living in rural areas is being threatened by climate change and variability, which is the major limiting factor in agriculture production, resulting in food insecurity and low-income generation (Lema and Majule 2009). Mongi, Majule and Lyimo (2010) discovered in 2006, when a major drought hit the country, that the cost of the food shortage to the Tanzania economy during that year amounted to 200 million US dollars in food imports and distribution. In spite of the fact that climate change and variability impact heavily on agriculture, Orindi and Murray (2005) observed that most people in East Africa, including Tanzania, still consider climate change and variability a distant problem and thus employ only *ad hoc* initiatives to reduce the vulnerabilities of local communities. This attitude may result in a slow pace in adapting to floods and droughts, due to the lack of the right information for preparedness.

Though a number of research institutes in Tanzania carry out studies on various issues in agriculture, such as best farming practices, quality seeds, insecticides, livestock breeding, training of extension workers and adaptation to climate change and variability, there is limited understanding of how information for adaptation to climate change and variability is packaged and disseminated to farmers. Appropriate means of disseminating timely information to farmers for adaptation to climate change and variability, as well as its access, is vital in enhancing crop production. Supporting this notion, Tarhule (2007) observed that many African countries have yet to benefit from climate change and variability research. Tarhule found limited access to climate research information, very low ability to utilise the information generated and disseminated to them from climate research and the ineffectiveness of institutions with statutory responsibility to manage the impacts of climate change and variability to contribute to the problem. The author thus found these factors were preventing adaptation strategies from being implemented in most African countries. The present study seeks to investigate how the information generated through research on adaptation to climate change and variability is packaged and disseminated to farmers to improve agricultural production among rural communities in central Tanzania.

1.3 Delimitation of the Study

With regard to delimitation, the study is confined to how information on climate change and variability is packaged and disseminated to farmers engaged in crop production in Maluga and Chibelela villages in central Tanzania. Animal production is not included in the study because in Tanzania most people who live in rural areas depend largely on crop production to earn their daily living.

1.4 Limitations of the Study

The scope of this research is limited, in that it has not examined researchers and research institutions. This would have made the study too broad and require more time and human and financial resources than a doctoral study should entail. The other limitation is the external validity, which is the ability to draw inferential or descriptive conclusions on generalising study findings from a small sample to a larger representative group in other settings.

The study partly relied on the type of methodology used to sample respondents which were purposive and snowballing sampling. The two non-probability methods do not provide a chance for any member of a society to participate in the study. As a result, the findings, to a

great extent, depend on the faithfulness of the person being interviewed. Snowballing sampling is subjected to the truthfulness of the person providing information about the next person to be interviewed. If that person misleads the researcher, then it is beyond the researcher's means to identify the correct respondent. From the researcher's experience, rural people tend to believe there are benefits to be derived from interviews and often insist that they are the right group of people to participate in the study.

There are limitations in the study sample in that it focuses primarily on CCAA project which trained a group of experimental farmers, the sample will focus on the same trained farmers. The group, however, might not be representative of the entire population of the village. In this study, the geographic location and the economic activity of farmers might be seen as a limitation on finding respondents in time and with time to spare. Explicitly, the economic constraints refer to the study being conducted on farmers who depend on farming to earn their livelihood and the study might have more than anticipated time, since in the study areas the farmers could have been in working on their respective farms or doing other income-generating activities. The geographic location limits the research as the study areas are in remote locations with infrastructural problems such as bad roads and a semi-arid climate. **Figure 1.1** shows the map of Tanzania, with the study regions shaded.



Figure 1.1: Map of Tanzania, showing Regions and Districts (Source: Nations Online Website 2011)

1.5 Study Assumptions

The researcher makes the following assumptions:

- Effective access to timely scientific information is vital for adaptation to climate change and variability by farmers.
- Adoption or rejection of an innovation is an attribute of both the innovation decision-making unit such as communication behaviour, knowledge, perceived need, cosmopolitanism, attitude and the attributes of an innovation such as compatibility, relative advantage, observability, complexity and trialability (Rogers 2003).

- Access to, and use of, an agricultural innovation is vital for increasing food production and adaptation to climate change and variability.

1.6 Objectives of the Study and Research Questions

The main objective of this study was to investigate how information on adaptation to climate change and variability is packaged and disseminated to farmers in Maluga and Chibelega villages in Central Tanzania.

1.6.1 Specific Objectives

The study attempts to address the following specific objectives:

1. Identify goals of information disseminated to farmers on climate change and variability.
2. Assess the status of knowledge adaptation to climate change and variability by farmers in the villages of Central Tanzania.
3. Determine access to, and use of, information on climate change and variability by farmers.
4. Investigate limiting factors affecting access and use of information on adaptation to climate change and variability.

1.6.2 Research Questions

The following research sub-questions are investigated:

1. What are the goals of information disseminated to farmers on climate change and variability?
2. What type of information on climate change and variability is disseminated to farmers?
3. What specific channels are employed when disseminating information on climate change and variability?
4. What methods are applied by farmers to mitigate the effects of climate change and variability?
5. What is the farmers' current level of adoption of information on adaptation to climate change and variability?

6. How is information on climate change and variability accessed and used?
7. What are the attitudes and perceptions of farmers towards climate change and variability?
8. What are the limiting factors affecting access and use of information on adaptation to climate change and variability by farmers?

1.7 Theoretical Framework

Various theories are used in behavioural studies in the fields of information science, communication, social sciences, natural science and health and psychology. These include Diffusion of Innovations (Rogers 1995), Social Learning Theory (Bandura 1977), Self-efficacy Theory (Bandura 1986), Protection Motivation Theory (Rogers 1975), Sustainable Livelihood Framework Theory (Carney, Drinkwater, Rusinow, Neefjes, Wanmali and Singh 1999), Rational Choice Theory (Homans 1961), Coping Theory (Lazarus 1966) and theory of Planned Behaviour (Ajzen 1991). In this study, the Diffusion of Innovations (DOI) will be used as the theoretical framework. The applicability of DOI model in agricultural innovation is evident in the works of Longo (1990) and Manda (2002), Gundu (2009) and Sell (2010).. Though the DOI model is not all-encompassing its flexibility in explaining the DOI resonates well with the research problem and sub-problems of this study, which are embedded in both positivist and interpretive paradigms.

Rogers (2003:20-21) points out that the innovation-decision process is an information-seeking and information-processing activity in which an individual seeks information at various stages in the innovation-decision process in order to decrease uncertainty about an innovation's expected consequences. These innovation adoption stages are knowledge, persuasion, decision, implementation and confirmation. DOI outlines attributes which influence the adoption of an innovation in a society. These include complexity, relative advantage, trialability, observability and compatibility. The Diffusion of Innovation theoretical framework classifies members of a social system on the basis of their innovativeness. These include five adopter categories, which are innovators, early adopters, early majority, late majority and laggards. The DOI model presents communication channels, time, attitude, social systems variables and perceived characteristics of innovation as independent variables which determine whether a new innovation will be adopted or rejected.

The DOI model is expected to assist in explaining how information generated through research is packaged and disseminated to rural farmers to enable them to mitigate the adverse impact of climate change and variability. DOI will also be used to investigate farmers' rate of adoption of new techniques for coping with climate change and variability. Farmers' knowledge, attitude and awareness are among issues this study seeks to investigate. The Diffusion of Innovation will seek to answer how farmers access and use information on climate change and variability. The Diffusion of Innovation and Sustainable Livelihood Framework (SLF) will be used to identify factors limiting farmers' access and use of information on climate change and variability. The detailed description of DOI and cognate theories underlined is provided in the theoretical framework in Chapter Two. Based on the DOI attributes explained above, see Table 1.1, which maps the research questions of the study to the attributes.

Table 1.1: Research Questions Aligned to Diffusion of Innovations Attributes

Research Questions	Diffusion of Innovations Attribute
What are the goals of information disseminated to farmers on climate change and variability?	Trialability, compatibility, perceived need, relative advantage, knowledge, adoption, persuasion, decision, confirmation
What type of information on climate change and variability is disseminated to farmers?	Knowledge, social system norm, communication sources, persuasion, decision
What specific channels are employed when disseminating information on climate change and variability?	Communication sources, communication behaviour, communication channels
What methods do you apply to mitigate the effects of climate change and variability?	Knowledge , social systems variables, attitude, compatibility, perceived need, relative advantage, complexity, communication sources
What is the farmers' current level of adoption of information on adaptation to	Adoption, communication behaviour, knowledge, communication channels,

climate change and variability?	social system norms, decision, cosmopolitanism, communication behaviour, confirmation
How is information on climate change and variability accessed and used by farmers?	Communication channels, communication integration/behaviour, decisions, communication sources, complexity, perceived need, attitude, cosmopolitanism
What is the attitude and perception of farmers towards climate change and variability?	Attitude, perception, compatibility, decision, communication sources, communication behaviour, communication channels, cosmopolitanism
What are the limiting factors affecting access to, and use of, information on adaptation to climate change and variability to enhance agricultural production?	Complexity, trialability, relative advantage, compatibility, perceived need, attitude, perception, social system norm, observability, tolerance of deviance, communication behaviour, communication channels

1.8 Paradigm Used and Methodology of the Study

This study adopted a post-positivist paradigmatic approach with a qualitative approach the dominant, and a quantitative the less dominant approach, respectively. The choice of qualitative approach as the dominant method is based on the type of data to be collected and type of analysis to be done, encompassing the study. The research aimed at identifying and investigating detailed qualitative factors which influence the adoption of an innovation, which in this study is farmers' adaptation to climate change and variability. A quantitative research approach was applied to enable quantification of the variables under study in order to reveal the issues such as adoption level and access to information on climate change and variability by farmers.

Other scholars who have similarly applied a qualitative research approach as the dominant approach and quantitative research approach as the less dominant in similar studies include

Mongi, Majule and Lyimo (2010); Munyua and Stilwell (2009); Lema and Majule (2009) and Gundu (2009). Some scholars, such as Erbaugh, Donnermeyer and Amujal (2007); Diederer, Bijak, Wolters, Meijl (2003), have used a quantitative research approach when applying the DOI theoretical framework, while others, such as Gundu (2009) and Baide (2005), have applied DOI with a qualitative research approach showing the flexibility of the theoretical framework in agricultural research studies.

Survey research design was found suitable and applied in this study because it provides a useful source of information on attitudes, population distribution and behaviour (Pons 1992). The study population comprises three categories of respondents, namely farmers, agricultural extension officers and the CCAA project manager.

The population of the study comprised 3155 farmers, two agricultural extension officers and one programme manager. The CCAA list of farmers was used as sampling frame while agricultural extension officers and the CCAA programme manager were identified through the agricultural regional office. Non-probability sampling technique was used to select the sample population. Purposive sampling was used to target all trained and untrained farmers in Maluga and Chibeleda villages. Using the sampling frame for farmers and with the initial guidance of village government leaders, the snowballing method was used to identify and reach respondents.

Data from trained and untrained farmers was collected, using researcher-administered semi-structured interviews. The research instrument was researcher administered, as most people in the villages under study are illiterate and cannot read and write. The interview process was conducted until saturation and stopped when sufficient information-rich cases had been reached (Holloway 1997:142). An interview schedule for trained farmers was used to capture the type of information and knowledge farmers received, how the information was packaged and how they accessed and used the information and methods they applied to mitigate the effects of climate change and variability. Another interview schedule was researcher-administered to untrained farmers to solicit information on the level of adoption of information on climate change and variability; how information/knowledge on climate change and variability is packaged and disseminated to them.

In-depth interviews were employed with the agricultural extension officers and CCAA programme manager. In-depth interview with the agricultural extension officers sought to

solicit information on types of information on climate change and variability disseminated to farmers, how farmers seek information for adaptation to climate change and variability, how information is packaged and disseminated to farmers, what methods farmers apply to mitigate the effects of climate change and variability and how farmers access and use information on climate change and variability. The programme manager was interviewed on how training was delivered, the progress and challenges which have emerged with the information packaging and dissemination process, the level of adoption by farmers of agricultural innovation, barriers to access and use of information on climate change and variability.

The agricultural extension officer representing each village was interviewed in depth on how this information on climate change and variability is packaged and disseminated to farmers, how farmers access and use information on climate change and variability, farmers' level of adoption of information on adaptation to climate change and variability, attitude of farmers towards climate change and variability and what the main problems in relation to access to and use of climate change that farmers' experienced. In order to effectively manage qualitative data from interviews, the data was categorised and analysed thematically (Patton 1990). For quantitative data, descriptive statistics such as the mean, frequencies, standard deviation, regression analysis and cross tabulation was generated using SPSS. A detailed description of the methodology is provided in Chapter Four.

1.9 Definition of Key Terms and Concepts

This section provides definitions of key terms and concepts

1.9.1 Access

Farmers access information through a number of sources and channels. These include meetings, neighbours, researchers, farmer field schools, farmer groups, opinion leaders, extension officers and researchers. Tadesse (2008) defined access as messages farmers receive related to agricultural production from sources such as mass media, extension service and on-farm research. The media farmers use to access information includes radio, Television, mobile phones, person and internet. Access to information enables users to adopt innovations which enhance their livelihood. In this study, access is defined as the ability of farmers to receive information on climate change and variability from sources.

1.9.2 Adaptation

Smit, Burton, Klein and Wandel (2000:228) defined adaptation as the process of adjusting to the resulting outcome or condition aiming at better suiting the new conditions. There are methods which help individuals to cope with the impacts of climate change and variability. Nyong, Adesina and Elasha (2007) describe adaptation methods as strategies which enable individual or community to adjust or cope with the impacts of climate change and variability in their local settings. The strategies include among others, the adoption of efficient agricultural and environmental practices such as planting of early maturing crops, new drought resistant varieties in areas where there is a decline in rainfall.

1.9.3 Adoption of Innovations

Rogers (1995:21) defines adoption as a decision to make full use of an innovation as the best course of action available. Rogers (2003:12) defined an innovation as any idea, object or practice that is perceived as new by members in a social system. For the purpose of this study, adoption of innovations refers to the ability of farmers to accept and embrace new information on adaptation to climate change and variability to improving yields. Innovation in this study is perceived in the context of climate adaptation measures which have been introduced to farmers as a result of climate change and variability.

1.9.4 Climate Change and Variability

Hellmuth, Moorhead, Thomson and Williams (2007:4) defines climate change and variability as variations of the climate system, which includes oceans and the land surface as well as the atmosphere, over months, years and decades caused by from human activities. In this study the climate change and variability definition by Hellmuth, Moorhead, Thomson and Williams (2007) will be adopted.

1.9.5 Communication Channels

A communication channel is the means by which information flows from one individual to another (Rogers 2003). They are described as dissemination pathway used by information providers to disseminated information to users (Garforth 1998). The communication channels are categorised into interpersonal or mass media. Interpersonal channels include researchers, extension officers, NGOs, farmers groups and civil societies. Mass media channels include radio, mobile phones, Television, internet, newspapers, fliers and meetings/gatherings.

1.9.6 Diffusion of Innovations Model

Diffusion is the process by which an innovation is communicated through certain channels, over time, among the members of a social system (Rogers 2003:5). For the purpose of this study, innovation is new information available to farmers in the context of climate change and variability which have been introduced to farmers to enhance their adaptation capacity.

1.9.7 Indigenous Knowledge

Orlove, Roncoli, Kabugo and Majugu (2010) described indigenous knowledge (IK) as the knowledge based on a place originated in local cultures and associated with communities which have long lived in that particular area and have strong ties to their environments. IK is built through people's day to day experience emanating from present and previous generations' observation and testing of the knowledge in their surrounding environment (Nyong, Adesina and Elasha 2007; Orlove, Roncoli, Kabugo and Majugu 2010). Meyer (2000) noted that IK is mostly communicated orally from one generation to another through storytelling, poetry, drama, songs and taboos and ceremonies. In this study, IK is defined as the knowledge possessed by a community in as a result of a long interaction with their environment.

1.9.8 Information Dissemination

Feather and Sturges (2003) define information as data which has been processed into a meaningful form. Information dissemination is the spread of information from the source to a wider targeted audience. This study defines information dissemination as the process of sharing information and knowledge from researchers to a wider community of farmers to promote access to and use of innovations.

1.9.9 Information Packaging

Sturges and Chimseu (1996b) use the term to refer to organising the information content in an efficient and effective way to make it useful so that it can reach a wider community in a format which is understandable. In this study, information packaging and repackaging will be used interchangeably describing the preparation and tailoring agricultural information before disseminating to farmers to promote usage.

1.9.10 Knowledge

Knowledge is described by Davenport and Prusak (1998) as a fluid mix of framed experience, values, contextual information, and expert insight that provides a framework for

evaluating and incorporating new experiences and information. Alavi and Leidner (1999) defined knowledge as the information related to concepts, procedures, ideas, observations and facts in the mind of a person. In the context of this study, knowledge will be defined as the level of understanding possessed by a farmer and which has been received through experience.

1.10 Summary

This chapter gave an introduction to the subject on climate change and variability and the importance of timely information in enhancing crop production. The major issues described in the chapter include the background to the problem, the problem statement, delimitations and limitations, research objectives and research questions. The study presented a theoretical framework, the paradigm used in the study and a methodology adopted in collecting data from the study population. The chapter provided definition of key terms used in the study. In the Tanzanian context, studies show a need for assessing the current farmers' status of knowledge and adoption of information in adaptation to climate change and variability.

1.11 Outline of the Thesis

The thesis structuring has been discussed by a number of scholars, including Patton (2002:33-35), Sekaran (2003: 338-351) and Neuman (2006:473). However, although these authors present thesis, structuring differently they all emphasise the basic elements of a thesis which are introduction, literature review, theoretical/conceptual framework(s), research methodology and presentation and discussion of the research findings. The present work is categorised into seven chapters, based on the UKZN College of Humanities PhD thesis write-up guidelines, which consist of seven chapters. A detailed elaboration of the chapters is provided hereunder.

Chapter One provides general introductory information on the research study. It includes background information of the study, statement of the problem, the major research question, research objectives, subsidiary research questions, significance and assumptions/limitations initial literature survey of the study including a brief outline of the methodology. Chapter Two presents review of literature on climate change Variability and adaptation by farmers in the agricultural sector. The section describes issues related to access and usage of information in the agricultural sector, adoption of innovations, information use and dissemination so as to explore the gap in knowledge in the study area which it addresses.

Chapter Three elucidates various social learning theories such as the theory of reasoned behaviour, the self-efficacy theory, the social learning theory, the coping theory, the protection motivation theory, the theory of planned behaviour and the diffusion of innovations theoretical framework, which is applied in the study. The DOI model stages of adoption process and adopters categories are described, to show the relationship between variables and how they link to the research problems. Chapter Four describes the paradigm, approaches, research designs, population, sampling procedure, data collection procedure, data analysis, validity/reliability of instruments and ethical considerations.

Chapter Five presents the results of the study. In this chapter qualitative results are presented thematically, while quantitative results are presented using frequencies, charts, figures, tables and narrations. Chapter Six discusses and interprets the results compared to existing literature. Chapter Seven provides a summary, conclusion and recommendations. Areas for further research are suggested.

CHAPTER TWO

THEORETICAL FRAMEWORK

2.1 Introduction

The purpose of this study is to investigate adaptation to climate change and variability by farmers using information disseminated to them in central Tanzania. Chapter Two presents the theoretical frameworks suited for studying diffusion of innovation with more focus placed on the Diffusion of Innovations (DOI) framework (Rogers 2003) and how it has been applied to farmers' adoption behaviour with regard to information for climate change and variability. Other theoretical frameworks described in this chapter include Dervin's sense making theory, Ellis's theory of information behaviour, Kuhlthau's (1991) theory of information seeking behavior and Wilson's (1996) theory of information seeking behaviour. Theoretical frameworks in research are aimed at guiding researchers with regard to the problem under study by elucidating the importance of the phenomenon under study (Leedy and Ormrod 2005:141; Ocholla and LeRoux 2011). The organisation of this chapter is based on a model for presenting a theoretical framework. This chapter is organised in six sections. Section 2.1 briefly introduces the chapter; 2.2 discusses theories related to the study; 2.3 describes the theoretical framework underpinning the study; 2.4 critically elaborates on the Diffusion of Innovations shortcomings; 2.5 explains the Sustainable Livelihood Framework and section 2.6 outlines a summary of Chapter Two.

2.2 An Overview of Theories Related to the Study

Theory is basically defined as a set of interrelated constructs (variables), definitions and propositions that presents a systematic view of phenomena by specifying relations among variables, with the purpose of explaining natural phenomena (Kerlinger 1979:64). It is a system of assumptions, principles and relationships posited to explain a specified phenomenon (Fisher 2005:2). Thus a theory explains how and why the variables are related, acting as a bridge between or among the variables (Creswell 2003:139). A theory is usually in a form of a visual model or series of hypotheses or visual statements (Leedy and Ormrod 2005:141).

In literature the concepts of theory and model often tend to be used synonymously. However, the two are related, but not similar. People define models in different contexts. A model can be defined as a simplified representation of a real situation; including the main features of the real situation it represents (Kousoyiannis 1979:3). It can be described as a simulation or a representation of relationships between, and among, concepts (Sekaran 2003:98). A model can be of great help in achieving clarity and focusing on key issues in the nature of phenomena (Cohen, Manion and Morrison 2007:13). It is worth noting that models are most useful at the description and prediction stages of understanding a phenomenon, while theories are essential in developing an explanation for a phenomenon (Fisher, Erdelez and McKechnie 2005:3). Models are of great value in the development of theory, as they are a kind of proto-theory, a tentative proposed set of relationships which can be tested for validity (Fisher, Erdelez and McKechnie 2005:2).

As highlighted in Chapter One, various theories are used in behavioural studies in the fields of information science, communication, social sciences, natural science and health and psychology. These include Diffusion of Innovations (Rogers 1995), Wilson's revised theory of information behaviour (1996), Dervin's sense making theory (1983), Ellis's theory of information behaviour (1989), Kuhlthau's information search process model (1991), the social learning theory (Bandura 1977), the self-efficacy theory (Bandura 1986), the protection motivation theory (Rogers 1975), the sustainable livelihoods framework theory (Carney, Drinkwater, Rusinow, Neefjes, Wanmali and Singh 1999), the rational choice theory (Homans 1961), the coping theory (Lazarus 1966) and the theory of planned behaviour (Ajzen 1991). In this study, the Diffusion of Innovations (DOI) was used as the theoretical framework.

2.2.1 Dervin's Sense Making Theory

Dervin's sense making theory is described as possessing a set of assumptions, a methodological approach, a set of research methods and a practice concerned with making sense of a reality in both a chaotic and orderly form (Dervin 1983). The theory which is presented in a triangular framework has three major elements. The first element is a situation in both time and space in a given context. The second element is the gap and the third attribute is an outcome. The situation describes a context where information problems emerge; a gap signifies the uncertainty situation of a person which differentiates between a particular situation and the anticipated situation. The outcome of the quest for information in

a particular situation is an outcome of a sense-making process which is achieved by means of a bridge which ends a prevailing gap between the situation and outcome elements. Among others who have applied Dervin's sense making theory in studies related to agriculture are Menou (1995), Easdown and Starasts (2004) and Munyua (2011).

2.2.2 Ellis's Information Behaviour Theory

Ellis's theory of information behaviour (1989) describes information as having eight features. The first feature describes a situation where a user recognises a need for information and initiates information seeking by asking knowledgeable people. The second feature is chaining, where a user follows citations and footnotes in sources such as citation indexes. Browsing is the third feature of Ellis' theory, where a user is involved in a semi-structured seeking process. The other feature is differentiating where a user sorts information retrieved from various information sources. Ellis (1989) describes monitoring as a fifth stage, where a user seeks information by searching current awareness information sources to keep pace with the search for new information. Thereafter a user extracts the information of his/her choice by identifying appropriate information from a source. The eighth stage in the Ellis theory is verifying where a user cross-checks the degree of accuracy when relating the information retrieved to the problem at hand. The last feature is ending, where a user concludes the search process. Studies which have used Ellis's theory are those by Ellis (1989), who assessed information seeking patterns of academic social scientists, and Downs-Rose (2009), who assessed information seeking by geoscientists in the public and private sector.

Wilson (1996) categorises features similar to those described above into two different groups. The first is micro-analysis of search behaviour, which involves starting, chaining, verifying and ending. The second is macro-analysis of information behaviour, which has browsing, monitoring and differentiating features.

2.2.3 Kuhlthau's Information Search Process Model

Kuhlthau's (1991) theory of information seeking behaviour, centres on the information search process, which has six stages in which a user is involved in initiation, selection, exploration, formulation, collection and presentation. Wilson (1996) describes the initiation stage of Kuhlthau's theory as one of possessing feelings or thoughts on the problem and uncertainty which prompts one to seek background information after recognising a need for information. The next stage is selection, which involves identifying a relevant broader topic to be searched

for in an information source. The exploration stage involves an information search on the broader topic identified while in the formulation stage a user is concerned with a specific problem relating to a topic of interest. During the collection stage the user gathers relevant information from a source and finally uses the collected information in the presentation stage. Studies which have applied Kuhlthau's theory are those by Kuhlthau (1999) who investigated the role of experience in information search, Byron (2000), on information seeking in a virtual environment, and Hyldegard's (2006) study, which explored Kuhlthau's Information Search Process (ISP) in a group education setting.

2.2.4 Wilson's Model

Wilson's (1996) model of information seeking behaviour is mostly applied in the field of information science. Its strength is attributed to two main components. First, by shedding light on the social, environmental and cognitive factors which influence the information seeking process (Niedzwiedzka 2003). Second, by borrowing other theories which are social learning theory, stress/coping theory and risk/reward theory from fields of education, sociology and economics. Wilson's model comprises five main components. These are the context of information need, the activating mechanism, intervening variables, information seeking behaviour and information processing and use. The model presents the sequential cyclical steps a user engages in, in the process of information seeking, from the rise of information need to a stage when the information is being utilised. The first component of the model is information need, which concentrates on the information needs of a person. The context can be determined by the person him or herself as a factor. The role that the person plays in work and life influences the context, and the surrounding environmental factors such as social, political or economic factors (Niedzwiedzka 2003) determine the nature of the context.

Activating mechanisms act as catalyst which stimulate and motivate the information seeking process. Activating mechanisms are explained by the stress/coping theory, the risk/reward theory and the social learning theory. The intervening variables form the third component of Wilson's model. The intervening variables, mentioned by Wilson, include psychological, demographic, environmental, role related/interpersonal and characteristics of a source. The intervening variables are deemed to be supportive as well as preventive to a person seeking information. The information acquisition stage of Wilson's model involves a passive search, an active search and ongoing search categories. In the passive category a user absorbs

relevant information from the environment unintentionally. The active search involves a purposeful quest for information, while the ongoing search is a continuing searching process which results in a behaviour of seeking information aiming at updating and expanding knowledge. The last category is information processing and use, where information accessed by a user is processed and used. Thus, depending on the content of information, a user may be satisfied or not satisfied. If not satisfied, the user may be prompted to redefine his/her information needs and continue with a information seeking process. A number of scholars have applied Wilson's model of information seeking behaviour. These include Niedźwiedzka (2003), who assessed information seeking behaviour of managers in Poland; Chiware, (2008) who assessed the business information needs, seeking patterns and information services in small, medium and micro enterprises sector in Namibia, and Nussbaumer, Slembek, Lueg, Mogenicato and Schwabe, who in their 2009 study sought to understand information seeking behaviour in the provision of financial advice in Switzerland, Austria and Germany.

Despite the above-mentioned models being strong in the information science field in explaining the information seeking processes of a user, none of the theories could be utilised as the theoretical framework for this study, due to the nature of the problem under study, which leans more towards the adoption of innovations by farmers with regard to climate change and variability and factors shaping their decision to adopt. This problem is well explained in the Diffusion of Innovations theory.

2.3 Theoretical Framework Underpinning the Study

A theoretical framework is described as a theoretical system with assumptions, concepts and forms of explanation having formal or substantive social theories (Neuman 2003:62; Neuman 2006:74). It is a logically developed, described and elaborated network of associations among the variables deemed relevant to the problem under study and identified through processes such as interviews, observations and literature surveys. These variables are explained in the DOI, where adoption is hypothetically said to be influenced by communication sources, perceived need, knowledge, attitude, cosmopolitanism, social system norms, trialability, relative advantage, complexity, compatibility and observability of an innovation. Experiences and intuition also provide guidance in developing such a framework (Sekaran 2003:97). Ocholla and LeRoux (2011) describe the theoretical framework of a study as a structure which supports a theory. A theoretical framework thus aims at envisaging and exploring the

study as an inquiry and the methodology to be used in order to come up with the solution to the phenomenon in question (Leedy and Ormrod 2005:141; Ocholla and LeRoux 2011).

Though the DOI model is not all-encompassing, its flexibility in explaining the DOI resonates well with the research problem and sub-questions of this study, which are embedded in both positivist and interpretive paradigms. DOI resonates well with the current research problems, as the research questions seek to identify issues explored most suitably by methods of both a qualitative and quantitative nature which influence farmers' adapting to climate change and variability. The issues to be identified emanate from farmers who make decisions about an innovation and the innovation is introduced to them externally. Rogers (2003:20-21) points out that the innovation-decision process is an information seeking and information-processing activity in which an individual seeks information at various stages in the innovation-decision process in order to decrease uncertainty about an innovation's expected consequences. These innovation adoption stages are knowledge, persuasion, decision, implementation and confirmation.

DOI also outlines attributes which influence the adoption of an innovation in a society. These include complexity, relative advantage, trialability, observability and compatibility. The DOI framework classifies members of a social system on the basis of their innovativeness. These include five adopter categories, which are innovators, early adopters, early majority, late majority and laggards. The DOI model also presents communication channels, time, attitude, social systems, variables and perceived characteristics of innovation as independent variables which determine whether a new innovation will be adopted or rejected. The DOI model assisted in explaining the different farmer categories in terms of the rate of adoption of new techniques for coping with climate change and variability. A detailed conceptual description of the DOI follows in the next section, 2.3.1, of this chapter.

2.3.1 Diffusion of Innovations Model

Rogers (2003:12) defined an innovation as any idea, object or practice that is perceived as new by members in a social system. Diffusion is the process by which an innovation is communicated through certain channels, over time, among the members of a social system (Rogers 2003:5). Innovation in this study is perceived in the context of climate adaptation measures which have been introduced to farmers as a result of climate change and variability. Using DOI, the study investigates how information generated through research is packaged

and disseminated to rural farmers to enable them to mitigate the negative impact of climate change and variability. Figure 2.1 shows components of Roger’s Diffusion of Innovations Model.

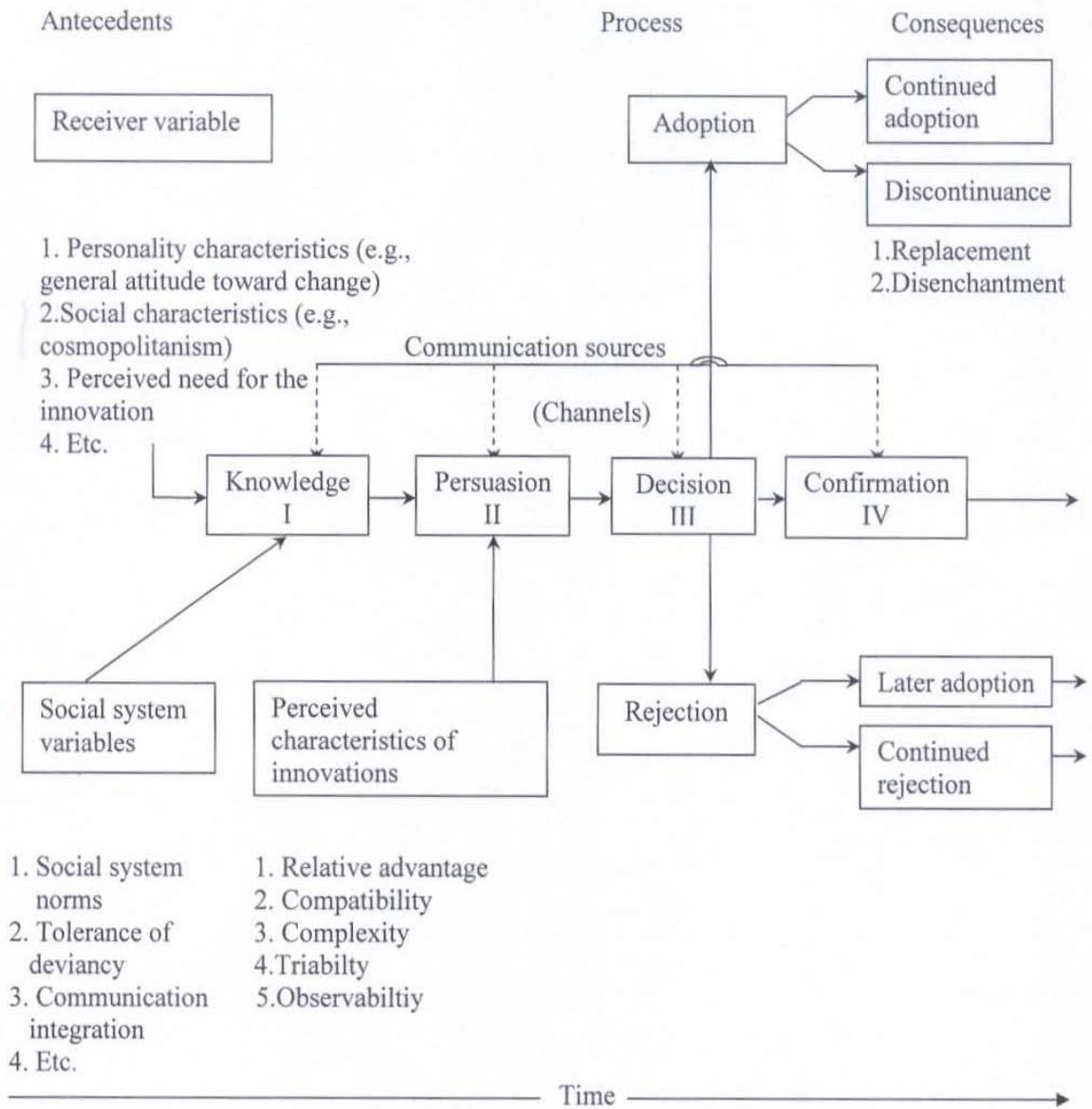


Figure 2.1: Components of Roger’s Diffusion of Innovations Model (Source: Rogers 1995:162)

Diffusion is a special type of communication concerned with the spread of messages that are perceived as new ideas. Rogers defines communication as a process in which participants create and share information with one another in order to reach a mutual understanding. Diffusion has a special character, because of the newness of an idea in the content of the message. Thus some degree of uncertainty is involved in the diffusion process. Information is a difference in matter-energy that affects uncertainty in a situation where a choice exists among a set of alternatives.

The perception of an innovation by the members of a social system, determine its rate of adoption. The present study will investigate factors which contribute to adoption or non adoption of innovation by the forming of positive or negative attitudes to a particular innovation by farmers. The study will therefore explore how attributes of innovation influence attitudes to an innovation. Innovations disseminated to farmers need to be packaged in a simple and understandable way, as many farmers are illiterate. The information on climate change and variability generated through research and training must be disseminated in a user-friendly way, to be compatible with the methods and means of farming known to farmers. Since most farmers in rural areas are illiterate, the more complex the innovation is, the less likely it is expected to be utilised by farmers.

2.3.1.1 Communication Channels

A communication channel is the means by which information flows from one individual to another. Mass media channels are more effective in creating knowledge of innovations to a wider audience. These channels of communication enhance flow to, and the exchange of information among, users by facilitating the adoption process. For example, while the radio is very important at the awareness creation stage, the extension agent becomes a critical source of information during the adoption itself. In this regard, the DOI model has had a major influence on the way information is disseminated to end-users, such as farmers, and in creating awareness (Rogers 2003). Thus the media provide information and influence opinion and judgment. Interpersonal channels are more effective, however in disseminating information to a confined group of people who share similar social-cultural values. Thus, interpersonal channels play a major role in forming and changing attitudes to an innovation decision involving adoption by farmers. Most individuals evaluate an innovation, not on the basis of scientific research by experts, but through the subjective evaluations of near-peers

who have adopted the innovation. These near-peers serve as role models, whose innovation behaviour tends to be imitated by others in their system (Rogers 2003).

2.3.1.2 People Involved in Innovation

DOI describes a change agent as an individual who attempts to influence clients' innovation-decisions in a direction that is deemed desirable by a change agency. In this regard, the nature of networks and the roles opinion leaders play determine the likelihood that the innovation will be adopted. Opinion leadership has been described as the degree to which an individual is able to influence other individuals' attitudes or overt behaviour informally, in a desired way, with relative frequency (Rogers 2003:27). Opinion leaders exert influence on audience behaviour via their personal contacts, but additional intermediaries called change agents and gatekeepers are also included in the process of diffusion. In this study, government leaders at village level and influential people in the village are referred to as opinion leaders. Their role is to sensitise farmers on innovations which aim to improve their livelihoods. Information is disseminated and channelled through various means such as agricultural extension officers, person-to-person, community radio, research findings dissemination workshops, government agencies, politicians, government leaders, television, fliers and brochures. Indeed, without these channels, the farmer cannot have access to new agricultural innovations practices such as research on new varieties of seeds which are drought and disease tolerant, new farming practices, small-scale irrigation, water conservation mechanisms such as harvesting, change and use of technology in farming, diversification on agriculture and food conservation techniques.

2.3.1.3 Supporting Mechanisms

The new agricultural knowledge acquired by the farmers will either be adapted to suit their environment or neglected (non-adaptation). To adapt, farmers will need supporting mechanisms or an environment which enhances the knowledge transformation to impact agricultural production. These include timely access to information, a well-framed institutional framework for information transfer, proper infrastructure, confidence as a result of practice and the availability of financial services. On the other hand, the failure to adapt can be caused by the lack of timely access to information sources, education (formal or informal), attitude, poverty, economy, inadequate knowledge, poor infrastructure such as roads and dwellings, and ignorance. In the present study, the channels of information and communications will be analysed to reveal an understanding of information packaging and

dissemination. More details on the description of these variables are furnished in Chapter Three of this study.

2.3.1.4 Attributes of Innovations

DOI also outlines the attributes influencing diffusion of innovations and adoption of users in a particular system. These, as stated earlier, include complexity, relative advantage, trialability, observability and compatibility. Relative advantage is defined as the degree to which an innovation is perceived as being better than the idea it presents (Rogers 2003: 229). Relative advantage is largely expressed in terms of economic and social benefits. Conversely, compatibility is the degree to which an innovation is perceived as consistent with the existing values, past experiences and needs of the potential adopter (Rogers 2003:240). Rogers further explains that an idea that is more compatible to users is less uncertain to the potential adopter and conforms to the individual's situation. Rogers (2003: 257) describes complexity as the extent to which an innovation is perceived as relatively difficult to understand and use. Rogers stresses that complexity is of critical importance when new ideas are introduced into a social system. This lies in the fact that any new idea introduced to people may be clear or not clear in meaning and thus classified on the complexity/simplicity range.

Trialability, according to Rogers (2003:266), is the level to which an innovation may be experimented with, on a limited basis. Rogers postulates that the complexity of an innovation, as perceived by members of a social system, is positively related to its rate of adoption. Additionally, observability is defined as the degree to which the results of an innovation are visible to others (Rogers 2003:266). Rogers hypothesised a positive relationship between observability of an innovation, as perceived by members of a social system, with the rate of adoption. A more detailed description of the perceived characteristics of an innovation is given in Chapter Three.

2.3.1.5 Heterophily

The DOI model describes heterophily as the degree to which two or more individuals who interact are different in certain attributes, such as beliefs, education and social status (Rogers 2003:19). The present study will seek to investigate the level of heterophily of the information disseminators (researchers and extension officers) and receivers (farmers) (See the research question in Section 1.6.2 in Chapter One, which addresses factors affecting access and use of information on adaptation to climate change and variability by farmers).

Most human communication takes place between individuals who are homophilous, a situation that leads to more effective communication. Therefore the heterophily that is often present in the diffusion of innovations leads to special problems in securing effective communication. Societal norms and attitudes of farmers towards innovation and confirmation or rejection of an innovation also play a crucial role in adaptation to climate change and variability. Hence, heterophily was used in this study to see if the differences between information disseminators (researchers, extension officers) and information users (farmers) affect the access and use of disseminated information on adaptation to climate change and variability from source to users (see questions j76 and j78 in appendices 1 and 2, respectively).

2.3.1.6 Time

Time is involved in diffusion in the innovation-decision process, the innovativeness of an individual or other unit of adoption and an innovation's rate of adoption in a system, usually measured as the number of members of the system who adopt the innovation in a given period of time. The innovation-decision process is the process through which an individual (or other decision-making unit) passes from first knowledge of an innovation to forming an attitude toward the innovation, to a decision to adopt or reject, to implementation of the new idea, and to confirmation of this decision (Rogers 2003:20).

2.3.1.7 Stages of the Innovation Process

In the innovation-decision process, five steps are involved. These are: (1) knowledge; (2) persuasion; (3) decision; (4) implementation; and (5) confirmation. Knowledge is gained when an individual learns of the innovation's existence and gains some understanding of how it functions. Persuasion takes place when an individual forms a positive or negative attitude towards the innovation. A decision occurs when an individual engages in activities that lead to a choice to adopt or reject the innovation.

The implementation stage takes place when an individual puts an innovation into use. Re-invention is said to occur during the implementation stage. Confirmation is the last stage in the decision process, and occurs when an individual seeks reinforcement of an innovation-decision that has already been made, but he or she may reverse this previous decision if exposed to conflicting messages about the innovation. Societal norms and attitudes of farmers

towards innovation and its relation to confirmation or rejection of an innovation play a crucial role in adaptation to climate change and variability.

Rogers (2003:20-21) points out that the innovation-decision process is an information seeking and information-processing activity in which an individual seeks information at various stages in the innovation-decision process in order to decrease uncertainty about an innovation's expected consequences. The innovation-decision process involves knowledge acquisition of an innovation to enhance shaping ones attitude toward adopting an innovation.

Rogers's DOI distinguishes three main types of innovation-decisions. These are optional innovation-decisions, which comprise choices made by an individual independent of the decisions of the other members of the system to adopt or reject the innovation. The second type of innovation-decision is collective innovation-decisions, where choices are made by consensus among the members of a system and the third is the authority innovation-decisions, whereby choices to adopt or reject an innovation are made by relatively few individuals in a system possessing power, status, or technical expertise. Rogers (2003:30) points out a fourth category, which consists of a sequential combination of two or more of these types of innovation-decisions, termed contingent innovation-decisions which are choices to adopt or reject that are made only after a prior innovation-decision. A social system thus influences diffusion and adoption of an innovation through shaping an individual's knowledge and hence determines adoption or rejection of an innovation.

2.3.1.8 Social System

DOI delineates a social system as a set of interrelated units that are engaged in joint problem-solving to accomplish a common goal (Rogers 2003:23). A system has a structure defined as the patterned arrangements of the units in a system, which gives stability and regularity to individual behaviour in a system. The social and communication structure of a system facilitates or impedes the diffusion of innovations in the system. Norms are the established behaviour patterns for the members of a social system and serve as a guide or standard for the behaviour of members of a social system (Rogers 2003:26).

2.3.1.9 Members of a Social System

Innovativeness is the degree to which an individual or other unit of adoption is relatively earlier in adopting new ideas than other members of a social system (Rogers 2003:22). Classifications of the members of a social system on the basis of their innovativeness include

five adopter categories. These are innovators, early adopters, early majority, late majority and laggards. Innovators are those people who are first individuals to respond by adopting an innovation. They apply the information disseminated to them by taking a risk and being ready to try an innovation so as to enjoy the benefits (Rogers 1995). Early adopters are those individuals in a society who take some time to learn from innovators on an innovation before making a decision to adopt an innovation. Early adopters make a decision to implement and confirm an innovation when they have seen the benefits to the innovators (Rogers 1995). The early majority is the third category of individuals who take more time than innovators and early adopters to utilise an innovation (Rogers 1995). This category usually looks at the innovators' and early adopters' achievements before adapting to an innovation.

The late majority forms the fourth category of members of a social system. The late majority is a category of individuals who take a much longer period of time to observe how the other subsequent categories have implemented their innovations, before embarking on an innovation. The late majority category is said to describe those who are doubtful and fear to implement an innovation, as they foresee uncertainty (Rogers 1995). Laggards are the last category of members in a society to adopt an innovation. Laggards are believed to be traditional. They dislike changes and are less motivated by an innovation (Rogers 1995). Rogers (2003) describes the rate of adoption as the relative speed with which an innovation is adopted by members of a social system. The rate of adoption is said to be contributed by a number of factors such as access to information, level of education, knowledge, finance and local institutions. A detailed description on factors, influencing adoption is explained in Chapter Three, the literature review.

In spite of the amount of research being done, and the awareness created in Tanzania to address the problem of agricultural production in relation to adaptation to climate change and variability in rural areas, little has been done to determine the impact of these efforts on rural farmers. The DOI model presents communication channels, social systems variables and perceived characteristics of innovation as independent variables. The independent variables influence the knowledge acquisition and persuasion of adaptation, which then determine whether the farmers will adopt or reject the new innovation. Once the information received is perceived as of advantage to farmers, they may adopt and continue using it, or discontinue using it at a later stage. They may decide to reject the acquired new knowledge and later on adopt it or constantly continue rejecting the new knowledge on adaptation to climate change

and variability. Hence, this study, among other issues, attempts to ascertain farmers' knowledge on climate change and variability.

It is hence anticipated that when farmers have access to information and adapt to new agricultural practices, there is a higher chance that food productivity will increase at the level of households and nationally will enhance food security. However, the fight against food insecurity cannot be achieved without reflecting on climate change and variability as a serious threat to agricultural production. The above explanations show a mutual relationship between agricultural crop production and climate change and variability. For farmers to cope, adapt and mitigate the adverse impacts of climate change and variability, they need to have adaptation information and knowledge in agricultural production. Lack of timely access to information impedes farmers' ability to make decision such as what to plant, where to plant, in which season and how to ensure food is preserved. It also affects farmers utilising opportunities arising due to climate variability, access to markets, coping knowledge to engage in other economic activities and so on. Based on the arguments above, it is the National Adaptation Programme of Action (NAPA) which aspires to imparting knowledge on best practices concerning adapting to climate change and variability to citizens in the country. Farmers will fail to adopt and practise new knowledge if the information disseminated does not reach the targeted farmers on time. Therefore this study intends to investigate how the information on adaptation to climate change and variability is packaged and disseminated to farmers within the agricultural sector in Tanzania.

2.3.2 The Applicability of DOI Model

The applicability of the DOI framework in agricultural innovation is evident in the works of Mawusi (2004), Masangano and Miles (2004), Baide (2005) and Gundu (2009).

In Kenya, Mawusi (2004) studied farmers' knowledge and perceptions of sustainable adoption regarding sugar beet. The study used structured interview schedules to collect primary data. The study observed that farmers' knowledge of sugar beet was significantly low and varied across farmers, despite their positive perceptions of the adoption of an already introduced sugar beet crop innovation. The study noted that farmers' desire to adopt was influenced by the economic returns of the crop. The findings showed that factors which influenced farmers' adoption were education on cultivation, crop prices, markets, drought, pest and diseases, availability of a factory and financial aid. Trialability seemed to play a

huge role in adoption, as it was observed that sugar beet trial farmers were more aware and possessed more knowledge of sugar beet than non-sugar beet trial farmers. The findings of the study are narrated in relation to the DOI theoretical framework attributes, such as attitude to change, relative advantage, trialability, knowledge and communication channels and channels involved in disseminating information on innovations.

The study by Masangano and Miles (2004) in Malawi assessed factors influencing farmers' adoption of the Kalima bean variety. The study employed a structured interview schedule and focus group discussions in collecting data from farmers. Key findings showed that limited access to seed, inadequate information, literacy levels, knowledge, attitudes and gender were factors influencing the adoption of the Kalima bean variety by farmers. Nevertheless, the study observed that education level, land size ownership and income were not determining factors for adoption. Additionally, it was found that for sustainable applicability of an innovation disseminated to farmers, it should be less complex, sensible when compared to what they know (relative advantage) and easy for farmers with low literacy levels to utilise. The study observed that, for farmers to adapt to the innovations, researchers should closely collaborate with farmers and extension officers to identify farmers' priorities and constrains. The authors also learned there was inadequate information disseminated to farmers. The study thus identified effective information dissemination and exchange sources for agricultural innovation to be workshops and meetings, farmer training, on-farm research and field visits. The research findings stress the role of Diffusion of Innovations attributes such as relative advantage, knowledge, attitude towards an innovation, complexity and social system norms in adoption.

A study by Gundu (2009) in Zimbabwe assessed the effect of literacy on access to, and utilisation of, agricultural information for household security. The study used interviews, focus group discussions, non-participant observation and documentary review to collect data. The study applied the DOI framework and, among other findings in Zimbabwe, established that literacy levels impeded rural women's access to and use of agricultural information. Thus, the low literacy status of women farmers in Zimbabwe contributed to failure to access information on credit, extension services, food insecurity, participation in agricultural training, post harvesting, managing agricultural produce and active participation in economic activities. The study revealed that farmers lacked information on farming methods, pest and

disease control, marketing and pricing, farm security and livestock management and innovative knowledge to assist them in diversifying to other economic activities.

The study observed that informal information sources and channels and social networks were mostly relied upon by farmers with low education levels, due to ease of access and the low cost of the search for information. The low level usage of formal information sources such as radio was attributed to the failure of the source to address the farmers' need. The study learned that print sources were least used and university researchers, non-governmental organisations, churches and other private companies were involved in disseminating information to farmers. The findings described resonate well in the DOI model, through its attributes such as knowledge, persuasion and dissemination and access of information through communication sources and channels, innovation complexity and perceived need for an innovation. These described findings reflect the DOI attributes such as inadequate information dissemination and access have resulted in a negative attitude towards innovations and their being viewed as complex. As a consequence, low usage of agricultural information has led to poor participation in socio-economic activities due to inadequate knowledge on best agricultural practices.

In the United States of America (USA) Baide (2005) explored the barriers to adoption of sustainable agriculture practices (SAP) in the Southern States. The study collected data through a semi-structured questionnaire from respondents' (change agents) emails. It was revealed that change agents involved in promoting awareness on sustainable agricultural practices among farmers were not delivering services adequately. The main reason observed was lack of sufficient knowledge and lack of receptivity by change agents on SAP. The study revealed that the barriers to adoption of SAP were complex sustainable agricultural practices which farmers could not understand and utilise. Other barriers included economic factors such as risk and uncertainty about adopting sustainable practices, cost of transitioning and delay of benefits for many sustainable practices. The study discovered that inadequate information and education on sustainable agricultural practices concerning innovations was an impediment to farmers' adoption. It was concluded that information sources were not effective in accumulating, organising and disseminating relevant information to farmers.

Baide's (2005) study learned that farmers were not adapting to SAP, as they were reluctant to change to new practices and abandon their farming cultures, norms and traditions.

Incompatibility of sustainable agricultural practices with the available known management strategies was also an obstacle to adoption due to additional operations such as labour being required. The study noted that social factors such as misleading perceptions and beliefs, personal characteristics such as age, adhering to old farming practices, as well as lack of an observable example showing the benefits of SAP were seen as influential factors in adoption. Last but not least, the study highlighted land tenure and lack of infrastructure such as farm inputs, equipment and market and financial institutions as factors determining farmers' adoption of sustainable agriculture practices. The findings hinge on DOI theoretical framework attributes such as perceived attitudes to an innovation, attitude to change, knowledge, awareness, communication sources, communication channels, relative advantage, complexity, observability, social system norms and compatibility.

The research questions of the present study covered issues such as types of information on climate change and variability disseminated to farmers, information packaging and dissemination, farmers knowledge of adaptation, access and use of information on climate change and variability, attitudes and perceptions of farmers towards climate change and variability and factors affecting access to, and use of, information on adaptation to climate change and variability.

2.3.3 Shortcomings of the Diffusion of Innovations Theoretical Framework

Notwithstanding the significance of the Diffusion of Innovations model in influencing agricultural policy formulation and implementation, the theoretical framework has been criticised by a number of scholars, as well as its applicability in developing countries. Baide's (2005) study of barriers to adoption of sustainable agricultural practices in the Southern States of the USA noted that one of the major shortcomings of the DOI theoretical framework is that it ignores external factors such as politics, infrastructure and economy, which heavily influence dissemination and acquisition of knowledge by farmers to enhance agricultural crop production. Supporting this point, a narrative study by Manda (2002), on the history of agricultural development in Tanzania, criticised the DOI framework for ignoring structural constraints such as the role of the state in the provision of seeds and fertilizers and the neglect of institutions that promote agricultural development. This then resulted in weak research and extension institutions which are crucial in the diffusion processes which affect agricultural development (Manda 2002).

Baide (2005) noted that DOI theoretical framework neglects the indigenous knowledge of farmers and assumes voluntary change. This model is Eurocentric, as it assumes information is well generated and packaged from the source and disseminated through proper communication channels in the diffusion process (Manda 2002). The DOI framework fails to show the participatory aspect which is crucial in ensuring information is exchanged and shared with farmers. In light of the above, Mawusi (2004) connotes that the DOI theoretical framework assumes pro-innovation, where researchers reinforce the adoption of innovations without actively involving farmers in identifying their need before the inception of a project.

The DOI theoretical framework is further criticised as it assumes an individual will adopt the information disseminated to him/her. This is not practical in the case of many farmers in developing countries due to the existence of wide social-economic gaps between individuals as a result of disparities in access to resources (Mawusi 2004). The shortcomings of the DOI are critical in most developing countries such as Tanzania, as their economies largely depend on agriculture and most farmers have low literacy and education levels. To address the DOI shortcomings, the Sustainable Livelihoods Framework (SLF) was used. The framework was applied in this study as it well elucidates other salient and influential factors, such as those pertaining to socio-economic, institutions structure and framework and infrastructure, which the DOI framework does not address. The research question which the SLF framework supported investigating was the limiting factors affecting access to, and use of, information on adaptation to climate change and variability by farmers. The SLF is more diversified in explaining other limiting factors such as human capital, social capital and natural and physical capital, which contribute to farmers' inability to adapt to climate change and variability.

A few authors who have applied this framework in climate change and variability studies are Elasha, Elhassan, Ahmed and Zakieldin (2005); Meena and O'Keefee (2007); Ospina and Heeks (2010) and Dulal, Brodnig, Onoriose, and Thakur (2010). Elasha *et al.* (2005), in Sudan, applied a sustainable livelihood framework to assess the adoption of environmental management and sustainable livelihood interventions towards reducing potential community vulnerability to climate change and building resilience to climate-related shocks. Meena and O'Keefee (2007) used the SLF to assess the role of capital assets and institutional and political factors in enhancing adaptation to farmers in Chaga community in Tanzania. The study showed that capital assets and institutional structures largely determine the ability of

vulnerable groups to cope with shocks and ultimately adapt to climate change and vulnerability. A study by Muthoni (2012) adopted the SLF to study gender and climate change in Mwanza district of Tanzania. Key findings of the study were that social networks were effective in enhancing women adaptive capacity to climate change and variability.

Ospina and Heeks (2010) used the SLF to demonstrate the role of ICTs in strengthening and consolidating efforts to build adaptive capacities of people to enhance adaptation. The study developed a model which could be used to explore strategies which might contribute in identifying approaches that will enhance capacity to adapt in order to accomplish development plans. Dulal, Brodnig, Onoriose and Thakur's (2010) study adopted the SLF and sought to assess factors which affect farmers in Nepal. The study showed that farmers' adaptation to climate change and vulnerability was greatly explained by capital assets and institutional frameworks which are essential mechanisms which support climate change adaptation. Some of the factors impeding farmers' options and strategies to adapt to climate change and vulnerability include low levels of literacy, depleted natural resources, inadequate land and lack of financial services. Section 2.4 of this chapter describes the Sustainable Livelihoods Framework (SLF) which was partly applied in the study.

2.4 Sustainable Livelihood Framework (SLF)

As mentioned in Chapter One, the SLF was borrowed from as a framework in response to the specific objective which investigated factors which affected farmers' adaptation to climate change and variability. The reason for using the SLF lies in the fact that factors which might impede farmers' adoption of innovations can be broadened to carry a number of livelihood assets, as described below. Factors which affect farmers' adoption have been described in detail in the Chapter Three. The SLF hinges on people's livelihoods and the relationship between factors which influence the sustainable livelihood system (Carney, Drinkwater, Rusinow, Neefjes, Wanmali and Singh 1999).

The SLF prioritises people's assets which are tangible and non-tangible and their aptitude to endure shock. Livelihood assets include financial capital, human capital, natural capital, physical capital and social capital (Carney *et al.* 1999). Financial capital is among the livelihood assets component which exposes people with various livelihood options through savings, capital, grants, credit, regular remittances or pensions. Carney *et al.* (1999) describes human capital as another livelihood assets' component which includes people's knowledge,

skills and health that enable someone to perform livelihood activities effectively. Natural capital is another SLF component which upholds natural resources stocks and enhances resources to be exploited. The natural capital resources include land, biodiversity, water, wildlife and other environmental resources. Physical capital assets include infrastructure in place, such as transportation equipment, roads, water, communications and energy. The physical assets provide the means which enable people to engage in a livelihood activity.

Social capital assets are resources which use networks, associations, group memberships and influential people in a society to pursue livelihoods. The SLF describe the vulnerability context, policies and institutions that affect poor people's livelihoods. The SLF shows a mutual relationship between livelihood assets and structures such as government levels and private sector. It also shows the mutual relationship between processes such as institutions, policies, laws and culture and livelihood assets (Carney *et al.*, 1999; Assessment of Impact and Adaptation to Climate Change (AIACC) 2005). Vulnerability in farmers can be reduced by ensuring livelihood assets and that transforming structures and processes are well structured. As a result, farmers' livelihood outcomes such as increase in income, food security, improved well-being and more participatory natural resources management plans can be effectively achieved. Figure 2 shows the Sustainable Livelihood Framework.

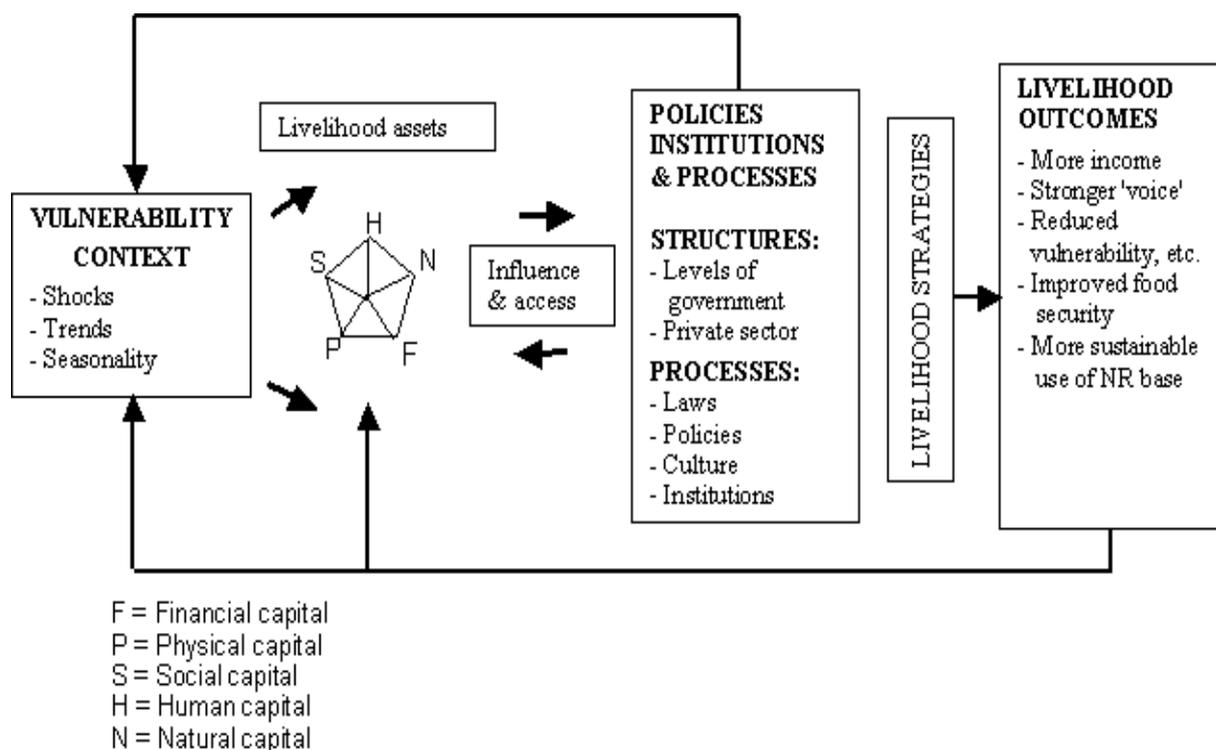


Figure 2.2: Sustainable Livelihoods Framework (Source: Carney, et al. 1999:1977)

2.5 Summary

This chapter gave a short introduction to the theories used in the field of information science and behavioural science. The theories reviewed include Wilson's revised theory of information behaviour (1996), Dervin's sense making theory (1983), Ellis's theory (1989), and Kuhlthau's (1991) theory of information seeking behaviour. These theoretical frameworks were briefly described and it was observed that, despite their potential contribution in explaining the research problem on how repackaging and dissemination of information on climate change and variability is done, the DOI was more explicit in illustrating and reflecting the research problems of the study. The chapter further discussed and conceptualised the Diffusion of Innovations model which underpins the study and showed its applicability in this study. The chapter briefly explained the Sustainable Livelihoods Framework, which is widely applied in the field of climate science and was borrowed to respond to the research problem which could not be elaborated on well if the Diffusion of Innovations model was used. Detailed descriptions of variables which have been highlighted in this chapter are demonstrated in the next chapter, Chapter Three.

CHAPTER THREE

LITERATURE REVIEW

3.1 Introduction

Chapter Three presents an overview of the role of the literature review and the literature reviewed for the study arranged by theme. The themes discussed are categorised into 16 sections reflecting the objectives and research questions of the study. Section 3.1 introduces the chapter; section 3.2 gives an overview of the purpose of literature review; section 3.3 explains dissemination and access to agricultural information. Section 3.4 discusses farmers adoption of innovation in agriculture; section 3.5 provides an overview of climate change and variability globally; section 3.6 describes education and awareness on climate change and variability; section 3.7 elaborates on adaptation to climate change and variability in agriculture. Section 3.8 explains the communication channels used in information dissemination; section 3.9 enlarges the role of information and knowledge on mitigation and adaptation to climate change and variability; section 3.10 discusses farmers' knowledge on adaptation to climate change and variability; section 3.11 explains farmers' attitudes to climate change and variability and section 3.12 discusses factors affecting access to, and use of, information on adaptation to climate change and variability. Finally, the chapter describes the determinants of adaptation to climate change and variability in section 3.13; section 3.14 shows the research gap; section 3.15 provides a summary for Chapter Three.

3.2 Literature Review: An Overview

Kumar (2005:30) describes a literature review as an integral part of the entire research process. Reviewing the literature is based on the assumption that knowledge accumulates and that people learn from and build on what others have done (Neuman 2003:96). The literature is reviewed by scholars with various objectives derived from the research they wish to conduct. Creswell (2003:29-30) and Bryman (2008:81) point out that literature is reviewed so as to be able to engage in a scholarly review based on the reading and understanding of other studies in the same field. Thus the existing literature acquaints a researcher with the available body of knowledge in one's area of interest (Neuman 2003:96; Kumar 2005:30). A review of the literature facilitates limiting the scope of a study and conveys to the readers the need to explore a particular topic (Creswell 2003:27). Bryman (2008:81) points out that the literature review process should not be to reproduce theories and opinions from other scholars, but to

be able to interpret what one has written, using one's own ideas to support a particular argument. A literature review also helps a researcher to clarify ideas, to focus on a research problem, to establish the theoretical base of a study and to develop a methodology (Kumar 2005:30). A literature review helps one compare the study's findings with those of others (Creswell 2003:30; Kumar 2005:30). In reviewing the literature one should be able to develop an argument about the significance of the research being conducted and where it leads (Bryman 2008:81). Thus the review of the literature shows the path taken by previous researchers in the field and how they link with the current one (Neuman 2003:96).

3.3 Dissemination of, and Access to, Agricultural Information by Farmers

Dissemination of information refers to the sending of agricultural information to farmers, while access refers to the ability of farmers to receive information from sources (See Chapter One section 1.9). Sub-section 3.3.1 discusses communication channels used in disseminating agricultural information to farmers. Sub-section 3.3.2 discusses the factors affecting the dissemination of agricultural information to farmers. Sub-section 3.3.3 describes the sources farmers use to access agricultural information.

3.3.1 Communication Channels Used to Disseminate Agricultural Information to Farmers

Information on adaptation to climate change and variability is being disseminated in a number of ways to farmers. These include agents such as non-governmental organisations, researchers, extension services and social networks, who use leaflets, posters, workshops, demonstrations, such as those at Farmer Field Schools (FFS), radio and television (TV) stations to disseminate the information. Studies indicate that the effectiveness of these information and communication media differ between developed and developing countries. Pounds (1985) found that knowing where people look for information tends to partly solve the problem but knowing where one can find the information is another part which ensures usage of the disseminated information. Cartmell II, Orr and Kelemen (2004) explained that for information to be used, it must suit their needs and be disseminated in a manner which ensures its reception. The authors furthermore point out that it is always essential to know the users, and the study methods used to disseminate information to them, for effective information delivery. As pointed out by Rogers (1995), for effective adoption and use, information disseminated to farmers should address issues such as complexity, compatibility and should be relatively better when compared with conventional innovations.

In their study on methods of information dissemination to limited-scale landowners in Oklahoma, USA, Cartmell II, Orr and Kelemen (2004) used snowball sampling to identify respondents and conducted in-depth interviews in collecting data. The study discovered that most farmers preferred direct mail and TV as the main source of information disseminated and the least preferred radio and workshops. Their findings indicated that less than half of landowners relied on, and used, extension services, while the majority did not use the services. Despite that observation on farmers' reliance on, and usage of certain channels, the findings were that most often these landowners sought agricultural information from extension services and the Internet. Information disseminated by extension services was about types of crops to plant, soil conservation, breeds of livestock suitable for farmers and water testing.

In the USA, Orr (2003) noted that, although extension officers still disseminated information through meetings, on-farm visits and field days, there was a shift by farmers to other means of accessing information such as the Internet, video and computer software packages. Cartmell II, Orr and Kelemen (2004) support this observation. They found that most limited-scale landowners used the Internet to access information. The authors observed that demographic factors such as age and education status did not influence the limited-scale landowners' information access and usage positively. Agwu, Ekwueme and Anyanwu (2008) explored the adoption of improved agricultural technologies disseminated via radio by farmers in Enugu state, Nigeria. The study revealed that radio farmer programmes enhanced the extent of farmers' adoption of new technologies such as modern land preparation and planting of early season crops, improved early maize cultivation, yam harvesting and storage of the crops in barns. The programmes also helped farmers on site selection, processing of cocoyam into chips and flour, weeding and fertilizer application in yam, cassava, maize intercropping and pest and disease control in food crops. These findings corroborate those of Ingram, Roncoli and Kirshen (2002), who observed that radio was the preference of the majority of farmers in Burkina Faso in disseminating forecast information.

3.3.2 Factors Affecting the Disseminating of Agricultural Information to Farmers

The study by Agwu, Ekwueme and Anyanwu (2008) identified broadcasting time and language barriers and feedback as major constraints which hindered effective access to, and use of, information prepared for farmers. The programmes were explicitly described as too short and as being inappropriately scheduled. It was observed that the radio programmes were

scheduled at a time when farmers were busy with farming activities and thus could not listen. Agwu, Ekwueme and Anyanwu showed that the language used in presenting the programmes, the inability of farmers to ask relevant questions and poor feedback from radio presenters affected farmers' access to, and use of, information. Since most farmers in the rural areas rely on the radio for awareness and knowledge of various socio-economic issues, including agricultural development, poorly structured radio programmes and inadequate feedback deny farmers the opportunity to access and use information to enhance their knowledge. Inadequate knowledge reduces farmers' confidence in introduced innovations and develop a negative attitude towards trialability and observability, knowledge, persuasion, decision and application attributes as described by the Diffusion of Innovations theoretical framework (Rogers 2003).

The role of extension officers in disseminating information on climate change and variability is exceedingly important. Despite the crucial role played by extension officers, Agwu, Ekwueme and Anyanwu (2008) found that they were not disseminating agricultural information to farmers effectively. They thus hindered farmers' information sharing and usage of information about innovations. Ingram, Roncoli and Kirshen (2002) found that, although government extension officers were disseminating information to farmers, they were faced with financial challenges, as the budget from the government was not sufficient. In addition Mutekwa (2009), in Zimbabwe, observed that extension workers lacked accurate information and knowledge on climate change and variability, which is a prerequisite tool in adaptation strategies for enhancing the agricultural production of farmers.

Agwaru, Matsiko and Delve (2004) studied approaches to the dissemination of research information to farmers within their livelihood situations in the Tororo district, Uganda. They had different findings about information disseminated to farmers. The study revealed that, despite information being disseminated to farmers, farmers still had inadequate information on the availability and use of improved crop varieties, soil improvement, livestock breeds and post-harvest innovative practices. The study also indicated that farmers had a problem with accessing improved seeds and they needed more education and training for improving their farming practices.

Agwaru, Matsiko and Delve (2004) revealed that information sharing by farmers was based on group discussions and field demonstrations. However, the limited amount of information

available to farmers, which caused poor utilisation of their training, was due to poorly designed content and format of the information disseminated to them. Authors found that the training content was poorly prepared, badly scheduled and sessions which were essential for ensuring information usage were lacking. The study recommended more time for farmers to practise and intensive training sessions by extension providers. Their findings indicated that information can be disseminated but information users fail to utilise it due to a number of factors, amongst which are problems with the format and content of information, such as poorly packaged information and the complexity of the contents. Other factors are attitudes to an innovation, lack of perceptions of relative advantage and inadequate means of communicating information to farmers (Rogers 2003).

Ofuoku and Agumagu (2008) concluded that learning and adoption of innovations are more effective when audio and visual methods were used. The study suggested that extension teaching should be supported by adequate and appropriate visual aids for quick understanding and adoption of innovations. The authors stressed a need for training extension officers to enhance their skills in information dissemination by developing new communication mechanisms for use with farmers. Hassan, Shaffril, Ali, Ramli (2010) discovered that the print material which stored agricultural information for farmers was distributed to farmers through major events such as exhibitions, staff in district offices and meetings with department of agriculture officials and through the department's website. The study further showed that, despite the fact that farmers knew that there was information being posted on agricultural websites, they did not access information on the websites.

Feedback from experts on information disseminated to farmers is crucial in ensuring usage of information and adaptation to climate change and variability. Ingram, Roncoli and Kirshen's (2002) study in Burkina Faso showed that although information on the adaptation to climate change and variability was disseminated to farmers through various channels such as radios, friends and TV, the farmers preferred an expert to explain the envisaged climate risks and response measures available to them. Similarly, in Malaysia, the study by Hassan *et al.* (2010) revealed a strong cyclic feedback loop between farmers and extension officers, which enhanced information usage, as farmers were able to identify the information and knowledge gap. The study ascertained the means for feedback from farmers as interpersonal communication from agricultural officers, special field days, email and suggestion boxes. These efforts are vital in unpacking information to ensure diffusion of an innovation through

stakeholders by participatory means, thus creating a state-of-the-art practice, where an innovation is not complex, and can be assessed for compatibility, dependability and trialability.

Although information can effectively be disseminated to farmers, miscommunications, information delays, limited distribution of funds and poor co-ordination of ways of spreading the information have largely affected its usage by farmers (Hassan *et al.* 2010). These authors observed that despite farmers' need for printed materials for creating awareness, print resources were not easily accessible. Their availability to farmers was limited, as they were only prepared and supplied upon request. The study observed that information in print format was sometimes not reaching farmers at the grassroots level, due to problems such as inadequate numbers of copies of brochures produced. Although local institutions are seen as the platform and channel for collecting, storing and disseminating agricultural information, Agrawal (2008) underscores the essence of local governance and institutions as being catalysts which facilitate the implementation of adaptation strategies to improve livelihoods. He states that local institutions influence and shape the way people access and use resources at local level and, in that way, influence the impact of the interventions and the vulnerability of people.

Indeed, information being updated, reliable and timely is of paramount importance in ensuring its utilisation by farmers. Hassan *et al.* (2010) revealed that most of the printed materials used by farmers were produced annually, instead of more often. Access to outdated print sources might have contributed to farmers' low preference and usage of the sources. Thus, as pointed out by Machila *et al.* (2006), the frequency of publication tends to influence awareness of disseminated information by farmers. Producing publications for farmers on a regular basis can enhance their knowledge sharing and understanding of agricultural practices. Up-to-date and current information has been observed to play a critical role in enhancing the knowledge of farmers and thus being among the predictors of farmers' growth and development (Nielsen and Heffernan 2006). Thus access to timely information on climate change and variability is a great need for improving farmers' agricultural production and their well-being.

3.3.3 Sources Used by Farmers to Access Agricultural Information

Ofuoku and Agumagu (2008) researched farmers' perceptions of audiovisual aids in technology dissemination by an agricultural development programme in Delta State, Nigeria. The researchers found that radio, TV and posters were mentioned as the most common audio-visual formats for farmers in accessing information on agriculture. However, in terms of usage, farmers preferred a combination of TV and agricultural shows, followed by film shows and, lastly, agents and posters. The most effective audio-visual delivery technique as perceived by farmers was TV handbills and films. The least effective delivery techniques were meetings, chalkboard and computer compact disks.

In Malaysia, Hassan, Shaffril, Ali, Ramli (2010) explored the flow of information to farmers through the mass media and an agricultural agency. They discovered that farmers used printed materials, radio, TV and the Internet in accessing information. Interestingly, the study revealed that farmers preferred, and relied more on, TV and printed materials than radio and Internet in accessing and using information. Farmers' preference for TV was based on the ability to observe how other farmers' practised and applied the innovation which was being introduced. The study found that farmers did not use radio to access information and many were not even aware of the agricultural programmes on radio. Print sources were preferred due to their acceptance and being familiar to farmers. Agricultural information was packaged and spread through extension officers. Hassan, Shaffril, Ali and Ramli (2010) showed that the printed materials used by Malaysian farmers included books, bulletins, pamphlets and brochures. However farmers asked that the printed publications be prepared in a local language, to enhance the usage of the information. It was also shown that the low usage of newspapers by farmers to access agricultural information was attributed to poor awareness by farmers who did not know about the availability of extension services in newspapers.

In Zambia, Kaniki (1994) discovered that farmers' major sources used to access information were friends, relatives and neighbours. His study underscores the fact that, despite farmers using a number of sources for accessing information, they often rely on their personal experience in responding to their farming problems. The trend was similar in Tanzania, according to Chilimo (2008) and Lwoga (2009). Momodu (2002) in Nigeria found that farmers did not trust government sources of information and thought they were in the interests of the government only. Hassan *et al.* (2010) revealed that, apart from TV, which was mostly preferred by farmers to access agricultural innovations disseminated, there was

wide recognition of NGOs actively participating in disseminating information to farmers, especially on pesticide usage. Thus, as has been observed from the literature, the research findings on farmers' agricultural information in rural areas of many developing countries show that farmers prefer information from informal sources to that of formal sources. These findings are supported by Dutta (2009), who concluded that people in developing countries mainly rely upon informal social networks to meet their information needs. The explanation of the observed phenomenon might be poor telecommunications infrastructure and farmers' low levels of literacy and education.

Various studies findings in the literature revealed that most sources of disseminated agricultural information by farmers were radio and extension officers. Moreover interpersonal sources such as person-to-person means through social networking were widely used to access agricultural information. A trend showed that social networking through the exchange of information from one farmer to another in developing countries was highly preferred due to its easy access and low costs of usage. On the other hand, in developed countries, TV, the Internet, printed material such as magazines and newspapers, and fliers were most used commonly by farmers due to the developed infrastructure and financial conditions of farmers. However, from the literature reviewed, it has been noted that, despite a number of factors influencing farmers' usage of disseminated information, poorly packaged and complex information contents spread to farmers were a barrier to imparting knowledge and to enhancing the adoption and diffusion of innovations in most developing countries.

3.4 Farmers' Adoption of Innovations in Agriculture

Rogers (1995:21) defines adoption as a decision to make full use of an innovation as the best course of action available. He described adoption of innovations as having two stages. One is individuals' continued use of innovations while the other is rejecting using the adopted innovations. Adoption of innovation is of immense importance to farmers' adaptation to climate change and variability, as it exposes farmers to new knowledge on improving agricultural production. Boahene, Snijders and Folmer (1999) carried out a socio-economic analysis of the adoption of hybrid cocoa innovation and viewed the determinants as social, economic and cultural factors. However, the authors mention that various disciplines describe factors influencing adoption by adhering to the nature of that particular discipline, for example, economists lean more to profitability, cost and risk on innovation investments and

sociologists lean more to the compatibility of the values and norms of a society and communication channels.

Nevertheless, for adoption of an innovation to take place, farmers should first perceive a need for that innovation (Rogers 2003). Belkin (1980) described information need as the recognition of knowledge (ASK), which exists when a person recognises there is a gap or uncertainty in his/her state of information and knowledge about a situation or problem at hand. On the other hand, Case (2002:5), however viewed information need as recognition that personal knowledge is inadequate to satisfy a goal that needs to be achieved. Information need was described as a gap in an individual's knowledge in sense-making situations by Dervin, Foreman-Wernet and Lauterbach (2003).

3.4.1 Factors Influencing Adoption of Innovations

There are various studies across the world which shows factors affecting the adoption and use of the innovations packaged and disseminated to farmers. Erbaugh, Donnermeyer, Amujal (2007) assessed the impact of farmer field school (FFS) participation in the adoption of integrated pest management (IPM) in Uganda. They used probability sampling to select samples and applied structured interviews in data collection. The study found that farmers' access to knowledge was the major factor which promoted adoption of innovations. Other factors which influenced adoption of IPM strategies included education, size of land and total income. The study observed that climate change and variability, market access and labour availability influenced farmers' adoption. Contrary to many studies on the adoption of IPM, the Ugandan study postulates that higher total income farmers were less likely to adopt IPM strategies, due to farmers having other on-or-off-farm income-generating priorities other than cowpea farming. These other priorities meant that their interest, time and willingness to take on additional risks associated with the adoption of new practices was reduced. Age and gender did not influence adoption.

A study conducted in Ghana by Boahene, Snijders and Folmer (1999) found that the adoption was low and several factors contributed to the phenomenon. The research used simple random and purposive sampling and interviews to collect data from 103 farmers. The farmers had been involved in cultivating cocoa for a period of two years. Findings were that large-scale farmers had better access to bank loans thus increasing their chances of adoption, compared to small-scale farmers. The research found that small-scale-farmers' adoption was

highly influenced by information and communication through social networks. The study revealed that factors such as farmers' access to information through extension officers, farmers' education level and the availability of hired labour had positive effects on adoption. Contrary to the findings from a number of studies, this study found that access to land, income, skills and family size had no significant influence on adoption. The study observed that an indirect supporting role was played by farmers' social network supports and social status in the adoption of an innovation. The social network and status of farmers enhanced their adoption through access to bank loans, which they used in improving agricultural production.

Akudugu, Guo and Dadzie (2012) were other scholars in Ghana who explored factors influencing the adoption of modern agricultural production technologies by farmers. Their study used probability multistage and simple random sampling to identify respondents. They interviewed respondents using a household questionnaire. Key study findings were that households had a low adoption rate of modern agricultural production technologies. The study also deduced that economic factors which significantly influenced farmers' decision to adopt were farm size, expected benefits from the technology, access to credit and off-farm income-generation activities. The social factors influencing adoption were age of farmers, level of education and gender while institutional factors were the extension services. Thus the study revealed that farmers' decision to adopt agricultural technology can be greatly enhanced when socio-economic factors and institutional factors are favourable.

In Nigeria, Matthews-Njoku, Adesope and Iruba (2009) studied the acceptability of improved crop production practices among rural women in Anambra State. The study employed a structured questionnaire in data collection, where extension officers were used to administer the questionnaire. The study discovered that farmers were not receiving adequate technical information from extension officers, who were the key communication channels to enhance the spread of information. Inadequate receipt of technical information by farmers contributed to the low usage of improved crop production practices which, in turn, hindered agricultural production by women. These findings confirm those by Dimelu and Saingbe (2006), who reasoned that adoption and utilisation of appropriate agricultural technology by rural farmers is largely dependent on the relevance and effectiveness of information dissemination and the ability of the agents to convince the farmers. Matthews-Njoku, Adesope and Iruba (2009) observed that adoption of new agricultural technologies was affected by socio-economic

variables, such as household size, number of farms owned and access to land, farming experience, extension contact with the farmers, level of income, access to appropriate farm input and access to land and credit facilities.

The findings of Matthews-Njoku, Adesope and Iruba (2009) in Nigeria, tend to confirm, and yet also differ from those of Mukhopadhyay (1994:99) in West Bengal, India. They confirm what Mukhopadhyay (1994:99) observed, that the adoption of innovation and technology was promoted by attributes such as farmers' knowledge of local conditions, experience and availability of extension services, quality of land owned and availability of irrigation. Yet the two studies differ, as that in India adduced the factors which appeared insignificant to adoption in the Nigerian study, that is the size of the land owned, the level of education and the value of the assets of the household, such as the house, machinery, cattle and so on, which were contrary to the findings of Matthews-Njoku, Adesope and Irubas (2009).

In Malawi, Masangano and Miles (2004) investigated the factors influencing the adoption by farmers of a new variety of bean known as Kalima. The study applied an interview schedule and focus group discussions in data collection. Key findings were that the decision to adopt was promoted by factors such as gender, literacy level and level of education. The study discovered that farmers had negative perceptions of the Kalima beans' yield, pest susceptibility and tolerance, cooking time and colour. The study found that, despite other contributing factors such as gender, literacy level and education, favouring the adoption of the Kalima bean variety, information disseminated to farmers was poorly packaged and delivered. As a result, farmers accumulated negative perceptions, which restrained them from adopting the Kalima bean variety. The study stressed that to increase the rate of adoption, information concerning an innovation should be well structured and appropriately packaged to accommodate the low literacy level of farmers. Rogers (2003) stressed that for adoption of innovation to take place, farmers should have positive attitudes towards change, the information disseminated to the farmers should be less complex and compatible to their settings. The innovation should offer a relative advantage when compared to one they have been using.

In Kenya, Goldberger (2008) investigated the diffusion and adoption of organic agriculture in the semi-arid Makueni district. The study employed several data collection methods, such as structured and semi-structured interviews, observation and documentary analysis. The study

showed that farmers were confused by the information about the application of organic and artificial fertilizers from information providers such as local and northern non-governmental organisations and government extension officers. The confusion arose from the observed poor co-ordination of organic agricultural programmes. The content packaged and disseminated by information providers differed between providers. As a result, farmers experienced difficulties in deciding which information to use and which to abandon. The study further found that farmers' decisions to adopt an innovation was, to a greater extent, influenced by their personal preferences, knowledge levels, perceived needs and farm characteristics.

A study conducted by Rousan (2007) in Jordan, on factors influencing adoption of improved farming practices among women farmers, showed that, despite a number of interventions by the government of Jordan to improve agricultural production through women farmers' participation, the country still was experiencing low food production. The research study used a simple random technique and a structured interview schedule in data collection found out that key determining factors influencing adoption of innovation by Jordanian women farmers was cost, relative advantage of an innovation and simplicity of an application. The study revealed that adopter characteristics, such as attitude to change, land tenure system, risk taking, income level, technical skill, educational level and labour availability were strong adopter characteristics in adoption. Rousan (2007) discovered that the characteristics of the information source such as credibility and competency and climate change variability promoted adoption. Furthermore, when a correlation test was conducted to show the association of features persuading women farmers to adopt the innovation and actual adoption rate, the findings were that credibility, cost, land tenure, capability to be shared, communication ability and the relative advantage had a positive and significant relationship with adoption of the innovation. Thus, to a great extent, these factors delineated in the study resonated well with the Diffusion of Innovations theoretical framework attributes such as compatibility, complexity, attitude towards change, attitude towards an innovation and relative advantages (Rogers 2003).

It was observed that for an innovation to be adopted by farmers, a situational analysis should be conducted prior to the introduction of the innovation, so as to take into account the farmers' needs, beliefs, norms and taboos, rather than the researchers' beliefs and scientific arguments about agricultural innovation (Sturdy, Jewitt and Lorentz 2008). Supporting this,

Rousan (2007) found that cultural factors such as norms, beliefs and taboos greatly influence adoption. The social system norms which are a component of the Diffusion of Innovations theoretical framework accommodate the above factors which influence adoption.

In Honduras, Arellanes and Lee (2003) applied household interviews in collecting data to study farmers' adoption of sustainable agricultural technologies. The study, which explored the determinants of the adoption of low-input sustainable agriculture technologies in hillside areas, found that farmers' had adopted the use of minimum tillage agricultural practices. The minimum tillage practices included use of leguminous cover crops, commercial vegetation production and soil enrichment, including fertilizer usage. The study found that household income and farmers' characteristics such as age, gender and level of education did not significantly influence adoption of minimum tillage. The study deduced that adoption of *labranza minima*, a minimum tillage innovation, was significantly influenced by the simplicity of the innovation, affordability, the availability of water through irrigation practices, land ownership, soil quality and farm land with steeper slopes.

In the USA, Scandizzo and Savastano (2010) studied perceptions on adoption of Genetically Modified (GM) crops. The study reviewed a dataset on the adoption and diffusion of GM crops over a period of eight years and found that, despite criticism, modern GM crops still positively contribute towards enhancing the farmers' agricultural production, by minimising production risks. The benefit hinges on the ability of GM crops to resolve output and input uncertainties. Despite many scholastic studies, associating the slow pace of the adoption of GM crops with determinants such as lack of information, overstated risk perceptions and mistrust, findings showed that the economic return of GM crops through production and time investment through short duration profitability tend to supersede the risks. Apart from environmental concerns, the study underscores the finding that economic returns of GM crops in many developed countries such as China and Argentina can only be achieved if farmers' uncertainty is conquered. Thus, notwithstanding the observed economic profitability of GM crops, the authors strongly emphasise the need to address institutional information obstacles through effective information dissemination to farmers and overcoming the institutional barriers such as administrative and government interventions.

A study in El Salvador and Honduras, in Central America, by Bravo-Ureta, Solis, Cocchi and Quiroga (2006) conducted a database analysis on the determinants of farm income and

adoption among farmers participating in natural resource management interventions. The findings indicated that land use variables, such as soil conservation practices and structures, output diversification and adoption of forestry systems, had a statistically positive association with farm income. The research findings showed that land tenure was among the contributing factors to adoption, as farmers with larger farms and who owned land benefitted from higher farm incomes than those who did not. Thus, farmers' adoption of conservation practices to a greater extent depended on the income farmers' generated and the income generation was influenced by land ownership, farms size, access to credit and human capital.

In sub-Saharan Africa, Drechsel, Olaleye, Adeoti, Thiombiano, Barry and Vohland (2006) studied adoption drivers and constraints of resource conservation technologies. The study observed that adoption of resource conservation technologies is dependent on the farmers' perceptions of the attributes of innovation, such as relative advantage, complexity, compatibility, trialability, observability/visibility, uniqueness of the technology introduced, farmers' needs, the technology proposed and availability of land, knowledge, capital and credit, time, labour and skills, which are critical production factors. Other factors include information and knowledge sharing, farmers' attitudes to trialability in experiments and risk tolerance, institutional support and the relevant policy being in place. The study further shows that cultural norms and taboos such as local traditional practices and indigenous knowledge (IK) should be handled sensitively when introducing an innovation for effective technological adoption. These attributes are also explained in the Rogers Diffusion of Innovations framework (Rogers 2003).

In Tanzania, where the current study was conducted, various authors revealed factors quite similar to those from other international studies. Kaliba, Verkuijl and Mwangi, (2000) used documentary analysis to collect data from farmers on the factors affecting the adoption of improved maize seed and the use of inorganic fertilizer for maize production in the intermediate and lowland zones. The study found that there was a low use of improved maize seeds and inorganic fertilizers for maize production by farmers. Issues that contributed to the low usage of inorganic fertilizer were inadequate extension services to supply information to farmers, poor implementation of on-farm field trials and poor rainfall distribution. The study revealed other factors which influenced adoption as risk, economic returns from farmers' preferred maize varieties, which maximised profit with minimal loss, and the geographical characteristics of an area. The study found that collaboration between researchers and farmers

was of profound importance in enhancing the adoption of an innovation, because participation between researchers and farmers enhanced the identification of farmers' needs, information exchange and sharing for knowledge generation and usage. Similar findings were observed in South Africa by Sturdy, Jewitt and Lorentz (2008).

Other authors in Tanzania, namely Bengesi, Wambula and Ndunguru (2004), investigated farmers' utilisation of agricultural innovations through examining their adoption of hybrid maize production technologies in Mwanga district. The study applied interviews and observation methods in data collection and found that adoption of hybrid maize by Mwanga maize farmers' was, to a great extent, correlated with farm size, gender and annual income. In order to enhance farmers' cultivation and use of hybrid maize in agricultural production, sensitization and education was of great value.

Sturdy, Jewitt and Lorentz (2008), in the Bergville district of South Africa, sought to understand the agricultural innovation adoption processes through farmer-driven experimentation. The study used various participatory learning and action research techniques, such as semi-structured interviews, group discussions, informal discussions, presentations, work sharing, process notes, direct observation, personal diaries, matrix scoring, key informants mentioned and technical instrumentation. It was observed from the study that farmers were being faced with multiple stressors, both biophysical and socio-economic, which impeded their decision to adapt to the agricultural innovations introduced to them. The authors noted that it has widely been observed that researchers and extension officers have accused farmers of not adopting disseminated innovations. Nonetheless, the authors learned that, in most cases, this was a false observation as, in reality, farmers needed innovations to improve their agricultural production and livelihoods. The study did not ignore other factors such as social and economic issues surrounding farmers, which needed to be dealt with if innovation was to take place successfully. The study observed that perceived need, participation, investment options and risks were the major factors which influenced the farmers' adoption of agricultural innovations in this district.

For adoption to take place, scholars such as Salinger, Sivakumar and Motha (2005) demonstrated the need to engage farmers in participating in various agricultural projects, so that researchers can identify their needs and effectively disseminate information to farmers. Sturdy, Jewitt and Lorentz (2008) found that collaboration between agricultural information

disseminators was vital in enhancing effective information and knowledge transfer and sharing insights through farmers' trial and error. Their study showed that farmers who were willing to learn and practise on garden farming developed skills and acquired new knowledge which assisted them to improve their agricultural production. These findings by Sturdy, Jewitt and Lorentz (2008) corroborate those by Diederer, Meijl, Wolters and Bijak (2003) in the Netherlands. These authors observed that farmers who were innovators were more engaged in improving agricultural innovations and used extension services more than early adopters. Thus as observed by Sturdy, Jewitt and Lorentz (2008), farmer-driven experimentation was an effective farmer/extension agent participatory tool, which enabled farmers to evaluate an innovation and allowed researchers to assess their innovations newly introduced to farmers. Researchers could scientifically identify reasons for their acceptance or rejections.

Contrary to many studies, a study by Feder and Savastano (2006) in Indonesia on the role of opinion leaders in the diffusion of new knowledge on IPM found that social economic factors and farming skills did not highly influence adoption, but rather opinion leaders' superiority was a great determining factor to enhancing farmer's adoption of an innovation. The study raised the need for opinion leaders not to be excessively superior, as they might unconsciously serve the interests of those individuals with the higher status as they associate with one another.

Thus, from the literature reviewed, findings have demonstrated that the most influential factors for adoption in many developing countries are access to information, knowledge, packaging and information dissemination, education level, capital/loan/grant, access to agricultural inputs, attitude and technology. Adoption of an innovation cannot be achieved if farmers lack access to information on best agricultural practices to improve agriculture and combat adverse impacts of climate change and variability. Adoption and diffusion of an innovation heavily depend on the format of the innovation. The more complex an innovation is, the less likely it will be utilised. As a result, in developing countries, the situation is likely to be worse, as most farmers have low levels of literacy and education (Gundu 2009).

A review study on determinants of agricultural best management practice adoption in the USA in the last 25 years, by Prokopy, Floress, Klotthor-Weinkauff and Baumgart-Getz (2008), showed a similarity in most of the factors found to influence adoption in many

studies. However, a slight difference which farmers mentioned as influencing adoption is recognition of environmental issues, including climate change and variability. The study showed that highly cited factors promoting farmers' adoption and diffusion of innovation in the USA were education levels, capital, income, farm size, access to information, positive environmental attitudes, environmental awareness and utilisation of social networks.

3.5 Climate Change and Variability

Climate is defined as the average weather conditions for a given place or region, based on long-term averages usually depicting rainfall, temperature, wind and humidity rates, over 30 years or longer (Yanda and Mubaya 2011). Weather is described as daily and weekly atmospheric variability while climate variability refers to variations of the climate system, which includes oceans, the land surface and the atmosphere, over months, years and decades (Hellmuth, Moorhead, Thomson and Williams 2007). The FAO has described climate variability as referring to short-term deviation of climatic parameters of a region that vary from their long-term mean due to internal processes such as earthquakes, vulcanicity and external forces such as industrialisation, agriculture and urbanisation (FAO 2007). On the other hand climate change refers to longer-term patterns in average temperature or rainfall or in climate variability itself, and often to trends resulting wholly or in part from human activities, notably global warming, due to the burning of fossil fuels (Hellmuth, Moorhead, Thomson and Williams 2007).

Climate change and variability is a phenomenon which refers to weather changes over short and long periods of time (IPCC 2007). These changes have, and will have, both negative and positive impacts on societies. IPCC (2001a) noted that as a result of climate change and variability, atmospheric carbon dioxide will increase, causing a shift in agricultural belts. Thus, existing farming practices in various geographical areas will have to change, cope and adapt to new crop varieties, diversify other economic activities or stop practising farming and migrate to other opportunistic localities. Although developing countries are the lowest producers of atmospheric greenhouse gases compared to the developed countries, the impacts are higher in developing countries, due to the high cost required for adaptation to climate change and vulnerability (Mertz, Halsnas, Olesen and Rasmussen 2009). Thus developing countries are more vulnerable, due to low adaptive capacity, dependence on climatic resources and heavy reliance on rain-fed agriculture for economic development (Hernes,

Dalfelt, Berntsen, Holtmark, Naess, Selrod and Aaheim 1995; Salinger, Sivakumar and Motha 2005; Gwambene 2007; Mongi, Majule and Lyimo 2010).

3.5.1 Impacts of Climate Change and Variability

Coles and Scott (2009), who studied vulnerability and adaptation to climate change and variability in the USA, discovered that drought, floods and frost were the main climatic risks which affected farmers in agricultural production. The study observed that farmers depended more on groundwater use than rain-fed agriculture, while drought was a major concern to livestock/farmers, as they needed rain for pasture growth. In India, Dhaka, Chayal and Poonia (2010) observed that climate change and variability had affected the economy, as it had contributed to a number of climate-related disasters such as droughts, floods, cyclones, frost, hailstorms, extreme temperature and high winds. These factors caused adverse impacts on water resources, agriculture, food security and biodiversity, heavily reducing agricultural production.

Developing countries will experience the effects of climate change differently, not only because of differences in the projected change of climate parameters, but also because vulnerabilities and adaptive capacities vary greatly between nations and regions (Mertz, Halsnas, Olesen and Rasmussen 2009). In Africa it has been observed by Boko, Niang, Nyong, Vogel, Githeko and Medany (2007) that sub-Saharan Africa is highly vulnerable to climate change and other stressors and it has the lowest ranking on its adaptive capacity to climate change and variability (Haddad 2005). In southern Africa, Gregory, Ingram and Brklacich (2005) found climate to be among the most frequently cited drivers of food insecurity, whereas Mertz, Halsnas, Olesen and Rasmussen (2009) found that changes in agricultural strategies in a region in Senegal were not easily identified as adaptation to climate change and variability, but rather attributed to economic and policy drivers. In India key future impacts were identified by the IPCC (2007) and included increased water stress in India, loss of mangroves and other coastal lands in Southeast Asia due to sea level rise, and disturbance of forests and agriculture due to the possibility of more intense El Niño events, as mentioned by Cruz, Harasawa, Lal, Wu, Anokhin, Punsalmaa, Honda, Jafari, Li and Huu (2007).

Yanda and Mubaya (2011) stated that although Africa was least responsible for climate change and variability, it is more vulnerable to the impacts, such as food insecurity, increased

drought, floods and long dry spells, reduced crop production, increased prevalence of diseases and an increased threat of conflicts arising from the scramble for water resources and scarce fertile land. In Africa, estimates of changes in precipitation and evaporation for 11 major river basins indicate that eight of the systems could experience an overall decrease in runoff (Arnell 1999). These river basins include the Volta in West Africa, the Shabeelle in North-/East Africa, the Ogooué in West/Central Africa, the Rufiji, Ruvuma and Limpopo in East Africa and the Zambezi and Orange in southern Africa (Arnell 1999). Conversely, Obioha (2005) points out that the northern part of Nigeria, which is located away from the sea, has been experiencing continuous climate change and variability, characterised by reduction in rainfall and increase in the rate of dryness and heat, while the north-eastern part of Nigeria, which was mainly a savannah, is increasingly becoming an arid environment at the receding rate of six metres per year. This change is occasioned by the fast depletion of the amount of surface water and flora and fauna resources on the land.

Obioha (2005) researched climate change, population drift and violent conflict over land resources in north-eastern Nigeria and found that climate change and variability affects agricultural activity and that the magnitude of negative effect on animal husbandry is greater than in any other sector. The study observed that climate change and variability is causing conflict between livestock keepers and farmers involved in crop production. The conflict occurs when herdsmen are involved in searching for greener pastures which brings them into contact with sedentary populations who are involved in crop production.

In Tanzania, Mwandosya, Nyenzi and Luhanga's (1998) predicted a low yield in crops such as maize by 10% after a decade. Lema and Majule (2009) and Gwambene (2007) observed that an increase in climate change and variability has been associated with people adapting to, and coping with, other economic activities to sustain life by local communities in various areas of Tanzania. This means the majority of people who were formerly practising agriculture now have embarked on other economic activities for their livelihood. The study by Lema and Majule (2009) was conducted in the Manyoni district, in the central part of Tanzania which is semi-arid land. The study revealed that the villages studied were seriously affected by frequent food shortages as a result of rainfall uncertainty, exacerbated by climate change and variability. The study further revealed that climate change and variability in the area has caused an increase in rainfall unpredictability, increased pests and diseases and decrease in soil fertility in the Manyoni district. Similar findings were observed in semi-arid

areas by Lyimo and Kangalawe (2010) in Shinyanga region; Mongi, Majule and Lyimo (2010), in Tabora region in Tanzania and Slegers (2008) in Dodoma region.

Yanda and William (2010) found that, as a result of climate change and variability, rural people in Tanzania engaged in other economic activities such as selling charcoal, establishing restaurants (viosk), utilising non-wood forest products, expanding areas under cultivation to compensate for reduced yields during droughts by reducing fallows, switching to more drought-resistant crops such as sorghum and cassava, brick production and working as casual labour. Lyimo and Kangalawe (2010) observed that climate change and variability has caused an increase in food insecurity as a result of a decline in crop production. The authors state that the rural community's vulnerability was greatly aggravated by climate change and variability in the area.

3.6 Education on Climate Change and Variability

Farmers' education and awareness is of great concern in developing countries' efforts to mitigate the adverse effects of climate change and variability in these countries (Mandleni and Anim 2011). The following sub-sections discuss issues related to education and awareness of farmers regarding climate change and vulnerability.

3.6.1 Promoting Awareness of Climate Change and Variability

Awareness and knowledge of climate change and variability is of supreme importance in people's adaptation process. Supporting the argument, Corner (2011) points out that awareness and knowledge of climate change is crucial in directly determining how people respond to climate change and variability. The reason is that information dissemination is critical for creating awareness in people regarding climate change and variability for effective adaptation to take place. Mass media, researchers, extension officers, NGOs, civil societies, and Community-Based Organizations have been disseminating information to farmers on best farming practices, aiming at enhancing farmers' adaptation to climate change and variability and mitigating its effects.

To promote education and improve awareness and understating on climate change and variability issues globally, the United Nations Framework Convention on Climate Change (UNFCCC) formed a legal framework to ensure that countries adhere to the laws and regulations set and agreed by member states. Article six of UNFCCC and article ten (e) of the Kyoto Protocol are vicarious examples of the commitment of member states to espouse

climate change and variability. The two articles stress the necessity of development and implementation of educational and public awareness programmes on the effects of climate change and variability, promoting public access to information on climate change and variability and its effects, strengthening national institutions and training scientific, technical and managerial personnel (UNFCC 2012).

3.6.2 Factors Affecting Awareness of Climate Change and Variability

There are a number of studies globally which demonstrate the *status quo* regarding global awareness of climate change and variability. A study in selected developed countries by Anderson (2009) on media, politics and climate change observed that the media play a major role in shaping public views and policy agendas, thanks to their ability to reach a much wider audience. Notwithstanding this fact, the study observed that media reporting on climate change and variability, are to a great extent, influenced by socio-political factors and affected by political and industry interests. The study observed a paradigm shift in the media industry in which, recently, public media have increasingly emphasised human interest, celebrities and an entertaining style of reporting which heavily discourages the reporting of so-called imaginary, complex and multi-faceted climate change issues. The study adduced the globalization of news media ownership to be a contributing factor to not creating awareness of climate change and variability.

A similar study, also in developed countries, by Boykoff (2008), assessing the role of the media in scientific communication observed that mass media such as radio, TV, newspaper and Internet play a crucial role in shaping knowledge construction and maintaining debate on climate change and variability, by acting as a link between science and policy. The study found that factors such as journalism, culture, politics, economic norms and uncertainty influence discourses and awareness of climate change and variability. Despite the role of mass media in creating awareness, the study observed that uncertainty was being propagated by contrarians who opposed climate change and variability debates for their own benefit, including economic benefit. The author noted that some people who oppose the issues related to climate change also owned and controlled the media and thus influenced people's awareness in the direction of their preferences.

In the USA, Nisbet (2009) explored effective ways of disseminating and communicating climate change and variability information to the audience. Nisbet's study found that, despite

the mass media greatly ensuring that the audience received information, much of the information reached only a small proportion of the targeted audience. The study discovered that the content on issues related to climate change and variability were not well framed, resulting in low receptivity by people and influencing their level of awareness. Other barriers identified as affecting awareness on climate change and variability were the nature of the media system, which had a variety of content choices that were also complex for an ordinary person to understand.

Thus, from Nisbet's (2009) point of view, for effective information and communication to be in place, information should be framed in the form of interpretive storylines which could be used to capture common understanding of diverse audiences. As a result peoples' personal behaviour would be shaped for much more collective action towards sensitising people on climate change and variability. The study underscores the importance of using interpersonal sources of information, such as influential people in a society, for disseminating and communicating information as they are close to the community. The Diffusion of Innovations theoretical framework also stresses the use of social networks, including influencing people to be custodians and leaders of adoption of innovations (Rogers 2003).

In Japan, Sampei and Aoyagi-Usui (2009) studied mass-media coverage and its influence on public awareness in climate change and variability issues. Data was collected through documentary analysis for the period of January 1998 to July 2007. The study findings showed a slight increase in newspaper coverage of climate change and variability issues before January 2007 and a tremendous increase in coverage of issues related to climate change and variability from January 2007. According to the authors, the phenomenon might be influenced by the political arena in the USA, which involved international events on climate change and variability. The study stressed the use of personal communication as a sustainable strategy in raising the awareness of people.

Lorenzoni, Nicholso-Cole and Whitmarsh (2007) studied barriers perceived to hinder engaging with climate change and variability among the United Kingdom public. The study noted that, in order to develop sustainable solutions regarding peoples' understanding of climate change and variability issues, information should be provided regularly. People's involvement in these issues and providing more time for people to change attitudes are necessary steps to raising awareness on climate change and variability. The study categorised

the individual's state of knowledge on the awareness of climate change as comprised of cognitive, affective and behavioural components. Awareness in people can be achieved by sensitising people to the need to care for the environment, by motivating them to take action in adaptation plans for climate change and variability to be effective.

In Canada, McBean and Hengeveld (2000) explored the challenges of communicating the science of climate change. The study discovered a communication gap between scientists involved in climate science debates and other users of information. The study observed that lack of effective communication skills in scientists, misinformation provided by the opposition and lack of scientific knowledge by public media editors and journalists were factors contributing to the people's confusion about, and to, impediments to information on climate change and variability access and usage. Indeed, the journalist's state of awareness has been noted by Anderson (2009), who observed that journalists are faced with various challenges in covering news on climate change and variability, including their inadequate knowledge of climate change and variability issues and structural barriers in the media industry. The study by McBean and Hengeveld (2000) advocates the provisional access to credible and quality information which is understandable for the public community and is of paramount importance if awareness is to reach different categories of people.

In Uganda, Corner (2011) explored challenges and opportunities for communicating climate change. The study collected data through focus groups and interviews from government, private sector, media and community organisations. Key findings showed that, although many stakeholders have been involved in educating and creating awareness in people, there is still a low understanding of the term climate change by most people and only a few are knowledgeable about the term. The study found out that, although journalists are important channels for raising awareness in their audience, they experienced difficulties with their stories on climate change and variability being accepted by news editors. However, the study narrated that this phenomenon might be attributed to lack of knowledge by news editors or skepticism about information on climate change and variability. Contrary to this finding in Uganda, McBean and Hengeveld (2000) in Canada observed that editors and journalists exaggerated information in climate change and variability to capture headlines, while, in a real sense, they lacked knowledge and understanding on the issues on climate change and variability.

Mertz, Mbow, Reenberg and Diouf's (2008) study explored farmers' perceptions of climate change and agricultural adaptation strategies in rural Sahel. The study collected data using a household questionnaire, focus group discussions and interviews. Study findings indicated that households were highly aware of the issue of climate change and variability. However, the study found that farmers responded differently when prompted on questions of land usage and livelihood strategies through agricultural production by associating the problems with economic, social and political events. It is thus not certain whether or not farmers were aware of climate change and variability issues.

In Zimbabwe, Mutekwa (2009) investigated climate change impacts on farmers and adaptation in the agricultural sector. They came up with interesting findings. They showed that though information and knowledge on climate change was available, agricultural extension officers and non-governmental staffs were not educating farmers on the current changing climatic conditions and what the situation is likely to be in the future. The study of Deressa, Hassan, Ringler, Alemu and Yesuf (2008) on determinants of farmers' choice of adaptation and perceptions of climate change in the Nile basin, Ethiopia, discovered that farmers were not aware of the potential adaptation options and methods on climate change and variability. In order to sensitise people, the study emphasised the use of informal social networks to facilitate information access, sharing and use. Farmers should be exposed to the observable examples of other farmers who had utilised the improved new crop varieties, so as to be motivated. More research on the use of crop varieties and livestock species which suit drier, arid and semi-arid conditions should be advocated to promote farmer awareness. The study suggested investing in technological packages which increase farm income, facilitating access to credit, irrigation and creating an enabling environment for off-farm employment.

Jonge (2010) researched farmers' perceptions of adaptation to climate change in the state of South Australia. The study used phone interviews and workshops in data collection. The study found that farmers were aware of climate change and variability. Farmers, however lacked knowledge on climate change and variability as they associated the phenomenon with natural climatic variability and did not view it as human-induced. The study further observed that age, educational level and location tend to influence perceptions of climate change and variability. In this regard, notwithstanding the efforts to create awareness in people by stakeholders involved in information dissemination and communication, much has still to be done. Gwimbi (2009), Mutekwa (2009), McBean and Hengeveld (2000) have shown that

much of information on climate change and variability is at the higher levels, such as national and regional levels of decision-makers. In most African countries the information users, who are the basic targets for scientific research and discourses on climate change and variability, have not reaped the expected benefits (Tarhule 2007). Information needs to be spread to farmers in an understandable manner, to assist them in farm level decision-making.

Kadi, Njau, Mwikya and Kamga (2011) studied the state of climate information services for agriculture and food security in East African countries. The study used questionnaires, interviews, field visits, discussions and websites for data collection. The study observed that there is increased awareness on climate change and variability and that there is a call for adaptation in the East African regions. The study observed that half of the farmers in these East African countries have not been exposed to research and extension services. Laizer (1999) confirms farmers' difficulties in accessing agricultural information and found that only a small amount of information on various innovations is known by the majority of smallholder farmers. Similar findings by Mowo, Tanui, Masuki, Lyamchai and Adimassu (2011) were that, despite the availability of extensive information and experience from integrated natural resource management research this information could not reach potential users, as a result of its improper presentation. These authors learned that, even with their availability, these services in most cases do not encompass the effective needs of farmers. The study further observed that, despite farmers' awareness, effective adaptation strategies can be enhanced through assessing farmers' capacity to express their agricultural needs, create partnerships between information service providers and farmers and build capacity in service providers to enable them to respond to expressed needs.

Thus, from the literature reviewed, and in spite of the significant contribution of stakeholders involved in disseminating information on climate change and variability, it is still uncertain whether or not people are aware of climate change and variability. Orindi and Murray (2005) observed that awareness of climate change and variability in East Africa was low, as people saw it as a distant and not immediate problem affecting their socio-economic activities. The reviewed literature from several case studies globally, but mostly from Africa, have shown that farmers are aware of climate change and variability in their localities. It is not clear if they are adapting as a result of awareness received from sources of information or if they are practicing what they know from indigenous knowledge.

3.7 Adaptation to Climate Change and Variability in Agriculture

Adaptation to climate change and variability is broad and cuts across different sectors. It is defined differently by scholars from various disciplines. Moser and Ekstrom (2010:1) described adaptation as involving changes in social-ecological systems in response to the actual and expected impacts of climate change and variability, by considering non-climatic changes such as land use planning, infrastructure replacement and renovating buildings. Smit, Burton, Klein and Wandel (2000:228) defined adaptation as the process of adapting to the resulting outcome or condition aiming at better suiting the new conditions. Their study observed that adaptations can be passive, reactive or anticipatory. They can be spontaneous or planned. The study revealed that adaptation depends solely on the system's attributes, encompassing its vulnerabilities and sensitivities. Thus the nature of the forms and processes of adaptation can be differentiated by several characters such as timing, rationale and impact.

3.7.1 Impact of Climate Change and Variability Adaptation in Development

A number of scholars have observed a correlation between climate change and variability and development. Ayers and Huq (2009) highlight the impacts of climate change and variability that pose a serious threat to development and reason that there is an urgent need for action to be taken on adaptation by developing countries. This argument is supported by several studies (Majule 2008; Agrawala, Moehner, Hemp, Aalst, Hitz, Smith, Meena, Mwakifwamba, Hyera and Mwaipopo 2003 and Lema and Majule 2009), which were conducted in Tanzania. They revealed that climatic change and variability is causing serious impacts on various natural resources, including agriculture, which is the main source of livelihood in rural areas. Downing, Ringius, Hulme and Waughray (1997) pointed out that, in responding to the vulnerability posed by climate change and variability, African countries will have to invest more resources from their economies for adaptation strategies. Thus, climate change and variability pose a serious threat to the economy, development and livelihood of communities in developing countries, which most depend on rain-fed agriculture.

Adaptation to climate change and variability needs vast investment and budgetary flexibility. The United Nations Development Programme (UNDP) (2006) estimated that the funds countries spend for adaptation to climate change and variability will be more than US\$86 billion per annum. Supporting this point, Agrawal *et al.* (2003) learned that Tanzania received billions of United States dollars as official development assistance and between 12%

and 25% of the development assistance was channelled to the sectors which are mostly affected by climate risk. Mongi, Majule and Lyimo (2010) observed that, in Tanzania, in 2006 the country experienced a major drought, which caused severe food shortages and power crises. The study found that the cost of food shortages to the country's economy was estimated to be US\$200 million in food importation and distribution.

Thus, as pointed out by Mertz, Mbow, Reenberg and Diouf (2009), there is an urgent need to link climate vulnerabilities and development policies, because of the strong association with developing countries' development initiatives. The view was supported by Devereux and Edward (2004), who warned that climate change and variability should not only be seen as an environmental concern, but as a growing risk to poverty eradication strategies and sustainable development.

Other authors argue that African governments should mainstream climate change and variability issues into policy development and investment in decision-making. Moser and Ekstrom (2010:2) cautioned that adaptation cannot be effective if it ignores the provision of adequate information, stakeholders' participation, broad agreement and the social and biophysical breadth of the problem. Their study proposed a strategy for overcoming barriers to adaptation involving understanding, planning and managing stages. Understanding involves problem detection, problem redefinition, awareness heightening and information gathering and use. The second, planning stage, involves the development of adaptation options and selecting options. Lastly, the management phase involves implementing the selected option, monitoring the environment and outcomes of identified options and finally evaluating the situation.

In India, Dhaka, Chayal and Poonia (2010) stated that having knowledge of global climate change and variability is essential for embracing initiatives in developing mechanisms to adapt and respond to climate change and variability. Their study observed that adaptation to climate change and variability requires farmers to first note that climate has changed, so that they can identify possible useful adaptation options. In Canada, Smit and Skinner (2002) conducted a typological study on adaptation options in agriculture. The study found that technological developments, diversifying farm production practices, interventions through government programmes and insurance and farm financial management were components which stimulate adaptation in the agricultural sector. The authors emphasised the critical role

of information provision to motivate the above adaptation initiatives. The study learned that most adaptation choices are modifications to known public policy. Farm practice decision-making needs to conform to both climate change and variability and non-climatic conditions, including social, economic and political.

From the literature reviewed it is apparent that developing countries will need much more investment and capital for mitigation and adaptation to climate change and variability. This is because climate change and variability affects livelihoods and in most African countries the agricultural sector is depended upon for economic growth and employment (Mertz, Mbow, Reenberg and Diouf 2009). As the literature shows (Gwambene 2007; Barbier, Yacouba, Karambiri, Zorome and Some 2009; Ziervogel and Zermoglio 2009; Lyimo and Kangalawe 2010), poor people are the worst affected because of widespread poverty, low adaptive capacity and dependence on the natural environment. In this regard, the role of timely information for development and adaptation to climate change and variability can never be overemphasised (Chikozho 2010).

3.7.2 Government Strategies on Environmental Conservation and Mitigation of Climate Change and Variability in Tanzania

Tanzania has signed and ratified a number of international treaties and agreements on managing and preserving the environment. These concern Ozone Layer Protection, the Biodiversity Treaty, Wetlands, Climate Change, Endangered Species, Climate Change-Kyoto-Kyoto Protocol, Desertification and Hazardous Waste (CIA Fact Book 2013). Specifically, the treaties and agreements that government has signed at international level are the United Nations' Convention on Biological Diversity (CBD) of 1992 and the United Nations Convention to Combat Desertification (UNCCD) of 1997 (URT 2012b).

Others include the Basel Convention on the Control of Trans-boundary Movements of Hazardous Wastes and their Disposal of 1989; the Vienna Convention on the Protection of the Ozone Layer and the Montreal Protocol on Substances that Deplete the Ozone Layer of 1993; the Stockholm Convention on Persistent Organic Pollutants (POPs) of 2001; the United Nations Framework Convention on Climate Change (UNFCCC) of 1992; the Convention on Preservation of Fauna and Flora in their Natural State of 1993 and the Convention on Sustainable Management of Lake Tanganyika of 2004 (URT 2012b).

In addition, there have been a number of initiatives and studies aimed at addressing the adverse impacts of climate change and variability in Tanzania. These include the Inventory of Green House Gases (GHG) emissions; technological and other options for GHG Mitigation; the Assessment of Vulnerability and Adaptation to Climate Change; the Development of the Climate Change National Action Plan and the Adoption of the National Environment Policy (URT 2012b). Other government initiatives concerning responding to climate change and variability include the Preparation of the Initial National Communication to the UNFCCC; the Revised National Energy Policy; the National Adaptation Programme of Action (NAPA) and the Enactment of the Environment Management Act-Cap 1991.

Additional government initiatives to address climate change and variability are the Assessment of Technology Needs Assessment (TNA); the National Clean Development Mechanism Handbook; the National Strategy for Reducing Emissions from Deforestation and Forest Degradation (REDD+); Climate Change, Impacts, Adaptation and Mitigation in Tanzania (CCIAM); Climate Change Impacts Assessment-Tanzania and Climate Change Adaptation in Africa (CCAA) (URT 2012b).

Recently, there have been two major climate change and variability farmer-centred outreach programmes conducted between the government of Tanzania and donors in collaboration with higher learning institutions. The projects are aimed at disseminating information and innovations for adaptation of climate change and variability. The projects include the CCAA project, which commenced in 2007 and the CCIAM programme launched on 2009. The CCAA project aimed at imparting innovations and information farmers to enhance their capacity to adapt to climate change and variability. The CCIAM programme focused on Reducing Emissions and Desertification (REDD) in Tanzania. It is evident that Tanzania has engaged in diverse policy initiatives in this area. The current study investigates the role of the CCAA project in the dissemination of information on innovations to mitigate climate change and variability.

3.8 Specific Communication Channels Used in Information Dissemination for Farmers' Adaptation

A number of scholars have stressed the importance of access to, and use of, agricultural information for adaptation to climate change and variability. Basically, farmers access information through channels of information which may be interpersonal, such as person to

person, government leaders, workshop trainings and elders; researchers and extension officers; institutional such as NGOs and government leaders; and media such as radio, Television, newspapers, magazines and brochures.

Access to information on climate change and variability alone does not guarantee its usage in improving agricultural practices. Mengistu (2011) emphasises a pertinent issue in the adaptation to the climate change and variability discourse, which is not only ensuring that farmers have accessed information on climate change and variability, but that they should be assisted to understand and use that information for improving their agricultural activities. Mengistu suggested that, in order to enhance information sharing and exchange with farmers, elderly and religious leaders should be sensitised on the use of traditional climate forecasts in predicting climatic conditions for decision-making.

Speranza, Kiteme, Ambenje, Wiesmann and Makali (2010), in their study of climate change and variability in semi-arid Kenya used interviews, group discussions and questionnaires for data collection. Their study found that most farmers do not seek climate forecast information for the next season from any source and a minority depended on IK for decision making. Findings showed that only one third of farmers who had prior information and foreknowledge of drought could utilise it by deploying adaptive measures. The study observed that climate forecast information is mostly being accessed by farmers through radio, newspapers and TV. The study discovered that most farmers who had information on forthcoming droughts used the information to adapt by planting drought-resistant crops and seeds, planting early-maturing crops, saving money and not selling grain.

Agwaru, Matsiko and Delve (2004) assessed approaches used to disseminate research information to farmers in Tororo, Uganda. The study used face-to-face and group interviews to collect data. The study revealed that the channels for information transfer to farmers were trained extension providers, who spread information through practical training sessions. Information sharing with farmers was based on group discussions and field demonstrations. Mutekwa (2009) researched climate change and variability impacts and adaptation by farmers in Zimbabwe. He discovered that researchers and academics who were supposed to be sources of information to ensure that adaptation strategies are well packaged and disseminated to farmers, had limited awareness of the nature and magnitude of climate change and variability.

Coles and Scott (2009) studied vulnerability and adaptation to climate change and variability in the USA. They found that farmers unlike, their counterparts in developing countries, did not have the problem of access to information on climate for farm decision making, but rather had a problem of using the information to enhance their adaptive capacity. Farmers read the seasonal climate forecast out of curiosity and did not make use of it. Thus, notwithstanding the prospect of information dissemination and access and use through sharing information on adaptation, many farmers and ranchers around the world do not use information on climate change and variability in their farm managerial strategies (Hansen, 2002; Hill and Mjelde, 2002; Hansen, Challinor, Ines, Wheeler, and Moron 2006). Coles and Scott's (2009) study on farmers' vulnerability and adaptation to climate change in the USA showed that information on climate is being disseminated and accessed by farmers' through workshops, visiting individuals at home, receiving phone calls, office visits, distributing newsletters by mail or e-mail and providing information on the Internet. The study found that other farmers exchange information through chance encounters in public places, or while visiting friends and neighbours.

Mensah-Fosu, Vleck and Manschadi (2010) studied farmers' perceptions of adaptation to climate change in the Sekyedumase district in Ghana. They observed that farmers' adaptation was low and the problem could be linked with inadequate information given to farmers on adapting to climate change and variability. This observation, according to Mensah-Fosu, Vleck and Manschadi (2010) was attributed mostly to inadequate numbers of extension personnel, who also lacked knowledge on adaptation of climate change and variability in the district.

Sturdy, Jewitt and Lorentz (2008) in their study on the innovation adoption process through farmer-driven experimentation observed that collaboration between information and knowledge providers and users was critical in ensuring farmers' adaptation to new innovations. However, their study found that identifying and working with the stakeholders such as researchers, extension officers, NGOs, local organisations and farmers' associations was a challenge which needed a considerable investment of time and resources. In spite of the situation, their participation created crucial platforms for gaining knowledge on livelihood practices, adaptation, vulnerability, attitude towards risks and community assets and thus formed a basis for designing innovations which met the needs and priorities of farmers.

Ziervogel and Downing (2004) studied the role of networks stakeholders in improving seasonal climate forecasts in Lesotho. The study used interviews and workshops to solicit data. The authors reasoned that for new scientific information and knowledge to reach an extensive audience, it should be disseminated across networks diversely, to create awareness and effective usage. The authors highlighted the importance of understanding networks as crucial in identifying the barriers and opportunities stakeholders meet in the course of information sharing of disseminated forecast information. The role of networks in enhancing the flow of information to farmers has been stressed by Rogers' (2003) Diffusion of Innovations model, which explains the role of networks in spreading information for adoption by farmers.

Notwithstanding the importance of networks in disseminating information to farmers, the study by Agwu, Ekwueme and Anyanwu (2008) found that in Enugu state farmers' there was no farm association. Such associations are vital for the exchange and sharing of information by farmers. Most farmers relied on information from other farmers as a source of agricultural information. Although the 2008 study indicated that many farmers had a radio and believed that radio was a useful source of information for improved agricultural innovations, most did not listen to the farmers' radio programme. The study by Ziervogel and Downing (2004) found out that in order to ensure effective adaptation in existing development channels, information on climate change and variability should be readily accepted. Their study thus stressed the use of information and communication channels such as workshops which provide higher feedback mechanisms for stakeholders who are involved in preparing and disseminating information on climate change and variability for adaptation. The effectiveness of workshops as channels for government extension officers and the mass media for information exchange has also been highlighted in the studies of Phillips and Orlove (2004) and Patt, Ogallo and Hellmuth (2008).

Feder and Savastano's (2006) study on the role of opinion leaders in the diffusion of new knowledge on IPM in Indonesia found that opinion leaders were more effective in transmitting knowledge to farmers to enhance adoption than other channels. Leaders' social acceptance and superiority was a great determining factor in enhancing farmer's adoption of an innovation. The role of opinion leaders as highlighted in the Diffusion of Innovations theoretical framework as an essential component in enhancing information dissemination to farmers. However, the authors in the 2006 study explain that in order for opinion leaders to

disseminate information effectively, they should not be excessively superior socially to other farmers, as this would create a social gap as a result of differences between the two stakeholders in terms of communication and information exchange. Thus the information and knowledge would not reach the intended audience.

Roncoli's (2006), who used ethnographic and participatory approaches to research farmers' responses to climate predictions. She observed that researchers have been able to examine innovations introduced to farmers' through participatory means, as a result they are able to understand farmers' communication trends. The study noted that extension officers, NGOs, farmer representatives, village leaders and researchers were major channels of information dissemination and access to farmers. The author raised the issue that inadequate resources prevented farmers' from accessing and using the information disseminated and communicated through extension services and media. Thus, in many developing countries, although many farmers' are willing to access information but are unable to do so because of the difficulties they face. Some of these difficulties are a lack of electrification and inadequate cash for farmers to purchase batteries might hinder their usage. In contrast, Roncoli's (2006) findings, Mukhopadhyay (1994:99) in his study on adaptation to agricultural technology in West Bengal, India, found that although farmers had access to information on seed varieties, a farmers' decision to adopt the new agricultural technology High Yield Varieties (HYV) depended on discounted returns per unit cost and the added risk or uncertainty that HYVs entailed, compared with traditional varieties.

Although various studies in agricultural information access and use have shown that farmers rely on person to person-sources-of information, Orlove and Kabugo's (2005) Ugandan study on signs used by farmers' to predict climate and non-climate events found that there had been a paradigm shift. These authors found farmers discussed climate change and variability issues in conversations among themselves and in farmers' groups. Farmers' preference for interpersonal exchange of information, however, remained. The roles of farmer groups in information transfer, exchange, adoption of an innovation and knowledge acquisition have also been highlighted by Munyua and Stilwell (2009).

3.9 Role of Information and Knowledge in Mitigation and Adaptation

The role of information for effective adaptation can never be underestimated. Various scholars have emphasised the essential nature of information in the mitigation and adaptation to climate change and variability. Kandji and Verchot (2007) explained that information on climate change and variability was a critical component if farmers are to make the right decisions in agriculture and other socio-economic activities to enhance their livelihoods. The study states that the next step to ensure that farmers benefit from seasonal climate forecast information is to emphasise good interpretation of seasonal climate forecasts and effective communication of forecast outputs to build trust between producers and users. Kandji and Verchot (2007) denote the importance of insuring forecasts and the establishment of effective crop insurance for farmers. This is done in order to protect end-users from exposed risks which might be caused by bad decisions due to incorrect seasonal predictions. Scholars stress the use of information on climate change and variability as an intermediate variable promoting mitigation and adaptation through the application of improved crop management practices such as the use of rainwater harvesting, soil conservation and agro-forestry to enhance productivity among smallholder farming systems.

Mengistu (2011) researched farmers' knowledge and coping strategies in Ethiopia and collected data through the use of focus group discussions. The study exposes the role of accessibility and availability of information on climate change and variability as a prerequisite, for not only mitigating the adverse impact of climate change and variability but also making use of the beneficial effects, as most people depend on the natural climate. The study stressed the role of timely information on climate change and variability as being highly essential if farmers' wellbeing is to be improved. The author observed that to enhance mitigation and adaptation of local communities, knowledge was needed on adjusting the dates of crop planting, developing drought resistant varieties and creating awareness of these varieties and increasing awareness of the use of irrigation as farm-level adaptation measures.

It has been observed that lack of reliable information and knowledge on new options, such as using new seed varieties, drought crop resistant varieties and other agricultural cultivation practices generated through research and disseminated to farmers via proper channels are setbacks in the adaptation process. Gwambene (2007) and Salinger, Sivakumar and Motha (2005) singled out technology and innovation as being among the determinants of adaptation to climate change and variability in Tanzania and developing countries, respectively.

In Burkina Faso, Ingram, Roncoli and Kirshen (2002) noted the role of information in enhancing crop diversification and water preservation and harvesting. The study used a variety of data collection methods such as open-ended and in-depth interviews, focus group discussions and observation. The authors stressed the need for timely information on climate change and variability, such as seasonal forecast information, which will make farmers aware of the coming season and enhance their adaptive capacity through choice of what and when to cultivate, so as to minimise the adverse effects of climate change and variability. It will also help farmers to preserve water in advance if they are aware of the next season's climate changes.

In Zimbabwe, Gwimbi (2009) found that most farmers lacked access to timely weather forecasts and climate change and variability information, which was a pre-requisite in motivating them in adoption. The study gathered data from databases and conducted a time series analysis for a period of 30 years through using interviews. The author points out that although there is much information on climate change and variability at regional and national levels, this information was not accessed and used effectively by potential end-users due to poor interpretation of its relevancy. Gwimbi (2009) calls for well-prepared information on climate change and variability with content that ensures its practical value for farmers.

Mutekwa (2009) in Zimbabwe analysed the impacts of climate change and adaptation among smallholder farmers in Zimbabwe and observed that despite availability of information at regional, continental and global levels, most farmers still have inadequate awareness and knowledge of climate change and variability impacts and adaptation strategies. The study reiterates that for mitigation and adaptation strategies on climate change and variability to succeed, information on climate change and variability cannot be ignored.

Hisali, Birungi and Buyinza (2011), who researched farmers' adaptation to climate change in Uganda by analysing micro level data, found that information is among the essential factors which influence adaptation by farmers in Uganda. Effective adaptation should avail farmers of information on innovations such as pest resistant varieties and weather forecasts. Marx, Weber, Orlove, Leiserowitz, Krantz, Roncoli and Phillips (2007), Phillips and Orlove (2004) and Roncoli, Orlove, Kabugo and Waiswa (2011) also observed that in Uganda farmers' awareness and knowledge of scientific climate forecast information enhanced their participation in adaptation to climate change and variability.

In Nigeria, Apata, Samuel and Adenola (2009) recorded that effective and reliable access to information on climate change and variability was a critical factor in adaptation. They stressed that access to credit or grant facilities was crucial for helping farmers to acquire reliable information to make correct decisions in agricultural production. According to these authors, having reliable information through access to extension and credit will assist farmers in making relevant adaptation decisions.

It was found that even though climate forecast information is made available and disseminated in most African countries at the onset of the rainy season (Patt,Ogallo and Hellmuth 2008), the utilisation of this information for risk management in agriculture is being hindered by many factors. This includes the lack of correspondence of forecast parameters with farmers information needs, availability of resources needed for farming management options and the process whereby information is being packaged and disseminated to farmers after being translated (Roncoli 2006). Mutekwa (2009) revealed the remarkable findings that all of the farmers interviewed professed ignorance of the seasonal climate forecast information. They did not use this information to make decisions on farming which would have reduced the climate change and variability risks.

3.9.1 Role of Indigenous Knowledge in Mitigation and Adaptation

Many scholars have argued about the contribution of IK to adaptation to climate change and variability. Orindi and Murray (2005) crucially observed that it is essential to understand, document and strengthen existing livelihood coping strategies rather than imposing new, high-tech solutions which do not fit well with levels of understanding of many farmers in most developing countries. Salinger, Sivakumar and Motha (2005) point out that the best way to ensure that farming practices are adopted by farmers is to assess the existing indigenous technologies, traditional knowledge and local innovations used in farming systems.

Researchers had not previously given much attention to the wealth of information preserved by people in the form of IK. The main reason given by Green and Raygorodetsky (2010) is that researchers perceived local IK to be inferior to scientific knowledge. This perception dominated public and policy debates. Many scholars have investigated the nature of IK, after it was mentioned in the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) of 2007.

There are a number of authors who have shown the value of IK in adaptation to climate change and variability. Hisali, Birungi and Buyinza (2011), in their study of farmers' adaptation to climate change in Uganda, observed a notable difference in the choice of adaptation strategies by farmers and stressed that for adaptation strategies to receive attention, farmers' IK should not be ignored. Green and Raygorodetsky (2010), who researched IK in a changing climate, stressed that mitigation and adaptation strategies can only be effective by incorporating peoples' IK and scientific knowledge.

Speranza *et al.* (2010) investigated farmers' IK related to climate change and variability in semi-arid areas in Kenya and found out that farmers possess IK on indicators of rainfall variability. The study deduced that farmers believed and relied on IK's efficacy as the basic knowledge frame within which they interpreted meteorological forecasts and made decisions in ying out agricultural practices. The study found that, although farmers possessed IK to predict of climate change and variability, they were not applying this knowledge to change their farming norms. Factors mentioned as influencing their use of IK was poverty, inadequate resources, high rainfall variability and lack of preparedness. Even though farmers knew through IK indicators that they were exposed to risks of climate change and variability, they could not respond/adapt to the impact when it occurred, due to these limiting factors.

In Tanzania, Chang'a, Yanda and Ngana (2010), Tumbo, Mbilinyi, Rwehumbiza and Mutabazi (2010) and Kangalawe, Mwakalila and Masolwa (2011) studied farmers' use of IK in adaptation to climate change and variability. These studies mostly applied qualitative rather than quantitative methods such as structured interviews, semi-structured interviews and focus group discussions to collect data from farmers. Key findings showed that farmers use plant phenology, animals, birds, insects and astronomical indicators to predict weather and climate.

3.9.2 Impact of Climate Change and Variability on the Existence of IK

In Tanzania, Slegers' (2008) study indicated that farmers used IK to understand the coming season. They predicted weather through observing signs in natural phenomena such as trees and stars. These beliefs about indicators of rainfall are seen to originate from the hands of God. The study found however that recently there has been a paradigm shift from the use of IK in interpreting seasonal forecasts to more reliance on extension officers and the radio for

managing farm activities. The study revealed that farmers' dependability on IK in seasonal forecast predictions was fading as a result of its loss of accuracy.

Some studies show that IK is threatened with disappearing in the long term in society, as there is limited transfer from generation to generation (Speranza *et al.* 2010). This finding, according to Ingram, Roncoli and Kirshen (2002), might contribute to farmers' perceptions of the lack of dependability of the local indicators used in predicting the season. Speranza *et al.* (2010) suggested that the way to ensure IK preservation and use is to incorporate it in the education curriculum and link it with formal climate change and variability research through participation of the local people.

Timely access to information plays a significant role in mitigating and adapting to climate change and variability. Findings could not, however ascertain the level to which innovative scientific information on adaptation has been packaged and disseminated. It was not clear from the literature how information flows from higher levels, represented by scientists and decision-makers to the end-users of information for decision-making.

3.10 Farmers' Knowledge on Adaptation to Climate Change and Variability

To sustain natural resources and environmental management and improve livelihoods, there is a need to understand clearly the bases of communities' knowledge (Downing, Ringius, Hulme and Waughray 1997; Low 2005). Historically, local communities have acquired detailed knowledge, skills and strategies based on their interactions with the local environment over long periods of time. The stock of knowledge pervades the social structure and forms the basis for local level decision-making in agriculture, natural resources management, food preparation and determines the mode of conduct for other livelihood activities in rural communities (International Institute for Environment and Development (IIED) and ZERO 2004).

A study by Mengistu (2011) on farmers' perceptions and knowledge of climate change and their coping strategies in Adiha, Ethiopia, found that farmers have been practising such adaptation methods. Their practices were demonstrated through activities such as irrigation, planting early-maturing and drought-resistant crop varieties such as teff (love grass), or *Eragrostis tef*, maize and millet, practising soil and water conservation practices. The study revealed that, despite the usefulness of changing of planting dates and crop diversification in adaptation to climate change and variability, farmers were not commonly using these

strategies. The findings of the study raise concerns about the issues of inadequate information dissemination, which influences access to, and use of, innovations. If information was effectively disseminated, then farmers would have applied the innovation such as changing of planting date and crop diversification strategies efficiently.

Mengistu's (2011) study showed that farmers had accumulated vast IK on weather forecasting. Farmers used signs and signals, cultural beliefs and environment predictors to foresee the coming season's weather and climatic conditions. The cultural environmental indicators included the colour of the sky, the colour of the clouds and the wind directions. They use this to predict whether the coming season will be wet or dry. For example, a reddish sky colour, sparse clouds in the sky and wind blowing from west to east predict the dryness of the coming season.

The most common environmental indicators used for assessment by Adiha farmers in Ethiopia were closely observing animal behaviour, such as that of goats and insects such as bees. The study indicated that a particular sound produced by honey bees was a special sign predicting the instantaneous rainfall. In addition, existing coping strategies used by farmers in Adiha were the food for work scheme, credit, small businesses (charcoal and firewood selling), reduction of the size of the daily meal and migration. Apata, Samuel and Adeola, (2009) investigated farmers' climate change perceptions and adaptation among arable food crops in south-western Nigeria. They discovered that most farmers had diversified their economic practices and are gradually moving from farming to non-farm activities.

A study in Ethiopia by Deressa *et al.* (2008) analysed the determinants of farmers' choice of adaptation methods and perceptions of climate change in the Nile basin. Many farmers were not aware of adaptation options even though some were practising adaptation of agricultural practices, such as the use of different varieties of crops, tree planting, soil conservation, changing planting dates and applying irrigation. The study highlighted a critical issue arising in most climate change and variability research, which is, whether the farmers' responses are stimulated by the economic quest for farmers to improve their agricultural production or the reaction to information disseminated to them by various sources.

Hisali, Birungi and Buyinza (2011) researched farmers' adaptation to climate change in Uganda by analysing micro level data. The study used documentary analysis by assessing a national household survey for 2005/2006. The key findings revealed that households in

Uganda responded to climate-related shocks by reducing consumption, using their past savings, using technology and borrowing. The authors observed that these choices were influenced by land tenure security, access to off-farm employment, extension and credit access and agro-ecological zone. Whereas, in Zimbabwe, Gwimbi (2009) found that, despite farmers' preference for irrigation and short-term hybrid cotton varieties in enhancing agricultural production, the study revealed that farmers lacked knowledge on how to apply such adaptation strategies. Mensah-Fosu, Vleckand Manschadi (2010), who researched farmers' perceptions of adaptation to climate change in the Sekyedumase district, Ghana, learned that, although the majority of farmers perceived a change in climatic conditions, only a few of them had knowledge on adaptation strategies to apply in their farming practices. The study noted that most farmers applied two adaptation measures which included crop diversification and change of planting dates during warmer weather conditions.

In Senegal, Mertz, Mbow, Reenberg and Diouf (2008) explored farmers' perceptions of climate change and Agricultural adaptation strategies in rural Sahel. They found that farmers have knowledge of climate change and variability and apply adaption measures such as shifting to new crop varieties, keeping animals, replacing horses with cattle and using manure in farming. The study did not directly identify all the above-mentioned climate change and variability adaptation measures, although introducing new crops was practised by farmers to boost their incomes.

Jonge (2010) researched irrigation farmers' perceptions of adaptation to climate change in Riverland, South Australia, and found that they adapted to drought by purchasing extra water rights or improving irrigation efficiency. Farmers' perceptions on climate change and variability risks and lack of knowledge on water availability, future climatic conditions and adaptations options, tended to limit farmers' adaptation capabilities in Riverland. Adger, Arnell and Tompkins (2005), in their study on successful adaptation to climate change across scales, observed that farmers' perceptions of climate change and variability risks greatly influence adaptation.

Barbier *et al.* (2009) studied farmers' adaptation strategies in northern Burkina Faso. They discovered that farmers had changed their farming practices during the last decade. They had adopted a wide range of techniques to increase crop production. The techniques farmers have adapted include micro water harvesting, use of soil conservation practices such as stone lines,

storage of hay and sorghum residues and growing dry season vegetables. The findings indicated that farmers are now shifting from dependency on rain-fed agriculture to irrigation schemes. The study revealed that the use of improved seeds was not very popular among farmers. This could be attributed to lack of knowledge rather than a lack of interest as the majority of farmers showed interest in this innovation.

In South Africa, Nhemachena and Hassan (2007) carried out a micro-level analysis of farmers' adaptation. They discovered that farmers' most important adaptation options included crop diversification, using different crop varieties, changing planting and harvesting dates, increasing the use of irrigation, increasing the use of water and soil conservation techniques, and diversifying from farm to non-farm activities. In addition to those adaptation options, knowledge of crop diversification was found to be a critical component contributing to improving household food security, as was also observed by Mutekwa (2009). Crop diversification was deemed an essential adaptation strategy towards enhancing food security for farmers. Crop diversification distributes risk as crops are affected differently by the same climatic conditions. Also, given the high frequency of mid-season dry spells and shortening of the rain season, farmers have adapted to climate change by growing short-season and drought-resistant crop varieties, such as sorghum, rapoko (millet) and finger millet. Notably, the study revealed that farmers have changed their farming attitudes by growing staple food such as maize. Where this is evident, there has been a shift from planting local varieties planting hybrid maize. This variety takes a shorter period to mature and yields more than traditional varieties.

Coles and Scott's (2009) study in the USA found that climate changes and Variability has added more water pumping costs for farmers. As an adaptation strategy, farmers have been forced to incur more cost for underground water pumping for irrigation. The study revealed that ranchers were practising rotational grazing as an adaptation strategy for pasture management. Despite farmers having farming as their primary occupation, most of them had a supplementary off-farm income generating activity, this boosted their income during poor agricultural production seasons. Subsidies from the government reduced vulnerability of farmers. In India, a study by Dhaka, Chayal and Poonia (2010), showed that most farmers were adapting to climate change and variability by practicing integrated farming system methods such as crop rotation, intercropping and agroforestry. Their study indicated other adaptation strategies, including change in the time of farm operations, soil conservation

techniques, use of short-duration crop varieties, use of water conservation techniques and stubble mulching.

In Tanzania, studies have shown that rural communities have adapted various strategies to cope with weather changes. Mongi, Majule and Lyimo (2010) found that farmers in Tabora region have locally adapted to the impact of climate change and variability. The local adaptation is through expanding cultivation areas to compensate for reduced yields during droughts, reducing fallows, switching to more drought-resistant crops, such as cassava and sorghum, and diversifying their crops. The study found that farmers have adapted locally by practising off-farm activities such as charcoal-making, brick production and casual carpentry. Yanda and William (2010) observed that the majority of rural people adapt locally by engaging in other off-farm economic activities such as selling charcoal, establishing restaurants (viosk) and utilising non-wood forest products. Therefore, in order to enhance farmers' adaptation capacity, the study by Mongi, Majule and Lyimo (2010) stressed the combination of local knowledge of farming with the new measures introduced.

Lyimo and Kangalawe (2010), in the Shinyanga region of Tanzania, found that the most common local farming methods included growing drought-tolerant crops, buying fast-maturing crops, buying supplementary foods and cultivating the wetlands. In spite of the fact that farmers were adapting, the study revealed that these adaptation strategies were heavily influenced by their wealth status, which enhanced their adaptive capacities. Some of the adaptation strategies identified by the study were farmers engaging in non-farm activities such as selling charcoal, establishing shops, selling their labour, selling beer and migration to other areas to make their living. Notably, the study underscores the fact that although the above adaptation strategies exist, there were farmers who were extremely vulnerable, as they could not engage in these adaptation approaches due to inadequate finance.

Lema and Majule (2009), in the Singida region of Tanzania, had similar findings to those in the Tabora region. They found that farmers were adapting locally by applying soil fertility improvement strategies and timing farming activities such as early preparation of land for planting, burying crop residues to enhance soil fertility and burning crop residues, to speed up the nutrients spread on the soil for easy absorption. The study also observed that farmers possess knowledge of soil tillage practices, such as selecting certain types of crops to be planted on a certain soil. Farmers knew how to use contour points to ensure the efficient use

of rain water through infiltration, by reducing surface runoff. Other IK used by farmers includes staggered crop planting and mixed cropping. These methods were preferred, as they were effective in spreading crop risks and ensuring the efficient use of rainfall. The study learned that farmers were controlling crop pests such as stalk borer and easing cultivation by burning crop residues.

Slegers (2008), in the Dodoma region showed, that farmers had knowledge factors that contributed to the decrease in rainfall and suspected deforestation as the cause. Slegers found that farmers were aware that soil characteristics influenced plants' ability to survive in dry conditions. The study also found that adaptation strategies used by farmers to respond to climate change and variability included livelihood diversification, such as keeping livestock, selling labour, selling commodities at seasonally high prices, borrowing and mixing market and subsistence crops. The study noted that food security can be ensured through means such as food preservation, effective and efficient access to, and use of, weather forecasts and keeping livestock. Other agronomic strategies such as timely cultivation, ridge cultivation, mixed cropping, sowing before onset of rains, rotating tillage, using drought-resistant crops and preparing for a dry year should also be advocated for farmers to effectively adapt to climate change and variability.

The reviewed literature showed that most farmers had the knowledge to adapt and implement various strategies to mitigate the effects of climate change and variability. However, it is not clear how farmers have acquired their knowledge, whether they are applying their IK, or have adopted scientific information prepared and spread by information disseminators.

3.11 Farmers' Attitudes to Climate Change and Variability

Attitude has been observed by a number of scholars to promote or deter farmers' ability to adapt to introduced innovations and technology. Rogers (2003) stipulated attitude to change and attitude to innovation as being among the factors influencing farmers to adapt to climate change and variability.

In Ethiopia, Mengistu (2011) investigated farmers' perceptions and knowledge of climate change and their coping strategies. Mengistu recorded that farmers had observed a change in climatic conditions, an increase in temperature and a change in rainfall patterns. In the last two decades, farmers had observed a decrease in the amount of rainfall. Farmers had the perception that the surrounding villages were becoming drier, with more occurrences of

change in the timing of rains and frequent droughts. Similarly, in Ethiopia, Deressa *et al.* (2008) revealed that farmers were aware that there was an increase in temperature and a decrease in the amount of precipitation. Their study showed that farmers' perceptions were influenced by the age of the household head, information acquired on climate change and variability, wealth and social capital.

In Zimbabwe, Gwimbi (2009) assessed cotton farmers' vulnerability to climate change in Gokwe district. A survey indicated that farmers perceived an increase in temperature and drought and a decrease in precipitation. These perceptions conformed to the study's analysis of climatic data records from meteorological stations for the last decade. The climatic data records showed that in the Gokwe district there had been an increase in temperature and a decline in rainfall. However, farmers' perceptions of whether the climate was changing or not was highly influenced by their experience of the incidence of drought and changes in the seasonal timing of rainfall and floods. Maddison's (2007) study on perception and adaptation to climate change and variability in Africa found that experienced farmers were more likely to observe changes in climatic conditions.

In Ghana, Mensah-Fosu, Vleck and Manschadi (2010) assessed farmer's perceptions and adaptation to climate change in the Sekyedumase district. The study found that the majority of farmers perceived a long-term change in temperature and precipitation. Farmers had noticed an increase in temperature and a decrease in precipitation. Most farmers associated the rise in temperature and decrease in precipitation in the area with deforestation and bush burning. In this study, authors verified the farmers' perceptions of an increase of temperature by analysing historical mean temperatures for the last thirty-six years. They observed that there was a slight increase of temperature in the past decade.

Mertz, Mbow, Reenberg and Diouf (2009) studied the perceptions of farmers' perceptions of climate change and Agricultural adaptation strategies in rural Sahel. They found that farmers had perceived climate change and variability in their area. Farmers pointed out that they had in recent years, observed stronger winds in the dry season and an increase in rainfall as a result of deforestation and land mismanagement. The study also found that there had been a reduction in yields of wild plant species as a consequence of extreme weather events. Similar findings were made in North Africa in Burkina Faso by Barbier *et al.* (2009). This study revealed that farmers in the last decade had observed a change in weather pattern, with

increased intensity of rainfall and floods. Despite farmers practising adaptation measures in their daily farming activities they could not clearly associate their perception of climate change and variability with these practices. In Southern Africa, Nhemachena and Hassan (2007) carried out a micro-level analysis of farmers' adaptation in South Africa, Zambia and Zimbabwe. They found that nearly half of the farmers had perceived an increase in temperature and a decrease in precipitation.

In the USA, Coles and Scott (2009) studied vulnerability and adaptation to climate change and variability in the state of Arizona. They interviewed agricultural producers and agricultural extension officers in the counties of Pima and Cochise and had interesting findings. Contrary to the findings in many developing countries, in the USA it was shown that, although farmers could observe climate change and variability in their agricultural production, they did not perceive the changes to be significant. This is due to the well-structured agricultural infrastructure and assistance from the government. Coles and Scott (2009) indicated that farmers in Arizona have extremely high access to information, assistance programmes and financial support.

Coles and Scott (2009) further stated that drought and frost were the most critical climate risks which affected farmers. Changes of weather have caused changes in rainfall and frost and thus affected crop planting and harvesting for farmers. Despite the prevalence of climatic risks as a result of climate change and variability, ranchers were significantly affected by drought which adversely affected their pastures. This was obvious as ranchers solely depended on rainfall for pasture growth. The study observed that farmers did not perceive drought as a problem, because they were not solely dependent on rainfall, as they used groundwater for irrigation.

Dhaka, Chayal and Poonia (2010) studied farmers' perceptions and adaptation strategies to climate change in India. They used structured interviews to collect data from 500 farmers. The study revealed that it was perceived that temperature had increased and precipitation had declined. Farmers perceived an increase in long dry spells, late rainfall commencement and the early end of the monsoon. The study noted that factors such as farming experience, age, innovativeness, exposure to media and environmental consciousness had a positive and significant association with farmers' perceptions to climate change and variability.

In Tanzania, a number of studies on adaptation to climate change and variability have been done in the central regions and other agricultural production zones. These include those by Mongi, Majule and Lyimo (2010) in the Tabora region, Lyimo and Kangalawe in the Shinyanga region (2010) and Lema and Majule (2009) in the Singida region and Slegers (2008) in Dodoma region. Mongi, Majule and Lyimo (2010) studied the vulnerability of rain-fed agriculture to climate change and variability in semi-arid Tanzania. The study used structured interviews, focus group discussions, field observations and documentary reviews to collect data. The study indicated that most farmers perceived that rainfall was declining and temperature had been increasing in the area and that climate change and variability was the cause. However, the study found that a small number of farmers perceived the rainfall decline as being caused by not following the traditional foundations set by their forefathers. These findings show that cultural beliefs played a significant role in shaping behaviour of many people in rural areas. The findings showed that rain-fed agriculture was at risk due to changes in the growing season, an increase in heat stress and moisture and an increase in insects and pests.

Lyimo and Kangalawe (2010) assessed vulnerability and adaptive strategies to the impact of climate change and variability in semi-arid Shinyanga region. Data was collected through focus group discussions, key informants interviews and structured household questionnaire interviews. The findings indicated that local communities perceive climate change and variability through observations of decreases in rainfall, erratic rainfall patterns and increases in temperature and drought. The study observed that in the region, food insecurity had increased as a result of a decrease in crop production, resulting in the region being named as a food deficit area in Tanzania.

Lema and Majule (2009) explored the impacts of climate change variability and adaptation strategies on agriculture in semi-arid areas of Tanzania. The study employed focus group discussions and structured interviews in data collection. The findings indicated that in the Manyoni district local people perceived changes in rainfall and temperature, where rainfall was decreasing and temperature was increasing. The study found that crop production was reduced due to factors such as unpredictable rainfall, an increase in pests and diseases and a decline in soil fertility as a result of frequent drought. The study observed that the changes have seriously affected livelihoods by contributing to food insecurity through loss from crops and livestock.

Slegers (2008) explored farmers' perceptions of drought in Tanzania in the Kondoa, Dodoma, region. The study employed in-depth interviews, focus group discussions, questionnaires and field visits in collecting data. The findings indicated that dwellers perceived rainfall as being unreliable and an increased occurrence of drought over the past 10 to 20 years. The study showed a similar trend as other research studies conducted on semi-arid revealing erratic rainfall. Farmers were more concerned about the increased severity of drought than the increased frequency of droughts. Concurrently, the study analysed rainfall data for a period of 37 years and observed a similar pattern to that perceived by farmers relating to changes in rainfall.

Generally, findings from the literature showed that farmers have perceived climatic changes with more unpredictable rainfall patterns, drastic changes in temperature, increased pests and diseases and a decrease in soil nutrients.

3.12 Factors Affecting Access to, and Use of, Information on Adaptation to Climate Change and Variability

The literature has shown that, information on farmers' awareness concerning climate change and variability is crucial to the current mitigation and adaptation strategies, this is aimed at reducing the vulnerability of farmers. A number of scholars have stressed the importance of, and need to, ensure that information on adaptation for climate change and variability is disseminated to farmers. Salinger, Sivakumar and Motha (2005) pointed out that the serious challenges involving vulnerability are reduced in the agricultural sector. They suggest this is achieved by making better use of the existing information and dispersion of knowledge to the farm level. The authors explained that the best way to ensure that information is disseminated well to farmers is by using a combination of methods. The old methods, such as visiting farmers and using extension services should be combined with the new information and communication technologies this, should be adapted to local settings.

Salinger, Sivakumar and Motha (2005) have warned that the limited access to, and absorption capacity for, new technologies in developing countries and lack of appropriate local information on how to implement them under their local conditions is detrimental to the regional adaptation strategies. This argument has been supported by Deressa *et al.* (2008), who discovered that many farmers (42%) in the Ethiopian Nile Basin did not have access to

information on adapting to climate change and variability and hence continued to use indigenous agricultural methods in cultivation.

Gunasekera's (2011) study on how to reduce impediments to adaptation found that efficient and effective adaptation measures can contribute to reducing the adverse impacts of adaptation. These measures have been identified as access to reliable and detailed information, improved communication, information dissemination, improved public and private sector responsibilities in adaptation to climate change and variability and integration of adaptation into farm decision making. The study shows that effective and efficient adaptation is being influenced by timely recognition of need to adapt, adaptation ability and incentives to adapt. Gunasekera emphasises the point that adaptation can be improved through enhancing access to, and use of, research information generated in both quantity and quality packages.

Access to rural services such as credit, agricultural extension and information about climate change and variability played a significant role in the use of adaptation options by farmers (Deressa *et al.* 2008). These authors revealed a positive correlation between credits, agricultural extension and access to information on climate change and variability in fostering the adaptation process. Lwoga (2009) and Munyua (2011) observed that in Tanzania and Kenya, respectively, agricultural extension, social networks and village government leaders were key factors in disseminating agricultural information to local communities for agricultural development.

Deressa *et al.* (2008) found that social networks play a distinctive role in the adoption of agricultural technologies, by operating as a means for financial transfers, providing access to information about new technological developments and facilitating co-operation among farmers. This allowed the costs and benefits of adaptation to climate change and variability to be shared across the community. Availability, access and use of financial information on small-scale village credit unions, famously known as VICOBA (Village Community Banks) or SACOSS, may play a major role in easing financial constraints by allowing farmers to diversify into other employment opportunities, improve infrastructure and the market system to sustain their livelihoods (Yanda and William 2010). Farmers will be able to purchase inputs such as improved seeds and other agricultural crop varieties, irrigation facilities and fertilizers. This will promote food security at household level and hence nation-wide.

To enhance the usage of information on climate change and variability by farmers, Mutekwa's (2009) study in Zimbabwe gave insights into the need for agricultural extension officers to fully train and educate farmers on the significance of seasonal climate forecast information usage. This training will, in turn, assist farmers in distributing their limited resources through decisions towards farming practices. The study of Ingram, Roncolli and Kirshen (2002) goes beyond the notion of educating farmers, by stressing that farmers need more extensive descriptions and interpretation of information on climate change and variability. Farmers need to be educated on the forecast limitations, risks and possible ways of responding to abnormal changes in information provided.

The study of Deressa *et al.* (2008) in Ethiopia indicated that farmers were still not adapting. The reason was not only due to the lack of information on climate change and variability but also inadequate adaptation options. Other issues observed from the study were lack of financial resources, labour constraints and land shortages. In addition, awareness and adaptation was being influenced by household wealth, which enabled farmers to engage in various adaptation options such as planting trees, soil conservation, use of crop varieties and change of planting seasons.

Information on adaptation to climate change and variability by farmers can neither be accessed nor utilised where there are weak research institutes and extension services. Manda (2002) observed that, in Tanzania, for information to enhance the agricultural development, institutional funding, agricultural research and extension should be prioritised. In addition marketing and transportation infrastructure constraints and the gender inequality limitations, should be addressed. He further points out that this will ensure the establishment of strong links between agricultural research institutions, extension services and farmers to assess the information needs of farmers for effective information generation and dissemination.

Agwu, Ekwueme and Anyanwu (2008) observed there was a low usage of improved agricultural information, disseminated through radio programmes. This low usage was influenced by factors such as age, farming experience, poor social participation and poor access to credit facilities. This study revealed that the educational level of farmers contributed significantly to the adoption of new technologies. They observed that farmers who were illiterate could not follow even simplified technical language broadcast. The study by Ingram,

Roncoli and Kirshen (2002) highlighted the importance of using the local language on radio programmes in the dissemination of information to farmers.

The study of Deressa *et al.* (2008) showed that access to and use of, information for adaptation was promoted by household characteristics, which include the level of education, sex and age of the head of the household and household size. A higher level of education is linked to the wider access to information on climate change and variability, higher agricultural productivity and improved technologies (Deressa *et al.* 2008). Education plays a major role in creating awareness which, in turn, assists in farmers' adaptation measures. Deressa *et al.* (2008) found that, unlike female headed households, male-headed households were more likely to access and utilise agricultural information and adapt to climate change and variability. The explanation is that, agricultural work for the most part is done by men. However, this argument seems to relate to, and yet differ from, that of Manda (2002) whose findings revealed that in other African countries such as Tanzania women are less likely to access and utilise agricultural information than men. This is due to cultural issues.

According to Matthews-Njoku, Adesope and Iruba (2008:409-410), the smaller the household, the less likely it is to utilise and apply the information on agriculture for adapting to climate change and variability. This is due to the fact that, adaptation is confined to the availability of resources such as labour, which is an essential human capital in agricultural production. Ingram, Roncoli and Kirshen (2002), studied farmers in Burkina Faso and noted that access to, and use of, information on adaptation was influenced by farmers' access to credit and improved agricultural technology. These factors determined the ability of farmers to respond to climate changes and Variability by gaining access to new crop varieties, fertilizers, labour and land.

Ingram, Roncoli and Kirshen (2002) discovered that usage of information on climate change and variability was not only enhanced by farmers' access, relevancy, timeliness of disseminated information, but also its credibility. This is due to farmers' investing much of their resources, capital and human endeavour in improving agricultural production for sustaining their livelihood. Thus, having unreliable information, as in forecasts, would affect their urge to invest. Irrelevant information may result in the abject and irreversible poverty of the farmers. Their study stresses the importance of not only delivering credible information on climate change and variability, but also emphasising that its usage can only be assured by

making sure farmers can interpret and understand the disseminated forecasts in their local setting.

The farmers' experience has been observed by authors (Ingram, Rancolli and Kirshen 2002; Ngigi, Savenije, Rockstrom and Gachene 2005) to be a factor which influences farmers' use of information on climate change and variability. A poor harvest, signals the quest for information on seasonal climate change and variability such as onset and end of the rainfall, this is often in high demand. If the farmer used the forecast information and it caused adverse effects on crop production, a farmer might be afraid and refrain in the next season from relying on the same source of information. This is due to the high risk factor involved in practising farming, as poor agricultural production seriously affects a farmer and thus exacerbates his or her vulnerability.

In most studies, the benefit aspect of information on adaptation is taken for granted. Researchers assume that farmers will respond after receiving information which enhances their adaptive capacity. However, Fraisse, Breuer, Zierden, Bellow, Paz, Cabrera, Garcia, Ingram, Hatch, Hoogenboom, Jones, and O'Brien (2006) observed that in the USA disseminating information to farmers and ensuring its access was not enough to trigger its usage. The study found that information on climate change and variability usage was highly promoted by observable adaptive response options which are expected when a farmer makes a decision about his farming practices. Thus the study came up with AgClimate, a web-based information system, which was used by farmers, extension officers, crop consultants and policy makers as a tool for proactive adaptations to seasonal and inter-annual climate change and variability forecasts.

In Burkina Faso, Roncoli, Jost, Kirshen, Sanon, Ingram, Woodin, Some, Ouattara, Sanfo, Sia, Yaka and Hoogenboom's (2008) study on the stages from accessing to assessing disseminated forecasts information had interesting findings. The study used interviews to collect data and observed that farmers who acquired information on the use of information on climate change and variability forecast were ready to share with others. However the ability of farmers to evaluate and understand the information they receive from extension officers has been observed to be a barrier in the use of information. The Burkina Faso study thus highlights the crucial role of participatory workshops in not only providing users with useful information, such as climate services, but also to evaluate and understand information in depth and at

length for decision-making. The study notes that, whenever workshops and other participatory paths are used, local power dynamics should be taken into account as they shape information flows and exchanges between farmers. This observation was also made by Roncoli (2011), who assessed cultural styles of participation in farmers' discussions of seasonal climate forecasts in Uganda.

The literature reviewed has shown that socio-economic and institutional factors are major determining factors influencing access and use of information on climate change and variability for adaptation. Other factors such as attitude, experience, effective information dissemination and commitment also influence access to and use of information and knowledge for farm level decision-making.

3.13 Determinants of Adaptation to Climate Change and Variability

Moser and Ekstrom (2010:2) defined barriers as “obstacles that can be overcome with concerted effort, creative management, change of thinking, prioritization and related shifts in resources, land uses and institutions”. Indeed, in most developing countries, adaptive capacities are low, as most of the barriers named in the above definition are yet to be dealt with. Most of the issues that arose from Moser and Ekstrom's (2010:2) study hinge on attitudinal and behavioural change, which are of paramount importance in joint efforts, changing ways of thinking and a paradigm shift in the allocation of resources, institutions' settings and effective land use. Thus, barriers are strong determinants which influence and promote adaptation to climate change and variability and immediate action is needed if adaptation plans in place are to bear expected results.

A number of scholars have identified barriers to farmers' adaptation to climate change and variability. In Ghana, Mensah-Fosu, Vleck, Manschadi (2010) observed that farmers' are only partly adapting to climate change and variability, due to obstacles facing farmers. They listed factors such as land tenure, extension services, soil fertility and access to credit. These factors play a foremost role in determining adaptation by farmers in the Sekyedumase district. Their study found factors such as age, education level, farming experience and farm size not to influence adaptation. Barbier *et al.* (2009) found that, though farmers were adapting to the Changes in Climate Variability, they considered land scarcity and population pressure as the major limiting factors influencing reasons for their adaptation. Other factors mentioned by

Burkina Faso farmers were poor access to credit, capital, inadequate fertilizers and soil infertility.

Hisali, Birungi and Buyinza (2011), in their study on farmers' adaptation to climate change in Uganda, discovered that the age of the household head, access to credit, extension facilities and security of land tenure were the elements promoting adaptation to climate change and variability. Nhemachena and Hassan (2007), who studied the micro-level analysis of farmers' adaptation in South Africa, Zambia and Zimbabwe, discovered that access to credit, free extension services, farming experience, mixed crop and livestock farms, private property and perception of climate change were important determinants of the choice of farm level adaptation.

Mertz, Halsnas, Olesen and Rasmussen (2009), in their study on adaptation to climate change in developing countries, reason that if farmers have a secure income and a diversified food supply, they are less likely to be poor and to experience hunger as they will be able to respond to stresses by allocating resources differently. They indicated that the state farmers are in before the adverse effects of drought are experienced is what makes people vulnerable. As a result the condition hampers their capacity to adapt to potential future stress factors. The authors raised a pertinent question, which demands precautions when handling adaptation. The study shows that adaptation actions in response to a certain stress such as drought can itself exacerbate vulnerability, making farmers dependent on credit schemes to purchase drought-resistant crops and crop varieties. A complete crop loss not only causes hunger but leaves farmers with debts they are unable to repay.

Apata *et al.* (2009) found that in south western Nigeria, farmers' decisions to adapt to climate change and variability have been greatly influenced by farming experience and access to education. The study emphasises the critical role of education and information dissemination in enhancing awareness and implementing adaptation measures. Other factors mentioned to promote adaptation to climate change and variability were an increase in temperature, farm size, intercropping of cereal/legume, mulching and zero tillage. The study discovered that factors such as climate change and related frequency of droughts, household size, age and sex all had no significance effect on adaptation.

A different perspective was found in Zimbabwe by Mutekwa (2009), whose research showed that farmers' adaptive capacity regarding climate change was undermined by several factors.

This ranged from limited understanding of the nature and consequences of climate change, farm members' health status (particularly in relation to HIV/AIDS), unemployment that is supposed to both complement and supplement agricultural incomes, and poor rural infrastructure. This study collected data through interviews, questionnaires, a literature review and desk-based research. However, Deressa *et al.* (2008) found that adaptation was greatly affected by lack of information to farmers and to financial barriers. Deressa indicated other factors influencing adaptation to be education level, gender, age, wealth, access to extension and credit, climate change and variability, agro-ecological settings and social capital.

Jonge (2010) researched irrigation and farmers' perception of adaptation to climate change in Riverland, South Australia. The study found that lack of financial incentives, dependency on commodity prices and lack of knowledge on adaptation options and future water availability were the major obstacles in adaptation to climate change and variability. The study highlights providing incentives which will minimise financial risks for farmers at individual level as the best adoption practice to enhance adaptation. Agrawal (2008) reviewed the role of local institutions in adaptation to climate change and noted that local governance and institutions greatly influence adaptation to climate change and variability. It has an effect by mediating between individuals and collective efforts to climate impacts. This shapes adaptation outcomes, structure impacts and vulnerability and acts as a link for delivery and distribution of external resources to support adaptation efforts. The study observed that vulnerability to climate change and variability is socially and institutionally constructed. Thus, for adaptation to be successful, local rural institutions should be promoted this will ensure adaptive capacity to local people who are vulnerable to climate change and adaptation.

The review of local institutions by Agrawal (2008) cautioned that most National Action Plans for Adaptation (NAPA) lacked a link between local institutions, local people and national policies towards adaptation to climate change and variability. The study showed that NAPA had concentrated more on providing technical and infrastructural assistance to people than on ensuring local institutions and local people were in place to accommodate the innovations. The authors stressed the need to carefully examine local institutions before they are assisted on matters related to adaptation. The analysis will ensure that the resources allocated reach their targeted local populations and not only influential or wealthy people.

Ziervogel and Downing's (2004) in a study conducted in Lesotho found that lack of information dissemination, poor institutional co-ordination and stakeholders' involvement were among the major barriers to achieving an effective climate change and adaptation plan. The study found that, despite stakeholders' expressing their willingness to use forecast information, there were no mechanisms for them to efficiently and effectively receive and use the information disseminated. The study pointed out that information disseminated to farmers was not meeting the needs of users, as most farmers preferred normal forecast information, while the information provided was being dealt with by disaster management and drought warnings.

Roncoli (2006) reviewed ethnographic and participatory approaches to research regarding farmers' responses to climate predictions. The study identified various barriers related to farmers' culture which might also contribute obstacles of adaptation to climate change and variability. Roncoli observed that the language used in communicating information on climate might contribute to incredibility and the inaccuracy of information. This is caused by the misinterpretation of concepts, religion, beliefs and past experiences. The study also observed that farmers' surrounding environment and complexities of farmers in decision-making greatly influenced their ability to use information for adaptation to climate change and variability.

Roncoli (2006) observed that flexibility in ease of use of innovations allowed a farmer to respond rapidly. Examples were labour saving technologies and the availability of credit for climate change and variability. With regards how socio-economic and institutional factors influencing adaptation to climate change and variability, the study found that, in developing countries, seed, labour shortage and inputs shortages, inadequate land and credit, size of the family, politics and inadequate funding from the government weakened extension services. These services are essential agents in spreading information on climate change and variability to farmers. Attributes such as complexity, information format, communication sources and social system norms have been well elaborated in the Diffusion of Innovations theoretical framework.

In the USA, Coles and Scott's (2009) found that farmers' low levels of risk tolerance, poor marketing and uncertainty of seasonal forecast information on climate change and variability production were key factors affecting their decision to use seasonal information on climate

change and variability. Farmers instead continued to rely on their past experience and short range forecasts and continued to avoid using seasonal forecast information on climate change and variability in order to tolerate risk. The study revealed that Arizonan farmers' decisions to adapt took into consideration short-term seasonal forecasts, while also considering economic factors. It was observed that current and projected commodity prices still influenced the decision-making of farmers.

In India, Dhaka, Chayal and Poonia (2010) discovered that adaptation was promoted by experience, extension advice and environment awareness. Other factors which influenced adaptation were the size of the land and ownership, age, innovativeness and exposure to media. Similar results have been found in Tanzania by Lema and Majule (2009) and Ethiopia by Deressa *et al.* (2008), by Ingram, Roncolli and Kerishen (2002) in Burkina Faso and Mutekwa (2009) in Zimbabwe. In Tanzania, Mongi, Majule and Lyimo's (2010) study indicated that adaptation was influenced by farmers' level of education, livelihood activity and age. Slegers (2008) observed that that adaptation measures were influenced by farmers' ability to respond, access to credit and the attitude of the role-players.

Contrary to many developing countries' findings on climate change and variability, Coles and Scott (2009) found that farmers' access to information on climate change and variability was not a principal limiting factor in improving production decisions. Instead, farmers' experience was being utilised as an adaptive strategy. The study observed that wealthier farmers used Seasonal Climate Forecasts (SCFs) more than poor farmers.

3.14 Research Gap

The literature reviewed five research gaps, which this study aimed to investigate. The first research gap that emerged was the paucity of existing knowledge on how the information on climate change and variability is being packaged and disseminated by information producers to farmers. The second research gap identified, was that most of the surveyed literature showed that a number of research studies, globally, hinge on studying farmers' awareness and knowledge of seasonal forecast information in enhancing agricultural production. Little has been observed in Tanzania. The third research gap identified was that, despite several studies showing that farmers perceive climate change and variability differently in their localities, many farmers still seem to lack information on adaptation to climate change and variability.

The fourth research gap observed from the reviewed literature in Tanzania on climate change and variability was that, regardless of the findings showing that farmers are adapting to climate change and variability, it was not clear if farmers' adaptation was based on indigenous knowledge accumulated by the farmer in the past or a result of adoption of the scientific knowledge spread to them by information disseminators. The study also identified that globally, and in Tanzania specifically, a number of research studies tend to be context-based, leaning towards specific disciplines such as natural resources, climate science, information science and agriculture. No study could be traced which was interdisciplinary in nature, focusing on agriculture, information science and climate science. It was noted that most studies were based on information, knowledge management and agriculture, or research on adaptation to climate change and variability in agriculture in Tanzania.

A small number of study focused on climate change and variability in Agriculture included those of Lyimo and Kangalawe (2010), who assessed farmers' vulnerabilities and adaptive strategies to the impact of climate change and variability in semi-arid regions; Mongi, Majule and Lyimo (2010), who explored vulnerability and adaptation of rain-fed agriculture to climate change and variability in semi-arid areas; Lema and Majule (2008), who investigated impacts of climate change, variability and adaptation strategies on agriculture in semi-arid areas and Slegers (2008) who explored farmers' perceptions of drought.

Interdisciplinary research studies which addressed agriculture and information and knowledge included those by Manda (2002), who assessed information and agricultural development in Tanzania; Sife, Lwoga and Chilimo (2004), who investigated the appropriation of information and communication technologies (ICT) for poverty reduction in the agricultural sector; and Lwoga (2009), who addressed the application of knowledge management and information and communication technologies to manage indigenous knowledge in the agricultural sector. Gundu (2009) researched the effect of literacy on access to, and utilisation of, agricultural information for household food security in Zimbabwe. Finally, Munyua and Stilwell (2009) assessed the agricultural knowledge and information systems (AKIS) of small-scale farmers in Kenya. Having identified the gaps, the present study aimed at building new knowledge with regard to farmers' adoption and access and use of disseminated information, building on the discipline of information science.

The study draws on an extensive amount of research which has been done in the field of agriculture and natural resources. The originality of the study lies in two contexts. First, this study is unique in Tanzania, due to the fact that, despite huge investment in the CCAA project aimed at imparting farmers with knowledge on agricultural innovation systems to enhance adaption to climate change and variability in crop production, no research has been done in the area to monitor and evaluate the use of new knowledge in adapting to climate change and variability and improving agricultural production.

Secondly, the literature reviewed could not identify a related study which had been conducted in Tanzania to assess the contribution of information dissemination to enhance adoption of innovations for adaptation to climate change and variability. Thus, despite several studies being conducted in Tanzania and notably the semi-arid areas of Tanzania, no study could be traced which has explored how information is being packaged and disseminated to farmers and how the information is accessed and used by farmers to influence adoption of new agricultural knowledge for adaptation to climate change and variability. This study is therefore expected to build on existing knowledge gaps in existing empirical and theoretical evidence on how information generated through research on climate change and variability can be packaged and disseminated effectively to farmers to improve agriculture production in Tanzania. The originality of the study is addressed more fully in the final chapter.

3.15 Summary

This chapter introduced the literature review and reviewed literature on the essence of conducting a review of the literature in a research project. The chapter was then arranged into research themes, were guided by the DOI theoretical framework which was applied in this study. The themes discussed in this study reflect the research questions and the problem under investigation. The themes included farmers' dissemination and access to agricultural information, farmers' adoption of innovation in agriculture, an overview of different countries' experience of climate change and variability and peoples' education and awareness of climate change and variability.

The chapter described experiences in adaptation to climate change and variability in agriculture, elaborated on communication channels used in information dissemination, explained the role of information and knowledge towards enhancing mitigation and adaptation to climate change and variability and discussed farmers' knowledge on adaptation

to climate change and variability. The chapter explains farmers' attitudes to and perceptions of climate change and variability, it described the factors affecting access and the use of information in adaptation to climate change and variability. It discussed the determinants of adaptation to climate change and variability. Lastly, the chapter identified the research gap and provided a summary of the themes described.

CHAPTER FOUR

RESEARCH METHODOLOGY

4.1 Introduction

This chapter describes the research methodology used in the study to investigate adaptation to climate change and variability by farmers as a result of information disseminated in central Tanzania. The chapter is organised into 14 sections and eight sub-sections. Section 4.1 introduces the chapter and explains the elements constituting the chapter; section 4.2 explains the meaning of research methodology; section 4.3 describes the research design; section 4.4 discusses the philosophical paradigm guiding the study; section 4.5 distinguishes qualitative from quantitative research; section 4.6 elucidates the application of mixed qualitative and quantitative methods in research and sub-section 4.6.1 justifies the choice of the method.

Section 4.7 describes the study population; section 4.8 explains sampling procedures in research; section 4.9 defines the study area; section 4.10 describes the sampling of research elements; section 4.11 describes the methods used in data collection and sub-section 4.11.1 specifies the methods used in data collection. Section 4.12 discusses data analysis; sub-section 4.12.1 explains data analysis in qualitative research, while sub-section 4.12.2 describes data analysis in quantitative research; section 4.13 clarifies meaning of validity and reliability as applied in research; sub-section 4.13.1 describes on reliability in qualitative and quantitative research, while sub-section 4.13.2 discusses validity in qualitative and quantitative research. Sub section 4.13.3 explains the pre-testing of the research instruments; section 4.14 describes the ethical issues adhered to by the study and the last section provides a summary of Chapter Four.

4.2 Research Methodology

Research methodology focuses on the research process and the kind of tools and procedures to be used (Babbie and Mouton 2001:75). Research methods are techniques for collecting data, involving instruments such as self-administered questionnaires or structured interview schedules or a participant observation checklist (Bryman 2004:27).

4.3 Research Design

Research design is a plan of how one intends to conduct the research (Babbie and Mouton 2001: 74). It provides a framework for the collection and analysis of data (Bryman 2004:27)

and includes a blueprint for the collection, measurement and analysis of data (Kothari 1990:39). Thus it is a strategic framework for action that serves as a bridge between research questions and execution or implementation of the research by generating evidence (Terre Blanche, Durrheim and Painter 2006:34; Bryman 2008:30). In this study survey research design was applied. Survey design was chosen for this study as it provides a useful source of information on attitudes, population distribution and behaviour (Pons 1992). Leedy and Ormrod (2005: 183), described survey research design as a method used to acquire information about one or more groups of people on opinions, attitudes and experiences, by asking respondents questions and summarising responses with percentages, frequencies, or counts and then drawing inferences and conclusions. A survey was utilised due to its capability of reaching a wider audience.

The current study was a case study of farmers in Maluga and Chibelela villages in central Tanzania. The case study approach was applied as the dissemination of information process under inquiry occurred in a real-life context. Meyer (2000) noted that case study research is comprised of in-depth interviews and participant observation of a phenomenon. Yin (1981), Stake (1998) and Case (2002) observed that case studies enhance rigour and the researchers' confidence through the use of varied qualitative and quantitative sources of evidence. The ability to use both qualitative and quantitative sources enables case study research to best describe causality.

4.4 Philosophical Underpinnings of the Study

There are a number of philosophical paradigms used in social sciences, psychology, philosophy and education. A paradigm represents a worldview or way of thinking about a phenomenon and making sense of the complexities of the real world. Paradigms relate to the epistemology, ontology, methodology and philosophy of science that guide an inquiry (Guba and Lincoln 1994:107; Patton 2002:69-72). Conversely, a paradigm is considered to be the metatheory, the theory, the methodology and the philosophy being combined (Kuhn 1996). Paradigms are broadly rooted in the socialisation of believers and practitioners and tell users what is imperative, reasonable and legitimate (Patton 2002:69). Guba and Lincoln (1994:108) described the choice of a particular paradigm as depending on the proponent of the study's view of the nature of inquiry when attempting to address the ontology, epistemology and methodology under study. However, as highlighted in Chapter One, the interpretive and positivist paradigms are the two major paradigms used in research studies.

A qualitative research approach is referred to as inductivist, constructivist and interpretive approach in data collection and analysis (Neuman 2003:139; Creswell 2003:18; Terre Blanche, Durrheim and Painter 2006:51; Bryman 2008:366). A qualitative research method is referred to as a systematic inquiry process involving analysing a social phenomenon through a detailed observation in the written or oral record, photographs, and/or symbols in their natural setting, to explain how people interpret and create meaning in their social lives (Creswell 1994:1; Neuman 2003:139; Creswell 2003:18; Neuman 2006:88, Denzin and Lincoln 2011:3).

A quantitative research approach is referred to as the positivist approach which analyses the social phenomenon based on testing a theory, using experiments and surveys, collecting data in the form of numbers and using statistical procedures in data analysis to come up with a generalisation (Creswell 2003:18; Terre Blanche, Durrheim and Painter 2006:47-51; Bryman, 2008:140).

Positivism is an epistemological position that supports the application of natural sciences methods to study a social reality (Bryman 2004:19). Thus, in contrast to interpretivists, positivists tend to seek facts or causes of social phenomena without considering the subjective position of individuals. Borland (2001:5) noted that most practical research has resulted from combining both interpretive and positivist research paradigms through applying their traditional means and methodologies to generate knowledge. Borland pointed out that an interpretive paradigm was useful in studying human perceptions and experiences and developing theories and models. A positivist paradigm is practical in predicting a behaviour through identifying the reality of a phenomenon in an orderly cause-effect form (Borland 2001:8). A positivist paradigm is useful in generating knowledge by testing or confirming a theory through generalizing findings.

Recently growing recognition of other paradigms apart from the traditional interpretive and positivist approaches, such as post-positivist and pragmatist approaches, has been observed. The post-positivist paradigm was applied in this study to explore the role information played in farmers' adaptation to climate change and variability. The post-positivist paradigm denotes the philosophy that became prevalent after positivism and shares most of the basic principles of positivist paradigm, but it differs in that it relates to the collecting of qualitative data (Alasuntari, Bickman, Brannen 2008:18; Creswell 2009:6-7). Post-positivist thinking takes

the position that truth about knowledge or reality cannot be observed in a theory neutral perspective (Phillips and Burbles 2000; Wacquant 2003). Creswell (2009:7) explained that researchers cannot claim to be positive about their state of knowledge as they are studying human behaviour and action. This is in line with what post-positivists argue that reality is not static, but is influenced by its context and/or the construction of reality by individuals and as a result, is dependent on those individuals involved in the research (Crossan 2003). Reality construction in research is mostly influenced by culture, gender and the cultural beliefs of researchers (Proctor 1998).

Crossan (2003) points out that, in research, a post-positivist approach provides an alternative to the traditions and foundations of positivism as it involves searching for proof of a phenomenon contrary to a positivist approach, which establishes generalisation and laws. Post-positivists hold a deterministic and reductionist philosophy which identifies and assesses causes that influence outcomes with the aim of testing, verifying and refining a theory (Creswell 2009:7). Guba and Lincoln (1994:110) contend that post-positivism is a methodological perspective where emphasis is on critical multiplism as a means of falsifying hypotheses, rather than verifying them. Implicitly, it can be stated that post-positivism is positioned between positivist and interpretivist paradigms, as it shares the positivist view that there is reality which is external and independent of the researcher but acknowledges that understanding of the reality is confined to the researcher's theoretical way of thinking (Alasuntari, Bickman, Brannen 2008:18). Post-positivist approaches use both qualitative and quantitative methods (Letourneau and Allen 1999).

Guba and Lincoln (1994:110) described the post-positivism paradigm as one that possesses attributes such as critical realism, modified dualist/objectivist philosophy and a modified experimental/manipulative approach, based on the ontological, epistemological and methodological perspectives, respectively. The ontological perspective associated with post positivism is based on critical realism, where reality is believed to exist but is not ideally positioned due to the nature of phenomena and human intellectual faults. The epistemological perspective associated with post positivism is said to abandon dualism and objectivity remains a regulatory principle where replicated findings are subject to falsification.

It has been noted that knowledge developed through a post-positivist view carefully considers observation and measurement of the objective reality which exists in the world (Creswell

2009:7). Post-positivism therefore recognises the intricate relationship between individual behaviour, attitudes, external structures, and socio-cultural issues (Crossan 2003). In this regard, developing numeric measures of observations and assessing the behaviour of individuals turn out to be critical for a post-positivist approach (Creswell 2009:7). The pragmatism paradigm, as elaborated by Patton (2002:71), aspires to surpass superiority application of one-sided traditional paradigms, either qualitative or quantitative by advocating more concrete and practical methodological options, as observed by the researcher. Morgan (2007: 71-73) supports the notion above by explaining the core pragmatist elements to be advocated in research. Pragmatism attributes include abduction, transferability and inter-subjectivity reasoning.

Abduction entails reiterating back and forth when using induction and deduction reasoning research methods, for example, changing observations into theories and further evaluating the same theories through practice/action. Transferability explains that the methods/approach used in one research should not be restricted to that context, or being looked to, whether there is a possibility and/or an impossibility of generalisation. Instead the knowledge is transferred and used in other settings. Inter-subjectivity explains that complete objectivity in research is impractical and a researcher needs to assume a dual role, by continuously referring to his/her frames of reference when applying pragmatism in research. Pragmatism therefore entails a researcher evaluating the quality of a study by its intended rationale, existing resources, procedures to be followed and expected findings, all confined in a particular context and targeting a specific audience (Patton 2002).

A few scholars who have similarly applied a post-positivist paradigmatic approach in their research study in the agricultural sector area include Lema and Majule (2009); Mongi, Majule and Lyimo (2010) and Munyua (2011). Lema and Majule (2009) assessed the impacts of climate change, variability and adaptation strategies on agriculture in the semi-arid areas of Tanzania. Mongi, Majule and Lyimo (2010) investigated vulnerability and adaptation of rain-fed agriculture to climate change and variability in semi-arid Tanzania. Munyua (2011) evaluated agricultural knowledge and information systems among small-scale farmers in Kenya.

4.5 Distinction between Qualitative and Quantitative Research Methods

Quantitative research methods analyse social phenomena in a manner that is based on testing a theory, using experiments and surveys and collecting data in the form of numbers, mostly in research, which deal with large numbers of individuals. It uses statistical procedures in data analysis to come up with a generalisation (Creswell 1994:1; Creswell 2003: 18; Bryman 2008:22; Terre Blanche, Durrheim, Painter 2006:47). The quantitative approach mainly focuses on investigating observable human behaviour (Welman, Kruger and Mitchel 2005:7).

A qualitative research method is more practical in the type of research which focuses on small numbers of individuals, groups and organisations and on human and organisational behaviour (Patton 2002:40; Welman, Kruger and Mitchell 2005:188; Terre Blanche, Durrheim, Painter, 2006:139). Goulding (2005) points out that the qualitative approach has the ability to apply multiple data collection methods, such as survey and observation as a single phenomenon and also to enhance direct contact with the people being researched.

In choosing whether to apply qualitative and quantitative research methods in an inquiry there is the need to consider the research problem, the personal experiences of the researcher and the audience (Creswell 2003:21). The present study's choice of qualitative and quantitative methods was based on the research problem, which traced farmers' access and application of innovations for adaptation to climate change and variability. Terre Blanche, Durrheim and Painter (2006:47) explained that to choose whether or not to apply qualitative and quantitative research methods, one needs to consider the purpose of the research and the type of data that will achieve this purpose through interrogating the research questions. More than a decade ago most studies employed qualitative or quantitative approaches in research (Creswell 2003:4). However, it is reasoned that the present situation is less of the quantitative versus qualitative, but rather the emphasis is on how research practices lie on a continuum between the two approaches. Studies tend to be more quantitative or qualitative in nature (Creswell 2003:4), rather than exclusively one or the other.

Both qualitative and quantitative methodologies seem to fall short in terms of the research studies being conducted today and hence give rise to a mixed qualitative and quantitative methods approach (Creswell 2003:4). Therefore, by comprehending the strengths and weaknesses of quantitative and qualitative research methods, a researcher is in the position to mix or combine strategies (Onwuegbuzie and Johnson 2006). According to Ngulube (2010), a

mixed method approach is not a new concept in research, as researchers have been using mixed methods for some time, as in methodological triangulation. This study will use a qualitative approach as the dominant method and the quantitative research as the less dominant method. The research problem for this study hinges on investigating farmers' adoption of innovation practices and knowledge on adaptation to climate change and variability. The choice of the predominant qualitative approach is based on an analysis of the research problem and questions arising from it.

4.6 Mixed Qualitative and Quantitative Research Methods Approach

Cohen, Manion and Morrison (2011:195) defined triangulation as the use of two or more methods of data collection in studying human behaviour. Triangulation techniques attempt to map out and explain fully the richness and complexity of human behaviour, by studying it from more than one standpoint through the use of quantitative and qualitative data. Methodological triangulation involves comparing and integrating collected data through both qualitative and quantitative methods in a complementary style (Patton 2002: 556-557). This aims to provide answers to diverse questions which do not easily come together to provide a single, well-combined image of the situation. A mixed methods approach is based on a philosophical assumption which employs strategies of inquiry that involve collecting data from both quantitative and qualitative research methods, either simultaneously or sequentially to best understand research problems (Creswell 2003: 18; Creswell and Plano-Clark 2007:5).

This approach is explained by combining both quantitative and qualitative research methods to provide a better understanding of the research problem, yield more satisfactory answers and gather richer data than either approach alone would allow (Creswell 1994: 177; Creswell and Plano-Clark 2007:5; Cohen, Manion and Morrison 2011:26). Leedy and Ormrod (2005:97) explained that during data analysis there is no mutually exclusive distinction between qualitative and quantitative research and thus many researchers combine both approaches in the method known as mixed methods design. Mixed methods design also increases the accuracy; provides a more complete picture of the phenomenon under study than use of a single approach, and hence it overcomes the weakness and biases of single approaches and aids sampling. A data collection tool such as a questionnaire can provide a dual purpose, being used to collect data and identify potential participants who will be approached for further interviewing processes (Denscombe 2008:272).

Factors for the application and use of mixed methods strategies in data collection have been explained by Creswell (2003:210-213) and include implementation, priority, integration and theoretical perspective. In implementation, the researcher collects the qualitative and quantitative data in either a sequential order or concurrently. A priority strategy gives a researcher the option to choose whether greater priority should be given to the qualitative or quantitative approach. An integration strategy involves mixing quantitative and qualitative approaches at the data collection or data analysis. The theoretical perspective guides the entire research design and may originate from the social sciences or advocacy/participatory perspective.

There are five major purposes or rationales for conducting mixed qualitative and quantitative methods in research. These as described by Greene, Caracelli and Graham (1989). They include initiation, which involves discovering paradoxes and contradictions that lead to a re-framing of the research question; triangulation, which seeks convergence and corroboration of results from different methods and designs studying the same phenomenon; complementarily, which seeks elaboration, enhancement, illustration, and clarification of the results from one method, with results from the other method; expansion, which seeks to expand the breadth and range of research by using different methods for various inquiry components and development, which uses the findings from one method to help inform the other method. In this study, the rationale for conducting a mixed qualitative and quantitative approach falls under the complementary and development categories.

A number of authors have applied mixed methods in data collection in adoption, agriculture and climate-related studies. These include Masangano and Miles (2004), who investigated the factors influencing farmers' adoption of a new variety of beans known as Kalima. Lwoga (2009) explored the application of knowledge management approaches and information and communication technologies to manage indigenous knowledge in the agricultural sector in selected districts of Tanzania. Mertz, Mbow, Reenberg and Diouf (2009) explored farmers' perceptions of climate change and Agricultural adaptation strategies in rural Sahel. Other scholars who applied mixed qualitative and quantitative approaches in their research are Gundu (2009), who investigated the effect of literacy on access to and utilisation of, agricultural information for household food security in Zimbabwe and Munyua and Stilwell (2009), who carried out a survey using a mixed qualitative-quantitative participatory methodology on the agricultural knowledge and information system of small-scale farmers in

Kenya. More details on other authors who have applied mixed methods in their research have been explained in Chapter Three and Chapter Six of this thesis.

4.6.1 Justification of the Methodology

The research study investigated detailed factors which influence the adoption of an innovation, which in this study is farmers' adaptation to climate change and variability. Kothari (1990:4) points out that a qualitative research approach is essential in behavioural studies aiming at discovering the underlying motives of human behaviour. A qualitative research approach was applied to identify and explain the farmers' behaviour regarding how they seek information, their attitudes to adaptation to climate change and variability, motivations driving farmers' choices for an agricultural innovation, and how the disseminated information is packaged and disseminated to them. From the literature reviewed, it was established that most climate change and variability research studies employ both qualitative and quantitative research methods to explain behavioural issues such as farmers' attitudes and knowledge of adaptation.

Lorenzoni, Nicholso-Cole and Whitmarsh (2007) and Nisbest (2009) clarify the importance of applying qualitative research methods for studying issues related to the packaging and disseminating of information related to climate change and variability. A quantitative research approach was applied to allow quantification of the variables under study in order to identify barriers to adoption and access to information on climate change and variability by farmers. Therefore the mixed qualitative and quantitative methods were applied in this study, for purposes of in-depth exploration of both qualitative and quantitative data to provide a complete analysis of the research problem in order to answer the research questions (Bryman 2006).

4.7 Study Population

A population is the theoretically specified aggregation of study elements (Babbie and Mouton 2001:173). Sekaran (2003:265) describes a population as the entire group of people, events or things of interest that the researcher wishes to investigate. Thus a population is the larger pool from which sampling elements are drawn and to which findings are to be generalized (Terre Blanche, Durrheim and Painter 2006: 113).

The research study population was made up of three categories of respondents. These were farmers, agricultural extension officers and the CCAA project manager. The identification

and selection of respondents' categories was based on farmers as information users, extension officers as agricultural information disseminators and the CCAA project manager as the custodian of the project, who was initiated to train farmers and manage the project from its inception. Farmers were identified through the CCAA list of farmers who had undergone training on coping with climate change and variability in the Maluga and Chibelela villages. The CCAA project manager was identified from the CCAA regional office. Agricultural extension officers were identified through the agricultural regional office in the two regions studied, as each village is served by one extension officer (Village Government 2011a; Village Government 2011b).

4.8 Sampling Procedures

A sample is a subgroup or subset of the population under study for which findings can be generalised to the population of interest (Sekaran 2003:266). A sample is therefore a subset or segment of the population that is selected for investigation (Bryman 2004:87; 2008:168). A sampling procedure entails the selection of research participants from an entire population and involves decisions about which people, settings, events, behaviours and social processes to observe (Terre Blanche, Durrheim and Painter 2006:49). Kothari (2004:55) described a sampling procedure as the process of selecting a representative sub-set of people and the sample size to be studied from the entire population.

The quantitative approach goal is to get a small collection of units from a much larger collection and devise an accurate generalisation of a population (Neuman 2003:210; Neuman 2006:219). According to these authors, the focus for a quantitative approach is the use of specific methods that produce highly representative samples which resemble the population. The qualitative research approach's goal is to collect specific cases, events, or actions that can clarify and deepen understanding (Neuman 2003:211; Neuman 2006:219). Thus the main focus in qualitative research is to assess how the sampled cases are unique, exclusive and distinctive to elucidate social phenomena (Neuman 2003:211; Neuman 2006:219; Cohen, Manion and Morrison 2011:161).

A quantitative approach primarily employs probability sampling, while qualitative studies utilise non-probability techniques (Neuman, 2003:210-211; Onwuegbuzie and Leech 2005; Welman, Kruger and Mitchell 2005:56; Terre Blanche, Durrheim and Painter, 2006; Creswell and Plano-Clark 2007; Teddlie and Tashakkori 2009:170; Cohen, Manion and Morrison

2011:161). Mixed qualitative and quantitative methods sampling involves the selection of units or cases of a research study using both probability and non-probability or purposive procedures (Teddlie and Tashakkori 2009:171). Though mixed methods may be used in research, any approach, qualitative or quantitative, can predominate, depending on the sampling implications (Cohen, Manion and Morrison 2011:162). The estimated population of farmers at Maluga village is 1451, while that of Chibeleda is 1704 (Village Government 2011b; Village Government 2011a). In this study, a purposive non-probability technique was used to select a sample population for data collection. The snowballing method was used to identify and reach respondents were respondents were selected to saturation was reached, that is no new data was being added. Initially those who received formal training and who were the focus of this study were 24 farmers from Maluga village and 52 farmers from Chibeleda village (Village Government 2011b and Village Government 2011a). The final sample was 21 trained farmers from Maluga village and 29 trained farmers from Chibeleda village. Initially, those who did not receive training from Maluga village were 20 farmers while from Chibeleda village there were 25 farmers. The final sample was 15 untrained farmers from Maluga village and 19 untrained farmers from Chibeleda village.

4.9 Study Area

This study surveyed farmers in the Maluga and Chibeleda villages of central Tanzania. The Maluga and Chibeleda villages are located in Iramba and Bahi districts in Singida and Dodoma regions of Tanzania, respectively. The reason for selecting these central regions is because they are prone to drought, as they are in climatically arid and semi-arid areas. Prolonged droughts affect the existing traditional rain-fed cultivation lands and diminish the government's efforts at poverty alleviation. Hillel and Rosenzweig (1989) stress the need for more climate research to be conducted in semi-arid regions as crop production and livestock-keeping are critical in enhancing food security and livelihoods. Climate change and variability has and will exacerbate farmers' vulnerability if drastic adaptive measures are not put in place for farmers. The second reason for the choice of the study areas is that farmers in these regions have been exposed to a number of research and training initiatives with regard to agriculture and adaptation to climate change and variability (Liwenga 2003; Liwenga and Kangalawe 2005; Lema and Majule 2009; Mongi, Majule, Lyimo 2010) and the Climate Change Adaptation in Africa project.

4.10 Sampling of Research Elements

Purposive sampling is a non-probability research method which uses the judgment of a researcher in selecting cases with a specific purpose in mind, to get a population which is informative. This purpose is difficult to reach for an in-depth investigation of a social problem (Neuman 2003:213). Sekaran (2003:207) and Cohen, Manion and Morrison (2011:157) describe purposive sampling as confined to specific types of people who can provide the desired information, so as to conform to some criteria set by the researcher, or because they are the ones who have it. In purposive sampling, sampling does not only depend on availability and willingness to participate, but cases which are representative of the population are selected (Terre Blanche, Durrheim and Painter, 2006:139). Supporting this view, Patton (2002:40) explains that applicability of purposive sampling in cases for study such as people, organizations, cultures and critical events mostly resonate with the choice of information-rich cases which shed light and insights on the phenomenon investigated and are not intended to be used for generalisation of the findings.

Purposive sampling was used to target all trained farmers (50) in both villages. Using the list of trained farmers provided by CCAA, and with the initial guidance of village government leaders, the snowballing method was used to identify and reach respondents. Similarly the 34 untrained farmers in both villages were identified through village government leaders and reached through snowballing. The agricultural extension officer from each study village was reached with the assistance of the regional agricultural and livestock office.

4.11 Methods of Data Collection

In the present study, primary data was collected using semi-structured interviews, in-depth interviews techniques and focus group discussion. Semi-structured interviews and focus group discussion were held with farmers while in-depth interviews were held with agricultural officers and the programme manager.

4.11.1 Semi-Structured and In-depth Interviews

In contrast to structured interviews, semi-structured interviews have a set of basic questions and procedures, but greater freedom is given to the interviewer on how to treat his/her respondents and in modifying the order of questions (Ractliffe 2002: 21; Robson 2002:270). Semi-structured interviews are mostly used in qualitative analysis (de Zeeuw and Wilbers 2004:8; Gray 2004:215). The preference for semi-structured interviews in qualitative studies

is that they are useful in obtaining information on a specific or general topic, to analyse problems and opportunities or to discuss plans, as well as to elicit perceptions (de Zeeuw and Wilbers 2004:8). They are flexible and they are thus likely to yield information that the researcher had not planned to ask for (Marshall and Rossman 1999:108; Bryman 2004:321; Gray 2004; Leedy and Ormrod 2005:137).

Data from trained and untrained farmers was collected, using researcher-administered semi-structured interviews. The research instrument was researcher-administered, as most of the people in rural areas are illiterate and cannot read or write. The study interviewed 50 trained and 34 untrained farmers from Maluga and Chibelela villages out of 76 trained and 45 untrained farmers who were initially targeted. The untrained farmers from Maluga and Chibelela villages were interviewed until saturation was reached. This decision is supported by the fact that in qualitative studies it is imperative to have a sample size consisting of information-rich cases (Holloway 1997:142). In supporting this view, Leedy and Ormrod (2005:96) indicated that in qualitative research researchers tend to identify and select a few participants who will best enlighten them on the phenomenon under investigation.

Patton (1990:185) explains that in qualitative studies the trustworthiness and importance of data generated depend largely on the information richness of selected cases and the analytical capabilities of the researcher, rather than on sample size. An interview schedule for trained farmers was used to record, the type of information and knowledge farmers received, how the information was packaged, how they accessed and used information and the methods they applied to mitigate the effects of climate change and variability. Another interview schedule was researcher-administered to untrained farmers, to solicit information on the level of adoption of information on climate change and variability and how information/knowledge on climate change and variability was packaged and disseminated to them and by whom. The rationale for involving untrained farmers was to compare their adoption practices in relation to information on climate change and variability with those of the trained farmers, as well as their attitudes to accessing and using information on climate change and variability.

In-depth interviews were employed with the agricultural extension officers and CCAA programme manager. An in-depth interview with the agricultural extension officer sought to solicit information on the types of information on climate change and variability disseminated to farmers, how farmers sought information for adaptation to climate change and variability,

how information was packaged and disseminated to farmers, what methods farmers applied to mitigate the effects of climate change and variability and how farmers accessed and used information on climate change and variability. The information gathered from the programme manager encompassed how training was delivered, the progress and challenges which emerged with regard to the information packaging and dissemination process. Others were the perception of the programme manager on the level of adoption by farmers and barriers to access and use of information on climate change and variability in the selected villages.

4.11.2 Focus Group Discussions

The focus group discussion (FGD) method is described as a means of obtaining information from people in a group on a specific topic raised by a researcher (Bryman 2004:345; Bryman 2008:473; Cohen, Manion and Morrison 2011:436). A group is typically made up of people who share a similar type of experience, but is not ‘naturally’ constituted as an existing social group (Terre Blanche, Durrheim and Painter 2006:304). The group composition of participants is six to eight interviewees (Creswell 2003:186; Teddlie and Tashakkori 2009), six to twelve (Krueger 1994:78), six to ten (Litoselliti 2003:6) and at least four (Bryman 2008:473).

One advantage of the focus groups is that the accuracy of the information and the rate at which it is generated is higher in groups than in individual interviews (Grenier 1998; Babbie 2004; Bryman 2008:475). Another advantage is gaining access to understanding the differences between people whom we might previously have thought as a homogeneous group sharing a common experience (Terre Blanche, Durrheim and Painter 2006:304). Focus groups are flexible and produce validated data and speedy results (Cohen, Manion and Morrison 2011:436). They also capture real-life data in a social environment (Krueger 1988:47; Marshall and Rossman 1999: 115; Hesse-Biber and Leavy 2011:165). They are important because the group develops its own conversation, raising issues and ideas that might not emerge in a discussion with the interviewer alone (Cohen, Manion and Morrison 2000:288; Bryman 2008:475; Hesse-Biber and Leavy 2011:164).

In this study FGDs were carried out in each village under study. The FGDs were made up of village elderly people, village government leaders, influential people in the village and farmers. This was done in order to gain understanding of how they perceived climate change and variability and the effectiveness of adaptation practices. The focus groups also helped the

researcher to obtain information on trends in climate change and variability over the past years. The focus group, through group discussion and brain-storming, is expected to provide clarification and understanding of factors affecting access and use of information on adaptation to climate change and variability and knowledge generation, use and sharing of climate change and variability knowledge among farmers. The FGD is one of the best methods for seeking clarification on issues perceived by people.

4.12 Data Analysis

Data analysis involves a number of closely related operations which are performed with the purpose of summarising the collected data and organising them in such a manner that they answer research questions (Kothari 1990:151). The aim of data analysis is to discover patterns among data that point to theoretical understanding of social life (Babbie 2004:376). Qualitative data analysis, searches for patterns in data, recurrent behaviour, objects, phrases, or ideas which are subjectively identified are interpreted in terms of social theory or the setting in which they occurred (Leedy and Ormrod 2005:96; Neuman 2006:467). In qualitative research studies, there is no clear point at which data collection ends and analysis commences (Terre Blanche, Durrheim and Painter 2006:321). Thus, in qualitative research the processes of data collection, data analysis and report writing are intertwined and are not distinct steps (Patton 2002:436; Leedy and Ormrod 2005:144; Creswell 2007:150).

Quantitative data analysis uses statistical methods to analyse research variables so as to describe data more concisely and to make inferences about the characteristics of populations (Terre Blanche, Durrheim and Painter 2006: 188). It uses a standardised set of techniques and procedures to make inferences on a phenomenon in a study (Neuman 2003:439). Quantitative data analysis emphasises the analysis of numeric data, using a variety of statistical techniques. Data consists of numbers representing scores on variables collected using instruments, checklists or public documents to answer research questions or to test hypotheses (Terre Blanche, Durrheim, Painter 2006:188; Teddlie and Tashakkori 2009). The major aim of quantitative data analysis using inferential statistics is to draw conclusions about populations on the basis of data and to confirm or reject the hypotheses, hence advancing a theory (Leedy and Ormrod 2005:97; Terre Blanche, Durrheim and Painter, 2006:208-209; Neuman 2006:177). Thus, in mixed qualitative and quantitative methods, qualitative data analysis is done using qualitative methods and quantitative data analysis using quantitative methods (Creswell 2003:220; Teddlie and Tashakkori 2009; Creswell and

Plano-Clark 2007:128). When mixed method analysis is used, there are different ways of reporting the findings. Greene, Caracelli and Graham (1989) describe the five approaches used when reporting mixed methods analysis is done. These include (a) no integration, analysing and interpreting qualitative and quantitative data separately; (b) analysing separate but some integration during interpretation; (c) integration during both analyses and interpretation; and (d) analysis procedures not reported. This study employed approach (b).

4.12.1 Qualitative Data Analysis

Qualitative data analysis involves organising, accounting for and explaining the data through participants, defining the study situation, noting patterns, themes, categories and regularities (Cohen, Manion and Morrison 2011:537).

In the present study, in order to manage the qualitative data collected from interviews effectively, the data was analyzed thematically using content analysis (Patton 1990). Data from the interview schedules was collected and systemically arranged into themes. The themes were based on the study research questions. Thematic analysis is a type of content analysis which is a detailed and systematic examination of the contents of a particular body of material for the purpose of identifying patterns, themes or biases (Leedy and Ormrod 2005:142).

4.12.2 Quantitative Data Analysis

Cohen, Manion and Morrison (2011:604) describe quantitative data analysis as a powerful research tool, in most cases associated with large-scale research emanating partly from a positivist traditional approach. Numerical data analysis in social sciences mostly employs software such as the SPSS, Minitab and Excel which ease the computation of data.

In this study, the SPSS programme version 20 was used to analyse the quantitative data from semi-structured interviews. For quantitative data, descriptive statistics such as the means, frequencies, standard deviations, regression analyses and cross tabulation were generated using SPSS. SPSS was used because it offers powerful and easy ways to extract data, reduces time required to analyse data, reduces errors involved in coding data, analysing data with in-depth statistics and producing charts (Pickard 2007:278).

4.13 Validity and Reliability

Validity and reliability are of concern in qualitative and quantitative measurements as they are concerned with how substantial measures are related to constructs so as to establish the truthfulness, credibility and believability of findings (Neuman 2003:178; 2006:188). In a broader sense, the reliability of a measure indicates the extent to which it is without bias (error free) and hence its application ensures consistent measurement across time and across various items in the instrument (Sekaran 2003:203). Ashatu (2009) points out that scientific knowledge's credibility can be enhanced by improving both internal consistency and generalisability, through combining both qualitative and quantitative methods in the same study.

4.13.1 Reliability in Qualitative and Quantitative Research

Reliability is concerned with whether or not the results of a conducted study are consistent, stable and repeatable (Neuman 2003:178; Sekaran 2003:203; Bryman 2008:31-32). Thus, dependability, consistency and replicability should be over time, over instruments and over a group of respondents (Cohen, Manion and Morrison 2011:199). In qualitative methodologies, reliability includes fidelity to real life, context-and-situation-specificity, authenticity, comprehensiveness, detail, honesty, depth of response and meaningfulness to the respondents (Cohen, Manion and Morrison 2007:149). Reliability in qualitative approach is ensured through properly designed and structured research to balance objectivity and subjectivity (Borland 2001:8). In quantitative research, reliability refers to the extent to which similar, consistent and stable results will be obtained if the study is repeated over time (Sekaran 2003:203; Payne and Payne 2004:195; Cohen, Manion and Morrison 2011:200). In this study, reliability was ensured through the use of proper transcription of data and pretesting of research instruments to ensure the proper use of correct terminologies familiar to respondents to avoid misinterpretation of constructed concepts.

4.13.2 Validity in Qualitative and Quantitative Research

Validity is concerned with whether or not an indicator devised to measure a concept really measures that concept in a research study (Babbie and Mouton 2001:122; Bryman 2008:32). Validity acts as a bridge between a construct and the data to establish the truthfulness of the data (Neuman 2003:185; 2006:196). There are diverse types of validity in both qualitative and quantitative research. Common types include internal and external validity. Internal validity is concerned with the extent to which a research study design and the data yielded

allow a researcher to produce accurate conclusions about constructs relationships (Leedy and Ormrod 2005:97). External validity is the extent to which the findings of a research study can be generalised in a wider context (Leedy and Ormrod 2005:97). In order to test the worthiness of instrument measures in research, validity tests are conducted (Sekaran 2003:206).

Qualitative research is more interested in authenticity referring to fairness and honest and balanced accounts of social life, rather than validity (Neuman 2003:185). Validity in qualitative research depends on credibility, skill, competence and the rigor of the qualitative inquiry, as the researcher is the instrument (Patton 1990; 2002:14). To minimise threats to validity and increase trustworthiness (Creswell 2003:196; Leedy and Ormrod 2005:100; Creswell 2007:204), a researcher should use triangulation, extensive time in the field, peer debriefing, negative information, feedback from other members in the field and use of rich thick descriptions, so that readers can make conclusions, validate a respondent, clarify bias and use an external auditor.

In quantitative research, validity must be faithful to its foundations of positivism and positivist principles by adhering to controllability, replicability and predictability (Cohen, Manion and Morrison 2011:180). In quantitative inquiry, validity pivots on careful instrument construction, to ensure the designed instrument measures what it is supposed to measure (Patton 2002:14). Of major concern in quantitative research is the measurement of validity in the research. Measurement of validity refers to how well the conceptual and operational definitions are interconnected (Neuman 2003:182; 2006:192). Threats to the measurement of validity include inadequate procedures and participants' experience, which might influence the real problem under observation. Other threats include the researcher drawing incorrect inferences from sample data to other settings, lack of knowledge on statistics and the use of inadequate definitions and incorrect use of variables (Creswell 2003:171). Threats to validity in quantitative research can be minimised through careful sampling, appropriate instrumentation and the appropriate statistical treatment of data (Cohen, Manion and Morrison 2007: 133; 2011:179). In the present study, validity was attained and ensured by pretesting the interview guides and having a truly representative sample of study elements at village level from the study population in Iramba and Bahi districts, as well as careful analysis of the data.

4.13.3 Pretesting of Data Collection Instruments

A pilot study and the pre-testing of the data collection instruments were done in Ulemo village, which is close to the village of Maluga. A total of eight trained farmers was selected and interviewed. This village was chosen for the pretesting because some of the farmers from Ulemo village had also received training by CCAA experts on adaptation to climate change and variability. The validity and reliability of the pretested data analysis was done through running regression and correlation tests on the data from the interview tools. The regression and correlation test indicated a Cronbach's alpha coefficient value of 0.742, at the 0.05 significance level. The study adapted and modified questions from similar studies on agriculture, knowledge and information systems and climate change and variability, such as those by Lwoga (2009), Gundu (2009), Pelum (2010) and Munyua (2011) and Baide (2005), to inform the instrument questions. The researcher selected eight untrained farmers to be interviewed in the pretesting. After the pretesting, interview questions in the interview schedules were modified clarify the meaning of concepts.

4.14 Ethical Considerations

Ethical considerations represent a moral attitude that involves conducting research to achieve not just high professional standards of technical procedures, but also respect and protection for the people actively consenting to be studied (Payne and Payne 2004). Common categories in which most research ethical issues fall include informed consent, protection from harm, honesty from researchers and the right to privacy (Leedy and Ormrod 2005:101). The moral integrity of the researcher is stated as a critical aspect of ensuring that the research process and a researcher's findings are trustworthy and valid (Hesse-Biber and Leavy 2011:59). Cohen, Manion and Morrison (2011:76) stipulated two critical components to be considered in attaining valid and reliable data in research. These are sensitivity concerning the problems investigated and the methods used in data collection.

Informed consent is a procedure carried out when social science research involves the study of human subjects (Hesse-Biber and Leavy 2011:63). It is said to involve competence, voluntarism, full information on, and comprehension of, the nature of the study (Cohen, Manion and Morrison 2011:78; Leedy and Ormrod 2005:101). Consenters should be able to make the correct decision, participants should be free to participate or not, participants should be fully informed on the research and participants should fully understand the nature of the research. One of the means to seek informed consent is to use an informed consent letter,

which describes the nature of the research. Each respondent in the study should sign it to show they agree to participate in the study (Hesse-Biber and Leavy 2011:63). Respondents were assured of confidentiality and anonymity with regard to the information they provided before the interviews were conducted with each respondent.

This study abided by the University of KwaZulu-Natal research ethics policy (UKZN 2013) and received clearance from the UKZN for the study. Among issues elaborated on in the research ethical issues were type of research, population under study and informed consent. The informed consent form explained to respondents the nature and purpose/s of the research, the identity and institutional association of the researcher and supervisor/project leaders, with their contact details. Important details on research participation were provided to participants, when where they were informed that they were free to withdraw from the research at any time without any negative or undesirable consequences to themselves. Thus informed consent forms were made available to all respondents and all who agreed to participate signed on the form to show their consent to participate in the research.

Confidentiality, anonymity and honesty were ensured throughout data collection and reporting by coding the responses provided by respondents. Since cultural issues are of great concern in most African countries including Tanzania where this study was conducted, the researcher wanted to ensure that all the necessary steps needed to gain acceptance of study subjects were adhered to, as has been pointed out by Cohen, Manion and Morrison (2011: 81). The researcher complied with Tanzania government research ethical standards by securing permission to conduct research in the study areas. Cultural issues were taken into consideration to avoid misconceptions which might have affected the data collection. This was done through the researcher meeting with the village leaders and explaining to them what the research was all about. The village leaders then informed the respondents about the research. Supporting this approach, Neuman (2011:351) explained that respondents are likely to provide information accurately and honestly when asked in a comfortable context, with mutual respect and trust.

4.15 Summary

This chapter discussed the research methodology adopted in the study. It explained the research design and described positivist, interpretive, pragmatic and post-positivist paradigms. The study showed why and how the adopted post-positivist approach fits the research study. The chapter described an evaluation of qualitative and quantitative methods and mixed qualitative and quantitative methods as they applied to the study. The chapter gave reasons for the choice of mixed qualitative and quantitative methods and described in detail the study population, sampling procedures and sampling of research elements. The chapter also discussed the study area, data collection procedure and instruments, qualitative and quantitative data analysis, validity, reliability and the pretesting of instruments. The research ethics, briefly discussed in Chapter One, was explained in detail.

CHAPTER FIVE

DATA ANALYSIS AND PRESENTATION OF RESULTS

5.1 Introduction

The present study sought to investigate adaptation by farmers to climate change and variability in the semi-arid Maluga and Chibelela villages of central Tanzania. The study specifically investigated how the information generated through research on adaptation to climate change and variability is packaged and disseminated to farmers to improve agricultural production among rural communities in central Tanzania. The study addressed eight research questions pertaining to information and climate change and variability. The research questions were: i) to identify the goals of information disseminated to farmers on climate change and variability; ii) to assess the types of information on climate change disseminated to farmers; iii) to identify specific channels used when disseminating information on climate change and variability; iv) to investigate methods farmers apply to mitigate the effects of climate change and variability; to determine the current level of adoption of information on adaptation to climate change and variability; vi) to investigate the access to, and use of, information on climate change and variability; vii) to ascertain attitudes and perceptions of farmers towards climate change and variability; and viii) to determine the limiting factors affecting access to, and use of, information on adaptation to climate change and variability by farmers.

The study was underpinned by Rogers' Diffusion of Innovations theoretical model. A post-positivist approach was used, with qualitative and quantitative methods being used in dominant and less dominant positions respectively. Semi-structured interviews, in-depth interviews and focus group discussions were the instruments used to collect data. The semi-structured interviews were carried out with 84 farmers. In-depth interviews were conducted with two agricultural extension officers and one project manager. Two focus group discussions were held, one in each village, with an extension officer.

This chapter presents results relating to the research study. In this chapter data is presented in themes, narrations and descriptive statistics, such as frequencies, using charts, graphs, figures and tables. The chapter is organised into sections, using research questions as themes. The chapter describes the demographic and economic profiles of respondents. The profiles described include gender, age, level of education and income. Farm sizes are described. The

chapter outlines the respondents' occupations and discusses the farming practices in the study areas.

The sections and sub-sections in this chapter include goals of information dissemination to farmers on climate change and variability; type of information on climate change and variability disseminated to farmers; packaging and dissemination of information on climate change and variability climate change and variability to farmers; and the knowledge of adaptation to climate change and variability held by farmers. The sections and sub-sections cover the major research question and subsidiary research questions of the study. The subsidiary research questions addressed are 1, 2 and 3 in sections 5.4, 5.5, 5.6, 5.7 and 5.8.

Other sections presented in this chapter include farmers' awareness and understanding of climate change and variability; sources of indigenous knowledge on weather prediction; preservation of indigenous knowledge for weather prediction; farmers mitigating the impact of climate change and variability and attitudes and perceptions of farmers on climate change and variability. The findings on farmers' local perceptions of rainfall patterns and temperature were compared to data analysed from the Tanzania Meteorological Agency (TMA), to examine the patterns. The subsidiary research questions covered in these sections are 4 and 7 in sections 5.9 and 5.10.

Chapter five describes farmers' current level of adoption of information on adaptation to climate change and variability; farmers' access to, and use of, information on climate change and variability and factors affecting access and use of information on adaptation to climate change and variability. The subsidiary research questions addressed in these sections and sub-section are 5, 6 and 8 in sections 5.11, 5.12 and 5.13. In addition, the chapter then provides a summary of the chapter on data analysis and results are presented.

5.2 Demographic and Economic Profiles of Respondents

Respondents were asked questions that elicited their personal information, such as sex, age, level of education and level of annual income from farming activities (cf. questions b1, b2 and c11 in Appendices 1 and 2). These biographical and economic data were solicited to describe the demographic profile of respondents who participated in the study. The demographic variables for farmers were used to inquire whether or not there is any correlation between these variables and the knowledge of farmers on climate change and variability and farmers' adoption of farming innovation practices. The other categories of

respondents were the district agricultural extension officers and the programme manager of the CCAA project.

5.2.1 Gender of Respondents

There were more female 58 (69%) than male 26 (31%) respondents. This result reflected the composition of the groups of targeted farmers who received training and those who were not trained by the Climate Change and Adaptation in Africa (CCAA) project. Thus, in the training there were more women in the groups than men. The findings from semi-structured interviews showed that in Maluga village 20 (55.6%) respondents were female, while 16 (44.4%) respondents were male. In Chibelela village, 38 (79.1%) respondents were female and 10 (20.8%) respondents were male, as depicted in Table 5.1 and Figure 5.1. The greater number of women in Chibelela is explained by the presence of many women in farming groups engaged in agricultural activities in that village. The field observation showed that the district agricultural extension officers and the programme manager were all male.

Table 5.1: Gender of Farmers

Sex N=84	Frequency	Percentage
Male	26	31
Female	58	69
Total	84	100

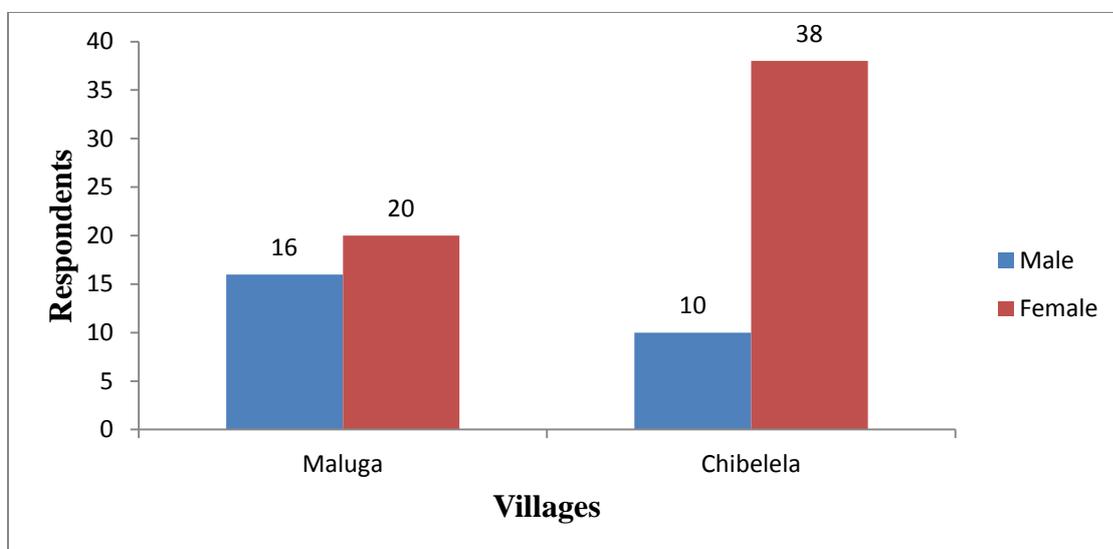


Figure 5.1: Distribution of Gender in Study Villages

5.2.2 Age of Respondents

Findings from the interviews show that most (26 or 31.0%) respondents were between the ages of 36 years and 45 years, followed by those above 60 years 20 (23.8%). The third group of respondents were between 51 and 60 years old (15 or 17.9%). The smallest group were between 15 and 25 years old (2 or 2.4%).

The age of both district agricultural officers involved in the study was between 36 years and 45 years while the programme manager's age was between 46 and 50 years. Table 5.2 summarises the results on the age of the respondents.

Table 5.2: Age Profile of Respondents

Category N=84	Frequency	Percentage
15-25 years	2	2.4
26-35 years	10	11.9
36-45 years	26	31.0
46-50 years	11	13.0
51-60 years	15	17.9
Over 60 years	20	23.8%
Total	84	100.0%

5.2.3 Respondents' Levels of Education

Findings of the study indicate that most (63 or 75%) of the respondents were primary school leavers followed by those who were illiterate (12 or 14.3%). Eight (9.5%) of the respondents attained secondary education and only one (1.2%) attended college/university. The level of education of the respondents is shown in Figure 5.2.

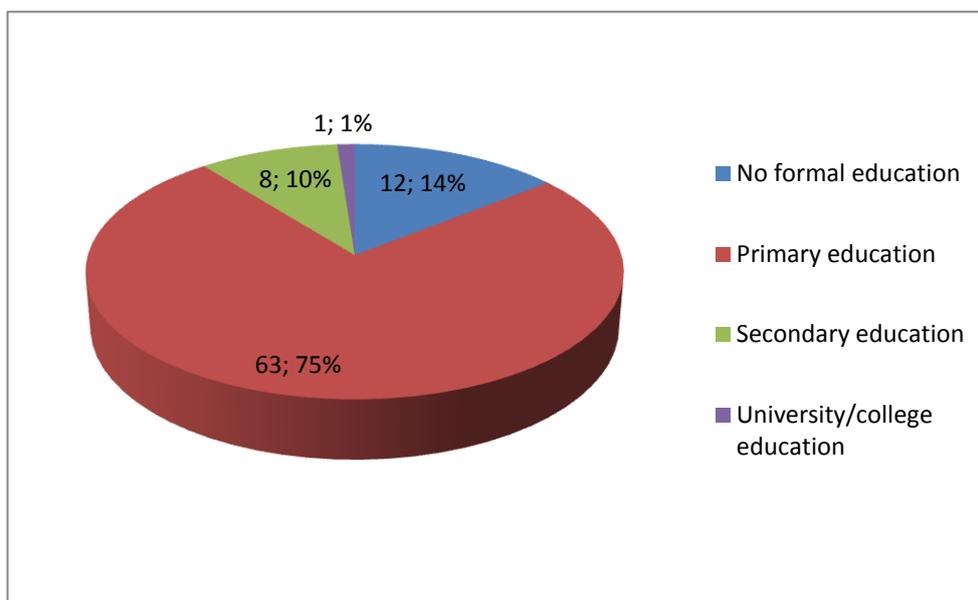


Figure 3.2: Level of Education of Respondents

5.2.4 Income Level of Respondents Based on Annual Production

The study sought to determine the annual income of farmers from their agricultural production practices. Five categories of respondents' annual income emerged. The categories were calculated based on wealth quintiles (Hoogeveen *et al.*, 2009). The categorisation of wealth income groups is similar to the one used in the Tanzania Household Budget Survey of 2007, which shows the distribution of household monthly consumption (Poverty and Human Development Report PHDR, 2009c). Annual income level is calculated on the basis of monthly income, over 28 days in a month, and over a year of 13 months (Deaton 1988). Those with an annual income of less than Tanzanian Shillings (Tsh) 50635 were grouped as the poorest and those with an annual income between Tsh 50636 and Tsh 86580 were grouped as poor. Respondents with an income between Tsh 86581 and Tsh 123370 per year were classified as average income earners, while respondents with income between Tsh 123371 and 177255 per year were categorised as better than average. Respondents with an income of between Tsh. 177256 and 361868 were grouped as least poor. Details are given in Table 5.3.

Table 5.3: Income Level of Respondents based on Annual Production

Wealth Quintile N=84	Level of Income per Annum (USD)	Level of Income per Annum (Tsh.)	Frequency	Percentage
Poorest (1 st)	0-32.67	Less than 0-50635	4	4.8
Poor (2 nd)	32.68-55.86	50636-86580	7	8.3
Average (3 rd)	55.87-79.59	86581-123370	4	4.8
Better than Average (4 th)	70.60-114.36	123371-177255	13	15.5
Least Poor (5 th)	114.37-233.46	177256-361868	56	66.6
Total			84	100.0

(PHDR 2009c)**Note: 1USD~1550 Tshs.**

Cross tabulation of farmers' income in the study villages indicated more poor in Chibelela village than in Maluga village. Findings indicate that in Maluga village there are few respondents in the 1st and 2nd wealth quintiles. These were one (14.3%) compared to 10 (90.5%) in Chibelela village. Findings indicate the 3rd wealth quintile had two (2.4%) respondents in each village. The 4th wealth category had seven (53.8%) respondents in Maluga village as compared to six (46.2%) in Chibelela village. The last wealth quintile group had 26 (46.3%) respondents in Maluga and 30 (53.6%) in Chibelela village. Table 5.4 shows the results in detail.

Table 2.4: Poverty Distribution across Study Villages

Income Categories	Maluga Village		Chibelela Village		Total
	Frequency	Percentage	Frequency	Percentage	
Poorest	0	0.0	4	4.8	100
Poor	1	14.3	6	85.7	100
Average	2	2.4	2	2.4	100
Better than Average	7	53.8	6	46.2	100
Least Poor	26	46.4	30	53.6	100
Total	36		48		84

5.2.5 Farm Sizes

The respondents were asked the size of their farms (cf. research question c10 in Appendices 1 and 2). Findings from the interviews show that most (50 or 59.6%) respondents possess farms of sizes above five acres. Another 27 (32.1%) respondents own farms of between 2.5 and 5.0 acres. The last category of respondents has farms of between 1.0 and 2.0 acres. Table 5.5 summarises the areas of the farms.

Table 5.5: Acreage of Farms Owned

Farm sizes (acres) N=84	Frequency	Percentage
1.0-2.0	7	8.3
2.1-5.0	27	32.1
Above 5	50	59.6
Total	84	100.0

The findings indicated that farmers in Chibeleda village had larger farms compared to those in Maluga village. Results showed 6 (85.7%) farmers in Chibeleda village with farm sizes between 1.0-2.0 acres, compared to 1 (14.3%) in Maluga village. Farmers with farm sizes between 2.5 and 5.0 acres were 11 (40.7%) in Maluga village and 16 (59.3%) in Chibeleda village. More farmers in Chibeleda had farms above 5 acres (26 or 52%), compared with 24 (48%) in Maluga village. The results are given in Figure 5.3.

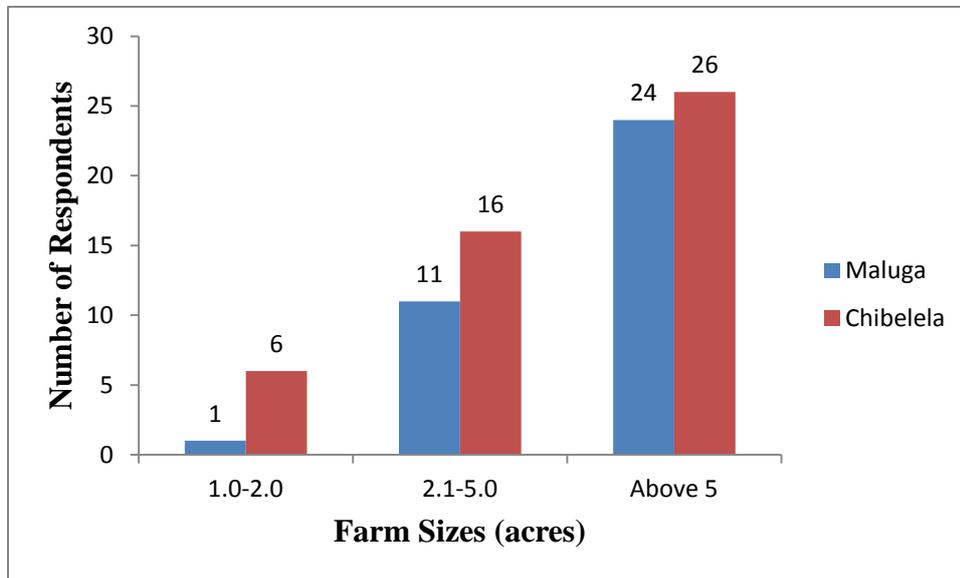


Figure 5.3: Respondents' Farm Sizes

5.2.6 Respondents' Occupations

Table 5 shows that most, that is 78 (92.8%) respondents, indicated their primary occupation as farming and a few (6 or 7.2%) stated that their primary occupation was non-farming. The study found that those respondents who are not primarily dependent on farming, but are salaried, were 4 (4.8%). Another 2 (2.4%) depended primarily on petty trading.

Findings indicate that the majority (28 or 33.2%) had livestock keeping as their secondary occupation. Twenty-three (27%) respondents engaged in petty trading. The results showed 4 (4.8%) had their secondary occupation as farming, while another 4 (4.8%) respondents stated their secondary occupation was government employment. Twenty four, 24 (28.6%) respondents did not indicate having any secondary occupation and were designated as not having a secondary occupation. Only 1 (1.2%) respondent's secondary occupation was beekeeping. The results are given in Tables 5.6 and 5.7.

Table 5.6: Respondents' Primary Occupation

Primary Occupation N=84	Frequency	Percentage
Farming	78	92.8
Salaried job	4	4.8
Petty trading	2	2.4
Total	84	100.0

Table 5.7: Respondents' Secondary Occupation

Secondary Occupation N=84	Frequency	Percentage
Livestock keeping	28	33.2
Salaried jobs	4	4.8
Petty trading	23	27.4
No secondary activity	24	28.6
Beekeeping	1	1.2
Farming	4	4.8
Total	84	100.0

5.3 Farming Practices and Farmers' Source of Water in Chibelela and Maluga Villages

Respondents were asked to state their farming activities. This question is consistent with questions c6 in the Appendices 1 and 2. The study observed that the major farming activities in Chibelela village are cultivation, selling crops and livestock keeping and selling. The respondents were asked to state their reason for being engaged in farming activities. Farmers in Chibelela and Maluga villages engaged in farming for food and income generation. Major crops grown in Chibelela village are sorghum, maize, sunflower, groundnuts, grapes, sesame, finger millet, cowpeas and rice. The major crops cultivated in Maluga village are sorghum, maize, sunflowers and beans. Farmers in Chibelela village grew sunflowers, sesame and grapes as cash crops, while sorghum, maize, rice and groundnuts serve as both food and cash crops. In Maluga village farmers grew sunflowers for cash, while sorghum and maize are

mainly used for food and as cash crops. The types of livestock kept in both villages are similar and include cattle, sheep, goats, pigs, donkeys and chickens.

The study sought to investigate existing farming practices from respondents (cf. questions c12 in Appendices 1 and 2). Farmers in Chibelela village practise a variety of innovations. These include traditional, adopted innovations and the application of new technologies as measures to combat the effects of climate change and variability. Traditional innovations include the use of hand hoes and unimproved seeds, while newly adopted innovations include the use of ploughs and manure, new soil tillage farm implements and new planting methods. Adoption of a particular farming practice depended on the farmers' knowledge and experience.

It was found that in the past farmers mainly practise mono-cropping, as well as mixed-cropping practices. However, despite mono-cropping being a dominant farming practice in both villages of Chibelela and Maluga, farmers are shifting towards inter-cropping farming practices. These results confirm those by Dhaka, Chayal and Poonia (2010), who reported that most farmers in India were adapting to climate changes and variability by practising intercropping farming systems. Crop rotation in both Maluga and Chibelela villages is currently not practised by many farmers, due to land scarcity and soil infertility. Comments gleaned from respondents were:

F1: "...the mono-cropping and mixed-cropping farming methods have been in our village way back". "However some of us have adopted the inter-cropping method as a new farming method as it enhances agricultural production".

F2: "Inter-cropping is a good farming method as you can attain good harvest by cultivating a fairly medium farm size".

F2: "Crop-rotation becomes difficult as our village population has increased, where will you get land easily".

F3: "... with the unpredicted weather, how can I risk to cultivate a place I am not sure of its soil fertility"? "I might end up not harvesting". "There is a high risk and uncertainty in practising crop-rotation these days".

The findings from the semi-structured interviews revealed that, despite efforts to create awareness about innovations for water storage and irrigation, farmers in the villages depended on rainfall as the major source of water in farming. Findings were that all 48 (57.1%) farmers in Maluga village and all 36 (42.9%) in Chibelela village depended on rainfall for agricultural production. These results concur with those of Mongi, Majule and Lyimo (2010), who showed that rain-fed agriculture is still predominant in semi-arid regions of Tanzania. Findings from the focus group discussion with farmers and the in-depth interview with the extension officer indicate a growing irrigation farming practice in Chibelela village and Bahi region, more generally. Comments showed an increased need for irrigation:

F1: “You know, poor harvest forces us to practise irrigation as these days you can plant and almost harvest nothing”.

F2: “Short seasonal vegetables such as onions and tomato have a much quick economic return...”

F3: “...Our farmers have witnessed the effects of climate change and variability in farming, they now diversify to irrigation farming”.

F4: “Vineyard as a cash crop pays us more. We don’t need to wait for rain to plant...”

In addition to farmers depending on rainfall for agriculture, the study found that in both Chibelela and Maluga villages, water was a scarce resource. Farmers lack reliable sources of potable water, as well as water for washing and other daily domestic purposes. Farmers dedicated much of their time to fetching water, using animals such as cows and donkeys. In the course of searching for water, farmers adapted and learned local innovations such as digging underground wells and using areas where the river runs during the rainy season. Water from the wells is also being used for irrigation purposes. Inadequate rainfall affects the recharging of underground water and results in water scarcity, due to inadequate water to replenish the villages’ constructed reservoirs. Figure 5.4 illustrates how farmers dig underground wells.



Figure 5.4: Wells Used by Farmers as a Source of Water

5.4 Climate Change and Adaptation in Africa’s Goals of Disseminating Information to Farmers

This section presents detailed findings on Climate Change and Adaptation in Africa project (CCAA) towards improving farmers’ livelihoods in Maluga and Chibelela villages.

5.4.1 CCAA Project Initiation

The programme manager was asked how the programme was funded and what the Climate Change Adaptation in Africa project was all about (cf. questions b4 and b6 in Appendix 4). The findings from the in-depth interview showed the Climate Change Adaptation in Africa (CCAA) project was funded by the Department for International Development (DFID) and International Development Research Center (IDRC). The CCAA project was implemented under the auspices of the Institute of Resource Assessment of the University of Dar es Salaam and Chancellor College of the University of Malawi. The project targeted both favoured and unfavoured agro-ecological zones in Tanzania and Malawi. The geographical location of the regions determines annual rainfall, which explains “favoured” and “unfavoured” agro-ecological zones. The favoured agro-ecological zones for the project were Mbeya and Iringa regions in the southern highlands of Tanzania and Mulanje and Mzimba regions in Malawi. The less favoured agro-ecological zones were Dodoma and Singida

regions, which are semi-arid central regions of Tanzania, and Chikwawa and Karonga regions in Malawi.

5.4.2 Choice of Study Areas

The study sought to determine how the project came to be allocated to the selected regions and how the study villages were chosen (see questions b7 and b9 in Appendix 4). Findings from the in-depth interview with the CCAA programme manager indicated that the study regions of Dodoma and Singida were chosen at stakeholders' consultation meetings. The stakeholders who participated in the meetings included the Division of Environment (DO), Researchers, Agricultural inputs providers and advisers (Stockists), the Tanzania Meteorological Agency (TMA) and NGOs. The current study selected the villages of Chibelela and Maluga for two major reasons. Firstly, the villages were being severely affected by climate change and variability and, secondly, the villages mostly had low annual potential agricultural production capacity. The observed effects of climate change and variability in the villages were significant changes in weather which caused frequent drought, increased dry spells, and crop failure. Other impacts of climate change and variability were food insecurity, increased plant diseases and the necessity for frequent food aid, which was a result of poor annual harvests.

5.4.3 Goals of Information Dissemination to Farmers

The programme manager was requested to explain the goals of information dissemination on climate change and variability to farmers (cf. research question b5 in Appendix 4). The in-depth interview showed that CCAA project's goal was to build capacity in farmers, organisations and the private sector, to enable them to improve agricultural innovation systems in both the favoured and unfavoured agro ecological areas of Tanzania and Malawi. The project specifically aimed at reinforcing farmers' ability to access and use quality information through training, in order to improve their agricultural produce. The project also endeavoured to involve both public and private sector stakeholders in developing efficient agricultural innovation systems. The project aspired to enable farmers to learn and share experiences for enhancing successful strategies to uplift the capacity of individuals, organisations and systems within the agricultural innovation systems. These objectives strived for the scaling up of best practices for adaptation to climate change and variability in central Tanzania.

5.4.4 CCAA Project Achievements

The study also revealed what the project's achievements were since its inception (see question b12 in Appendix 4). The in-depth interview with the CCAA programme manager indicated that project goals were achieved. The information disseminated to farmers on climate change and variability had a positive impact on farming. The programme manager stated that:

P1: "The CCAA project disseminated information which created awareness to farmers on climate change and variability and enhanced their decision-making on best practices to adopt under varying climate".

P2: "...farmers' attitude to access and use of information on climate change and variability for adaptation has changed as their access and use of both information on drought resistant and early maturing varieties and day-to-day weather-related information has increased".

P3: "Our farmers to a large extent, have been able to produce seed banks known as quality declared seeds and apply best agronomic practices and adopt innovations they received through us and they apply this knowledge as a strategy for adaptation".

P4: "...before receiving training, farmers had poor harvests, now farmers tell us they have increased their annual agricultural yield as a result of the information disseminated to them". "They have increased the use of improved quality seeds in farming, fertilizers, local wells, soil tillage methods and other agricultural best practices".

P5: "The project also managed to install weather metadata equipments such as rain gauges, anemometers, hygrometers and thermometers".

P6: "We also enabled the private sector and the government to collaborate to ensure farmers access agricultural inputs".

5.4.5 Project Sustainability

The study further investigated the project's sustainability and the challenges in service provision to farmers. Findings from the interview with the programme manager showed that, despite efforts to meet its objectives, the CCAA project faced limitation of funds in implementing its set goals. The study established that that the quest to prove benefit for many farmers in other villages in the district was hampered by inadequate financial resources. The

project manager indicated that the CCAA project had ultimately faced inadequate funding to sustain its service provision. The project aspired to cater for other villages in the districts to ensure farmers scaled up new acquired farming best practices.

5.4.6 The Objective of Information Disseminated through Extension

The study investigated the major goals of information packaged and disseminated through extension in improving agriculture (see questions a7 in Appendix 4). According to in-depth interviews with the two agricultural extension officers, there are a number of goals of information disseminated through extension. The extension officers stated:

E1: “Our first role is to enable farmers’ to access and use new innovations by disseminating our knowledge to them”.

E2: “We as extension officers also enable farmers to increase agricultural produce by applying new methods effectively and efficiently and get surplus”.

E3: “Our job is broad and don’t only ensure farmers apply best practices, but goes beyond by enhancing their access to market”.

E4: “Ultimate goal of our extension services is to improve farmers’ livelihood”.

5.5 Types of Information on Climate Change and Variability Disseminated to Farmers

The study investigated types of information disseminated to farmers on climate change and variability (see question c16 in Appendix 4). Findings from the in-depth interview with the programme manager ascertained that a variety of information was disseminated to farmers on climate change and variability. Information disseminated to farmers was on improved seed varieties, which included early-maturing and drought-tolerant seed varieties, rain water harvesting technologies (RWHT) and use of affordable new farm implements. The new affordable farm implements introduced were the Magoye ripper (a soil tillage implement) and the hoe, locally known as the Spring jembe, which is used in deep soil cultivation. Farmers received innovations on the use of fertilizers, nutrient retention, measuring weather forecasts, early farm preparation and type of plants to grow in season. Farmers were given information on space planting, inter-cropping, seed production, grain preservation and use of pesticides.

Farmers were asked to explain the type of information on climate change disseminated to them (cf. questions g49 and g50 in Appendices 1 and 2). Results shows that farmers received information on planting time, use of improved seed varieties, drought-resistant seeds, early-warning information, rainfall patterns, food preservation, fertilizer usage and types of crops to grow in a season. Findings from the in-depth interview with the agricultural extension officers were that information that was disseminated to farmers included the effect of drought on agriculture, access to, and use of, improved seeds, access to markets and early warning measures on floods, and the effects envisaged. Other information disseminated to farmers included awareness on availability and access to seeds, pesticides usage, fertilizer application and new farm implements and their appropriate usage.

The findings revealed that, in Chibelela and Maluga villages, a number of seed varieties were newly introduced to farmers. The seed varieties introduced aimed at improving yields in drought areas. In Chibelela village, the seed varieties introduced also referred to as Open Pollinated Seed Varieties, for sorghum included Pato, Wahi, Mesia and Mpya. Maize varieties included Tanzania Maize Variety 1 (TMV1), Staha and Situka. The sunflower varieties were Pana and Rekodi.

In Maluga village, sorghum varieties that were introduced included Masia, Karimtama, Pato, Gadam, Ukombozi, Wahi, Hakika, Seredo and Tegemeo. Improved varieties for finger millet were referred to as P224 and U15 (a new line that has been introduced to farmers but not officially released, hence no name assigned as yet). The improved maize varieties that were introduced in Maluga village included Kilima, Sitoka, Sidiko and Staha while the sunflower varieties were Rekodi, Pana and Kenyafedha. Farmers' exposure to innovations is essential in adoption, as most of the time users are not aware of the existing information and associated benefits (Rogers 2003). Farmers' decisions to use the new varieties of their choice were based on their perception towards relative advantage, compatibility, trialability, observability and complexity (Rogers 2003).

5.5.1 Types of Information Disseminated Versus Farmers' Information Needs

Farmers were requested to state the type of information on climate change and variability they needed to fulfil their agricultural needs. The findings indicate that farmers mostly needed information on timely access to seasonal rainfall, new seed varieties, proper use of fertilizer, both organic and inorganic, crop diseases, proper use of pesticides and types of

crops to grow in a particular season. Unlike other information services being disseminated to farmers, the study noted that, despite their critical role in coping and adapting to climate change and variability, only a few farmers mentioned the quest for information on soil characteristics, irrigation farming, pesticides and grain preservation. These findings agree with those of Kadi, Njau, Mwikya and Kamga (2011), who observed the importance of assessing farmers' needs for quicker adoption of innovations in East Africa.

5.5.2 Challenges Farmers' Challenges in Accessing and Using Information

Notwithstanding the fact that information disseminated to farmers to a greater extent met farmers' information needs, the study found that farmers were experiencing difficulties in accessing information. The study also found farmers had problems in purchasing agricultural inputs such as new seed varieties and pesticides from service providers. These findings confirm those by Rogers (2003:204-205) which emphasised that access to communication sources and channels was crucial in ensuring that an innovation is used. Farmers indicated that agricultural stockists have sometimes failed to describe proper use and application of seed varieties, pesticides and farm implements to farmers. Their comments include:

F1: "Most of the time you find farmers go to shops selling agricultural inputs but experience the problem of buying undesirable seed varieties and expired pesticides for their farms. This discourages us so much...."

F2: "... stockists failure to provide us with adequate information on how to use pesticides, fertilizers have forced us to rely mostly on information from experienced farmers or accidentally if one happen to find an expert."

The in-depth interviews conducted separately with agricultural extension officers indicate that, upon receiving information, farmers made their own decisions to adopt a seed variety of their choice (cf. questions c17 in Appendix 3). It was revealed that a situation where an extension officer recommends one a variety of seeds to farmers and that farmer makes a decision without being influenced is known as participatory variety selection (PVS). These findings concur with the Diffusion of Innovations (DOI) model, which stresses that, in order to ensure an adoption, change agents should inquire about users' needs and make sure they are compatible with the programme's goals (Rogers 2003:375). The choice to adopt a variety of their choice is influenced by the farmers' experience in using the variety and the benefits associated with an applied variety. In addition, the current study found that the extension

officers and researchers influence farmers decision making process upon being introduced to an innovation, on whether to adopt its usage or not.

5.6 An Overview on Climate Change Adaptation in Africa (CCAA) Training

The CCAA project manager was asked how the training was conducted with farmers (cf. question b11 in Appendix 4). Findings from an in-depth interview with the programme manager indicate that farmers underwent a series of training sessions aimed at creating awareness and addressing climate change and variability in farming. The CCAA project was a three-year project which commenced in 2007 and ended in 2010. The farmers' training was done by researchers with assistance from the agricultural extension officers in Maluga and Chibelela villages.

The field training was done at the village level, using demonstration/learning plots, also known as Farmer Field Schools (FFS). Farmers were trained in two groups, namely the primary group, referred to as the mother plot group and the secondary group, referred to as the baby plot group. In the mother plot group, farmers were guided by CCAA project experts, who practically demonstrated the best farming practices. Farmers learned and practised the adoption of new innovations in the baby plot farms. The study found that the training techniques used to disseminate information to farmers were effective as they used demonstration and interpersonal communication sources. These techniques were compliant with the farmers' level of education and capacity of understanding.

The study sought to discover how farmers were chosen for the CCAA project. Findings of the study, from the interview conducted with the programme manager showed that farmers participated voluntarily in CCAA training. Any farmer who was willing to learn was invited and participated in the training. The selection of farmers was based on existing farmer groups, opinion/influential/respected people and village leaders. The existing groups were Ufumbuzi in Maluga village and Chiwona, Nazareti, Wazachi, Wapendanao, Uwazachi, Wapendanao, Tahadhari, Amkeni, Ushirika, Wajane, Zaeni matunda and Muungano in Chibelela village. Most trained farmers participated in the CCAA project training as a result of their membership of farmer groups. These findings concurred with those of Munyua (2011), who found that if farmers were in a group, it promoted access to information and knowledge. The programme manager also indicated that other reasons which prompted

farmers to be trained were ambition to learn and gain new knowledge on farming to adapt to climate change and variability.

With regard to the farmers' attitude towards the CCAA project, the programme manager indicated that farmers' had a positive attitude towards the Climate Change Adaptation in Africa project. The current study findings showed that farmers and the village government were motivated by the project. The study found that most farmers were willing to learn not only from the CCAA experts on information disseminated on climate change and variability, but also to share the innovations with one another, to improve their food security levels.

Trained farmers were asked if untrained farmers were willing to learn from them on innovations they had received from CCAA experts (see question h59 in Appendix 1). Fifty trained farmers, indicated by 15 (30.0%) of the respondents, showed that untrained farmers were highly willing to learn innovations. Twenty-three (46.0%) respondents said that untrained farmers were willing to learn innovations and 4 (8.0%) respondents showed untrained farmers were not willing to learn innovations. Additional findings from trained farmers indicate that a small number 7 (14.0%) respondents indicated untrained farmers were fairly willing to learn innovations, while only 1 (2.0%) respondent said that untrained farmers were neutral. Details are presented in Table 5.8.

The findings illustrate that most untrained farmers were ready to learn innovations from trained farmers to adapt to climate change and variability. These findings are supported by Rogers' Diffusion of Innovations model, which explains the importance of observability in enhancing the rate of adoption (Rogers 2003:221-222). Rogers adds that "most farmers tend to evaluate innovations not based on the scientific research by experts but rather their fellows who have adopted the innovation" (Rogers 2003:36).

Table 5.8: Trained Farmers’ Responses reUntrained Farmers’ Willingness to Learn Innovations

Response N=50	Frequency	Percentage
Highly willing	15	30
Willing	23	46
Neutral	1	2
Fairly willing	7	14
Not willing	4	8
Total	50	100

Untrained farmers were asked whether or not trained farmers were willing to share with them information they had received (cf. question h60 in Appendix 2). Thirty four untrained farmers, showed by 11 (32.4%) respondents, indicated that trained farmers were highly willing to share new information, 15 (44.1%) respondents said that trained farmers were willing, while only 3 (8.8%) respondents said that trained farmers were not willing to share new knowledge on adaptation to climate change and variability with untrained farmers. Three (8.8%) respondents indicated that trained farmers were fairly willing to share new information with them. Two (5.9%) respondents showed that trained farmers were neutral about sharing new information with untrained ones. (See Table 5.9.)

Most trained farmers were willing to share the innovations acquired from CCAA experts. These results are supported by those by (Rogers 2003:170) in his Diffusion of Innovations model, which shows that the characteristics of the decision-making unit, such as the communication behaviour, influence one’s ability to acquire new knowledge. According to the DOI, earlier adopters, who in this study are trained farmers, have higher communication behaviour and personality attributes which connect them to later adopters through sharing of knowledge (Rogers 2003:289-290). Diederer, Meijl, Wolters and Bijak (2003) in the Netherlands observed that farmers who were innovators were more engaged in using extension services and developing agricultural innovations than early adopters.

Table 5.9: Untrained Farmers’ Responses reTrained Farmers’ Willingness to Share Innovations

Response N=34	Frequency	Percentage
Highly willing	11	32.4
Willing	15	44.1
Neutral	2	5.9
Fairly willing	3	8.8
Not willing	3	8.8
Total	34	100

5.6.1 Usefulness of Training

Respondents were asked if they were able to use innovations upon receiving training (see questions e38 and e38 in Appendices 1 and 2). The majority of farmers were able to use knowledge acquired from both trainers and fellow farmers after receiving training. These results are compatible with the Diffusion of Innovations model which suggests the necessity of using interpersonal communication channels in disseminating information (Rogers 2003). Most (67 or 79.8%) of the respondents were able to use innovative knowledge received from experts. Only 7 (8.3%) respondents were not able to apply and use new knowledge. Ten (11.9%) respondents were neutral on their understanding and application of innovations received from experts.

Respondents were requested to indicate their ability to understand innovations from trainers. Thirty six 36 (43%) of the farmers were able to understand and apply new knowledge from trainers, while 31 (37%) respondents were very able; 10 (12%) respondents were neutral; 5 (6.0%) respondents were less able to understand and 2 (2%) respondents were not able to understand. Rogers’ DOI model supports these findings, as it explains that know-how is an essential component in ensuring the effective use of an innovation (Rogers 2003:173). See details in Figure 5.5.

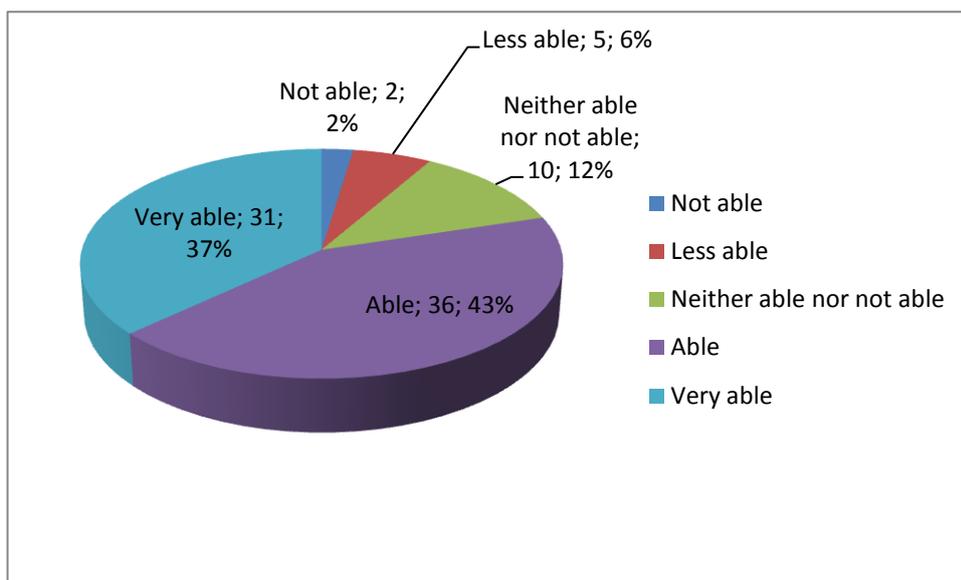


Figure 5.5: Farmers’ Ability to Understand and Apply Innovations

As the findings indicate in Figure 8 show, farmers’ acquisition of information and embedded knowledge from the training enabled them to change their attitude and farming practices. These study findings confirm those of Sivakumar and Hansen (2007:74), who showed that appropriate training of users is important in reducing the communication barriers and gaps between information providers and users. The Diffusion of Innovations model recognises the role of attitude as an important factor in an innovation-decision process in adoption of innovations (Rogers 2003:174-175).

Findings from the interviews with farmers, agricultural extension officers and the CCAA programme manager found that the knowledge acquired by farmers have benefitted them in through increasing their annual harvest two to four times for sorghum, sunflower and maize crops, in the application of farm water harvesting techniques using tiered ridges, in new planting methods such as space planting and in early land preparation. Farmers stated that other benefits gained included knowledge on weather forecast measuring equipment, grain preservation and the use of organic and inorganic fertilizers. Other benefits accrued included improved farm implements such as the Spring jembe, the Magoye ripper, the power tiller and tractors; improved use of seeds, pesticides and ash as a means of preventing insect damage to crops by insects.

5.7 Specific Channels Employed to Package and Disseminate Information on Climate Change and Variability to Farmers

In this section information packaging and repackaging are terms which will be used interchangeably depending on the context. The programme manager was asked how information on climate change and variability is packaged and disseminated to farmers (cf. question c17 in Appendix 4). The in-depth interview with the programme manager revealed that prior to the Climate Change and Adaptation in Africa project's commencement, a team of experts from the Ministry of Agriculture (MOA) packaged the information by assessing the content, target group and the communication strategy to be used to deliver information to farmers in selected villages. The MOA experts then conducted consultation meetings with key stakeholders, such as extension workers, farmers, researchers, NGOs and policy-makers, on the best means to package and effectively communicate researchers' scientific information and knowledge to farmers.

The programme manager explained that, through consultation meetings the experts from the MOA were able to assess farmers' needs and synchronise their needs with project objectives. The ultimate goal of packaging the information was to produce both research and knowledge products which were demand-driven rather than project-driven. Packaging also aimed at generating research products which are user-friendly and disseminated to farmers through means which were envisaged to be more participatory and understandable. The study sought to reveal how information on climate change was packaged and disseminated to farmers (cf. question c17 in Appendix 4 and g51 in Appendix 1). Research findings revealed that innovative information was being packaged and disseminated to farmers through Farmer Field Schools, public meetings, farmer groups, face-to-face meetings, demonstrations in learning plots, publications (compendium), fliers and pictures.

Findings from the two focus groups who participated in the two villages studied indicated that packaging and dissemination of information to farmers was predominantly through class lessons and, to a lesser extent, through pictures and drawings/symbols (see question 12 in Appendix 5). The study shows that audio-visual methods such as videos, pictures and drawings were less utilised in demonstrating issues related to climate change and variability adoption of innovations. The majority of farmers perceived audio-visual tools to be the best in disseminating information to farmers, as most could not read and/or write (refer questions g52 and g55 in Appendices 1 and 2). Farmers believed that the use of videos in disseminating

information would not only create an enabling learning environment, but would also attract farmers to learn by doing. These findings confirm those by Rogers (2003:204-205), who explains that communication channels have a significant role in creating knowledge and changing peoples' attitude towards an innovation. The only language medium used by experts delivering scientific information to farmers was through Kiswahili which is a native national language.

The in-depth interviews with the two district agricultural officers from the two study villages (refer to question b11 in Appendix 3) revealed that the regions and district councils receive scientific information pertaining to agriculture and climate change and variability from both the Ministry of Agriculture and the Ministry of Environment, on issues addressed to farmers each season. The study also found that early warning information provided by the Tanzania Meteorological Agency (TMA) is being channelled to the regional and district councils, where it is being repackaged and disseminated to farmers in villages. However, it was observed that in most SADC countries there is a weak link between meteorological experts and the extension services or other agricultural expert intermediaries in the Southern African Development Community-Regional Remote Sensing Unit (SADC-RRSU) (2002). These findings pose a major communication challenge to extension officers in translating and interpreting the probabilistic forecasts into easily understandable farmers' language (Sivakumar and Hansen 2007:9).

The agricultural officers were asked how information on climate change and variability is packaged and disseminated to farmers (see questions b11 in Appendix 3). The findings showed that information at the district level is disseminated by village executive leaders through meetings. These findings are explained by the Diffusion of Innovations model, which explains that opinion leaders are mostly used by change agents to inform others on innovations and to influence adoption (Rogers 2003:27). Findings from the interview with the Chibelela village district extension/agricultural officer indicated that regular early warning information from the TMA is sent to village executive leaders.

Despite results indicating that farmers rely on village leaders to disseminate information from extension officers, it was found that sometimes the information they disseminate did not reach farmers on time and did not contain content desired. These findings are supported by Rogers' Diffusion of Innovations model, by explaining that opinion leaders can speed up or

slow down the diffusion of innovation process if they are being overused by extension officers such as extension officers and hence deviate from the systems norms of the community (Rogers 2003:27). Findings further showed that if the information happened to reach farmers on time, it was through informal rather than formal means. These results confirm those by Rogers in his model of Diffusions of Innovations, which explains that “most human communication occurs between individuals who are homophilous” (Rogers 2003:37), which means that informal communication channels are effective in disseminating information to a targeted group with similar cultural values.

Farmers perceive village meetings to be more reliable in acquiring new knowledge, as they are mostly used to create awareness about what crops to cultivate in a season and not to educate farmers on new farming methods. These results are supported by those of Rogers (2003:205), who observed that interpersonal communication channels are more effective than other channels in reducing uncertainty and changing users’ attitudes about an innovation. The focus group discussions (FGD) findings with farmers indicated that, despite extension officers’ custodial role in packaging and disseminating information to farmers, most farmers stated they took more time to learn innovations themselves rather than learning from the extension and agricultural experts.

Rogers (2003:174) shows that the success or failure of the adoption of an innovation depends on the individual’s attitude to an innovation. The FGDs showed that weather and seasonal information on climate change and variability disseminated to farmers was broad and failed to cut across the villages’ information on climate change and variability needs. The major challenge emerging for the farmers was the accuracy and content of weather information from the TMA. Thus inaccurate information on weather information will deter users from adopting that innovation, as it seems to have no relative advantage (Rogers 2003). The information from TMA was specific with regard to agricultural zones and not for a region or village. The uncertainty and unpredictability of weather is envisaged as a major barrier in the dissemination process. To overcome the problem, senders of information need to consider ways of enhancing receivers’ understanding of the uncertainty and unpredictability of forecasts instead of blaming them for not understanding.

A need to repackage scientific information for farmers was highlighted by the CCAA programme manager, who observed that there is a communication barrier between

researchers and farmers in Tanzania (cf. question 35 in Appendix 4). The programme manager stated that “most researchers in Tanzania are not trained to communicate their findings with farmers”. While the first priority of most researchers is to introduce their findings to their peers, awareness of the need to disseminate the innovation to the grass roots once it has been recognised and validated by peers, needs to be enhanced. These findings confirm those by Rogers (2003:366-370) in his Diffusion of Innovations (DOI) model, which explains the importance of information repackaging by change agents (knowledgeable information disseminators). Supporting the importance of the repackaging of information on climate change and variability to users, Sivakumar and Hansen (2007:9) explain that effective use of information on climate change and variability, to a large extent, depends on information disseminators understanding potential users, their behaviour and how information flows between actors. The DOI describes the adoption of an innovation to be dependent on effective communication processes (Rogers 2003).

The programme manager further explained that the “majority of researchers don’t share and transfer what they know to farmers”. Study findings from the semi-structured interviews supported the observed trend of researchers’ failure to communicate their findings. One interviewee, DM, stated that “Most of the time we see researchers coming here and do research but they never return here to where the research was done to share and update us on their findings”. Farmers in the focus group discussions and the interviews pleaded with researchers to return and share their observations and scientific discoveries so as to communicate the knowledge to farmers. These findings agree with those by Kadi, Njau, Mwikya and Kamga (2011), who observed that half of the farmers in East African countries have not been exposed to research and extension services.

5.8 Knowledge on Mitigation and Adaptation held by Farmers

The knowledge of the farmer is critical in ensuring effective and efficient farm decision-making under observed climate change and variability. Awareness motivates users to engage more in an information-seeking process to acquire new knowledge which is critical in decision-making under a changing climate (Rogers 2003:173). However, effective decision-making hinges on farmers being supplied with timely and accurate information and their ability to make use of both the tacit and explicit knowledge they possess (Rogers 2003). This section discusses findings on farmers’ awareness on climate change and variability and investigates the relationship between awareness and demographic variables such as gender,

level of education, wealth and age. The subsequent sub-sections describe farmers' possession of indigenous knowledge and its reliability in weather prediction. The last section underscores ways of preserving and documenting indigenous knowledge in the society.

5.8.1 Farmers' Awareness and Understanding

Farmers were asked to state their awareness regarding climate change and variability (cf. questions d18 in Appendices 1 and 2). Findings showed most farmers are aware of the concept of climate change and variability. Study findings indicated that 78 (93%) of farmers were aware of climate change and variability and only 6 (7%) were not aware. The in-depth interviews with district agricultural officers indicated that farmers were aware of climate change and variability. These results are supported by the DOI of Rogers (2003) which indicates that communication channels have a significant impact on awareness and knowledge creation. The study findings, which indicate that most farmers are aware of climate change and variability, reflect farmers' exposure to change agents, among them experts and extension officers from the CCAA training. Figure 5.6 summarises these findings.

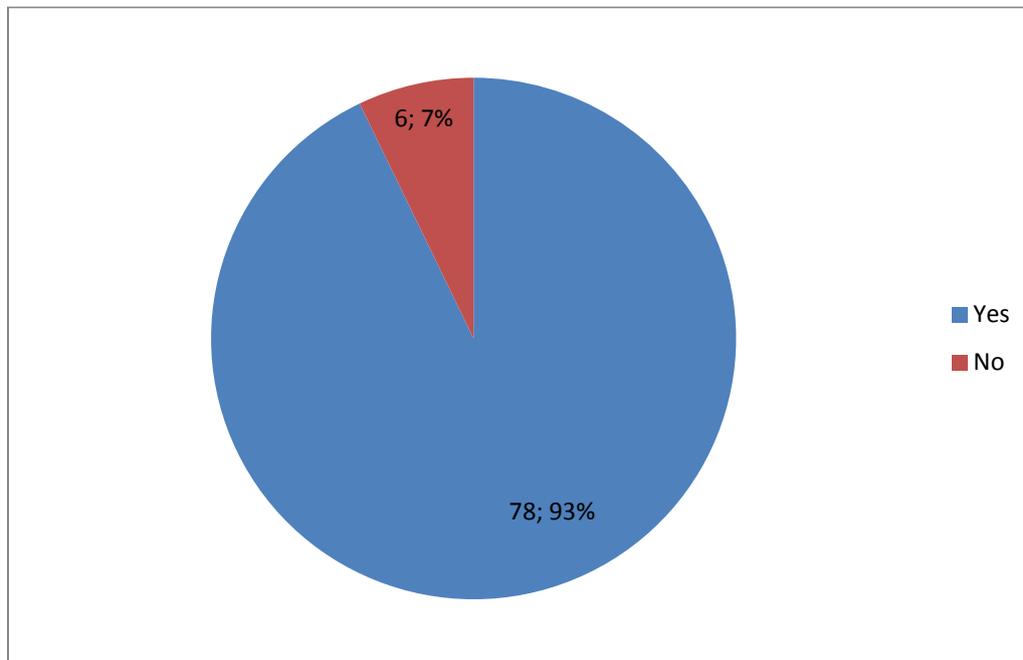


Figure 5.6: Climate Change and Variability Awareness by Farmers

In spite of farmers' awareness, the in-depth interviews with agricultural extension officers emphasised the need for more education and awareness campaigns for farmers. The extension officers stated that adoption of innovations, change of attitude and behavioural

change required time before being assimilated by farmers to impact farming practices. Findings from the FGDs suggest that the majority of farmers were aware of the effects of climate changes on the environment.

Despite the study findings from the semi-structured interviews with farmers indicating that more (4 or 66.7%) respondents in Chibelela and fewer (2 or 33.3%) respondents from Maluga village were not aware of climate change and variability, a cross-tabulation could not ascertain any significant difference in awareness between Maluga and Chibelela villages. This indicates that fewer respondents not being aware might be thanks to the sensitisation and training farmers had undergone. The findings from cross-tabulation on awareness between the two study villages indicated a Pearson Chi-square value of 0.239 and the significance value of 0.696 at 0.05 probability level significance. (See Table 5.10.)

Table 5.3: Cross-Tabulation between Study Villages and Climate Change and Variability Awareness

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	0.239 ^a	1	0.625		
Continuity Correction ^b	0.004	1	0.951		
Likelihood Ratio	0.245	1	0.621		
Fisher's Exact Test				0.696	0.483
Linear-by-Linear Association	0.236	1	0.627		
N of Valid Cases ^b	84				

a. 2 cells (50.0%) have an expected count less than 5. The minimum expected count is 2.57.

b. Computed only for a 2x2 table

Awareness of climate change and variability was cross-tabulated with gender, age, level of education and wealth. Findings suggest no direct correlation between gender, age and level of education and farmers' awareness about climate change and variability. Findings from the

cross-tabulation between sex and climate change and variability awareness shows a Pearson Chi-square value of 0.617, a significance value of 0.661 and a 0.05 probability level of significance. This test shows no direct relationship between the two variables. (See Table 5.11.)

Table 5.4: Cross-Tabulation between Sex and Climate Change and Variability Awareness

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	0.617 ^a	1	0.432		
Continuity Correction ^b	0.107	1	0.743		
Likelihood Ratio	0.686	1	0.407		
Fisher's Exact Test				0.661	0.393
Linear-by-Linear Association	0.610	1	0.435		
N of Valid Cases ^b	84				

a. 2 cells (50.0%) have expected counts less than 5. The minimum expected count is 1.86.

b. Computed only for a 2x2 table

The cross-tabulation between age and climate change and variability awareness did not ascertain any direct association between the variables. The findings from the cross-tabulation shows a Pearson Chi-square value of 9.812, a significance value of 0.081 and a 0.05 probability level of significance. This result suggests that there is no direct relationship between age and climate change and variability awareness. See Table 5.12 for more details.

Table 5.5: Cross-Tabulation between Age and Climate Change and Variability Awareness

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	9.812 ^a	5	0.081
Likelihood Ratio	7.329	5	0.197
Linear-by-Linear Association	3.216	1	0.073
N of Valid Cases	84		

a. 7 cells (58.3%) have an expected count of less than 5. The minimum expected count is 0.14.

The study did not find a direct relationship between level of education and awareness of climate change and variability. Findings from the cross-tabulation indicate the Pearson Chi-square value of 0.509, the significance value of 0.917 at the 0.05 probability level of significance. This result illustrates no direct relationship between the two variables. (See Table 5.13)

Table 5.6: Cross-Tabulation between Level of Education and Climate Change and Variability Awareness

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	0.509 ^a	3	0.917
Likelihood Ratio	0.522	3	0.914
Linear-by-Linear Association	0.003	1	0.959
N of Valid Cases	84		

a. 5 cells (62.5%) have expected counts of less than 5. The minimum expected count is 0.07.

There was no significant relationship between farmers' income levels and farmers' climate change and variability awareness. Findings from the Chi-square test show a calculated Pearson Chi-square value of 8.346 and significance value of 0.08 at the 0.05 probability level of significance. These findings are supported by Diffusion of Innovations model of Rogers (2003), which shows wealth is not the major factor which influences awareness in the adoption of innovations. Table 5.14 gives more details.

Table 5.7: Cross-Tabulation between Wealth and Climate Change and Variability Awareness

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	8.346 ^a	4	0.080
Likelihood Ratio	6.958	4	0.138
Linear-by-Linear Association	4.408	1	0.036
N of Valid Cases	84		

a. 7 cells (70.0%) have an expected count of less than 5. The minimum expected count is 0.29.

Farmers were asked to explain their understanding of climate change and variability. Content analysis showed that most farmers interviewed described climate change and variability as changes in weather, an increase in temperature and inadequate rainfall. The FGD findings indicated that farmers expressed their understanding of climate change and variability as a change of the environment and vegetation cover, reduced availability of water, increased drought, deforestation, disappearance of endemic tree species and increased wind. Some of the above findings were supported by farmers from Chibelega village who stated that “In the past, we used to throw seeds such as tomato, peas and maize on the soil without adding fertilizer or pesticide and have a hefty harvest, but these days one cannot plant that way and expect harvest”.

Farmers described other factors which are directly associated with climate change and variability and which are seen to be contributing factors to climate change and variability.

These are environmental pollution, increased population, reduced soil fertility, more diseases, insects and use of pesticide in farming, and increased carbon dioxide pollution from factories. The respondents were describing how they understand climate change. Therefore, these are their views on how they understand climate change and variability and it should not be linked literally with the level of pollution produced by factories in the villages.

The findings from the FGDs showed variation between farmers' levels of understanding of the concept of climate change and variability. Farmers who had been exposed to advanced training, workshops and who hold a higher level of education could explain more explicitly their understanding of the contributing factors to climate change and variability. Unlike those with a limited level of education, farmers who had a higher level of education were more able to explain their understanding of carbon dioxide pollution related to factories. These findings confirm those by Rogers (2003: 171,172,222,288-291), who observed that awareness can affect an individual's ability to acquire knowledge.

Despite farmers' ability to describe their understanding of climate change and variability, findings from both the interviews and FGDs demonstrate that many farmers still failed to interpret and contextualise the meaning of climate change and variability. It was evident from the interviews that farmers could not associate a direct relationship between the causes of climate change and variability.

During the focus group discussion in Chibelela village, a farmer, UK, stated, "You know, Mr. Facilitator, despite education and awareness interventions programmes done still many farmers are not in a position to understand and interpret issues related to climate change and variability". The complexities of farmers' understanding of climate change and variability emerged when another farmer, DM, in a FGD, asked rhetorically, "why are there areas with forests but still the same areas don't receive enough rainfall?"

Findings from the content analysis of both the interviews and FGDs showed that most farmers associated climate change and variability with erratic rainfall and drought/famine. Farmers designated a good and bad year based on the amount of rainfall, drought and harvesting, which, to a greater extent, described their understanding of climate change and variability. The research findings revealed that farmers' awareness, attitude and adaptation strategies towards climate change and variability were influenced by the incidence of

drought, food insecurity, water scarcity, reward from an innovation, NGOs and government interventions to lessen the severity of the effects of climate change and variability.

Most farmers' in their response on factors that contribute to erratic rainfall patterns indicated that deforestation is the major factor perceived for climate change and variability. Deforestation occurs as a result of increased human activities, such as tree cutting for charcoal, firewood and building. Other factors highlighted by farmers included climate change and variability, overgrazing, farm expansion and population increase as major contributing factors which cause unpredictable rainfall.

Agricultural extension officers were asked to explain their understanding of climate change and variability (cf. question e24 in Appendix 3). The agricultural extension officers described climate change and variability as change in rainfall onset, increased temperature and increased incidence of pests and diseases. They gave the causes of climate change and variability as industrial gases, deforestation, shifting cultivation, high livestock populations and the destruction water sources.

Thus, despite farmers' difficulties in interpreting climate change and variability, local indicators improved their understanding of new trends on changes in rainfall, temperature and wind. In section 5.8.2., the study presents findings on farmers' use of indigenous knowledge on weather prediction.

5.8.2 Indigenous Knowledge on Weather Prediction

With regard to farmers' current status in terms of applying indigenous knowledge (IK) to their farming practices, they were requested to state whether IK on seasonal weather prediction existed in their community (see questions d25 in Appendices 1 and 2). The findings from the semi-structured interviews with farmers ascertained that indigenous knowledge on weather and climate prediction does exist in the study villages of Chibelela and Maluga. Field data indicate that most (82 or 98%) of farmers believed that IK on seasonal weather forecasting was evident in their villages. These findings are supported by Rogers' Diffusion of Innovations model, which underlines the role of IK in adoption of innovation. For new knowledge to be absorbed by individuals it should be compatible with existing norms, values and beliefs (Rogers 2003:254-257). (See Figure 5.7)

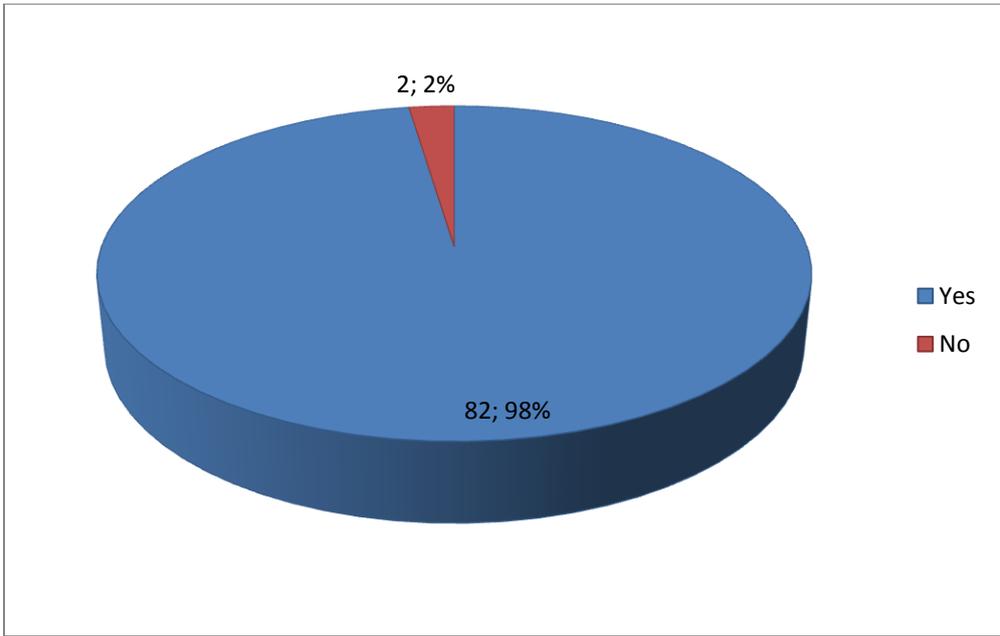


Figure 5.7: Existence of Indigenous Knowledge on Seasonal Weather Forecasts in the Community

The study sought to investigate if farmers possessed the IK for weather prediction. Table 5.15 indicates that most farmers possessed IK on seasonal weather prediction. These findings agreed with those by Stigter, Ying, Das, Dawei, Vega, Viet, Bakheit and Abdullahi (2007:214), who observed that farmers in most poor and rural communities make farm and other production decisions based on their local knowledge systems. These perceived indicators, have been developed from years of observation, experiences and experimentation, to predict weather patterns. Statistics show that 78 (92.9%) of interviewed respondents had knowledge of seasonal weather prediction, while 6 (7.1%) did not possess IK.

Table 5.8: Farmers’ Possession of Indigenous Knowledge on Seasonal Forecasts

Indigenous knowledge possession N=84	Frequency	Percentage
Yes	78	92.9
No	6	7.1
Total	84	100.0

The cross-tabulation analysis between age and indigenous knowledge could not ascertain any direct relationship between the age of farmers and the possession of IK. Findings showed the Pearson Chi-square value of 1.752 and the significance value of 0.882 at the 0.05 probability level of significance. (See Table 5.16.)

Table 5.9: Cross-Tabulation between Age and Possession of Indigenous Knowledge
Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	1.752 ^a	5	0.882
Likelihood Ratio	2.921	5	0.712
Linear-by-Linear Association	0.004	1	0.951
N of Valid Cases	84		

a. 7 cells (58.3%) have an expected count of less than 5. The minimum expected count is .14.

Findings from the interviews, showed that many people in the village possess IK and that there was no direct relationship between the age of the farmers and the IK they possess. The focus group discussions and content analysis indicated that many elders and a few youth possessed knowledge on weather predictions of a good or bad season. In this regard the study found that most elders contributed significantly when narrating IK issues related to climate change and variability, compared to young people whose knowledge of IK was limited. These research findings conform to those by Chang'a, Yanda and Ngana (2010), who found elders possessed vast IK concerning weather and climate forecasting.

The findings further showed that most farmers could associate the local weather forecast indicators with rainfall onset and not prediction of a good or bad season. The findings suggest that the majority of farmers had a vast knowledge of rainfall onset, while a few, mostly elders, had knowledge of identifying a good or bad season, using names of indicators and signs. The findings revealed that predictions of a good or bad season seemed to be the preserve of older people who had accumulated vast experience concerning local indicators of weather prediction.

Farmers' IK on weather forecasting is critical to formulating strategies to enhance adaptation to climate change and variability. The study investigated farmers' views on the reliability of IK for seasonal weather forecasting (cf. questions 29 in Appendices 1 and 2). The findings showed that, despite awareness campaigns and education programmes on scientific ways to lessen the impact of climate change and variability to farmers, most (64 or 76.2%) respondents still relied on IK for weather prediction. Findings showed that 9 (10.7%) respondents were uncertain if weather IK was reliable or not reliable in weather forecasting.

A few respondents (5 or 6.0%) felt IK was not reliable, while 6 (7.1%) respondents stated that IK was less reliable in predicting weather. Most farmers believed and relied more on IK concerning weather forecasts than on scientific information. The study captured two major contributing factors to the farmers' decisions to conform to IK for weather predictions. These were the unreliability and lack of timely access to scientific information on weather forecasts. These findings are supported by Sivakumar and Hansen (2007:9) and Mukhala and Chavula (2007:45), who explain that the effective use of climate forecast information is catalysed by the proper communication and timing of the release of the climate forecast. Table 5.17 gives the details.

Table 5.10: Farmers' Views of Reliability of Indigenous Knowledge for Seasonal Forecasts

Indigenous knowledge reliability N=84	Frequency	Percentage
Not reliable	5	6.0
Less reliable	6	7.1
Neutral	9	10.7
Reliable	41	48.8
Very reliable	23	27.4
Total	84	100.0

Despite farmers relying on IK for weather prediction, the study established that there was a significant positive change in farmers' attitudes, behaviour and farming norms with regard to the usage of conventional scientific information disseminated for adaptation to climate

change and variability. These findings agree with those findings by Rogers (2003), who observed that innovation attributes, such as prior needs, communication channels, communication behaviour and relative advantage influence individuals' knowledge and attitude to an innovation. However, despite farmers' change in behaviour, the study found a number of challenges threatening the existence and usage of IK by farmers.

The challenges outlined by farmers as threats to IK reliability on weather prediction include rainfall unpredictability, conventional scientific weather forecasts and inability of indigenous indicators to predict weather. Other factors include deforestation and the limited number of older people in the community. These factors contributed to uncertainty and ineffective use of IK for weather prediction.

The findings of the focus group discussion in Chibeleda and Maluga villages indicated that farmers blame agricultural experts, as the ones who contributed to this uncertainty. The decision to advocate that farmers reduce reliance on IK for weather prediction, consequently inferred that this reliance on IK is inaccurate. Nevertheless, contrary to these findings, farmers in both villages have not abandoned the use of IK as a local indicator to predict the weather.

Some farmers felt IK on local indicators was unreliable in predicting weather patterns, because of uncertainty caused by climate change and variability. The results concur with those of Ingram, Roncoli and Kirshen (2002) in Burkina Faso and Chang'a, Yanda and Ngana (2010), in Tanzania. They observed that increased climate variability has reduced the accuracy and reliability of local indicators predicting the season. They indicated climate change and variability to be the major contributing factor to their uncertainty. Most farmers in Maluga and Chibeleda villages pointed out that in recent years they had been facing difficulties in relying on weather prediction using IK. This is due to the unpredictable nature of rainfall indicators. Findings from the FGDs indicated that one might see the IK indicators signifying a particular weather pattern but the predicted scenario failed to occur.

Despite findings showing farmers use the belief system to inform their farming decision making, the results have also showed growing usage of the DOI weather prediction practices. The slow adoption of DOI weather prediction practices is contributed by the incompatibility of the way weather information is disseminated. Most farmers in the rural areas are used to oral communication channels which reduce the complexity in interpreting weather

information. However the findings have shown that climate change and variability affects the use of both IK and DOI weather prediction practices. In this regard, farmers tend to use the two weather information sources in a complementary way.

With regard to applying IK in weather prediction, the findings showed that farmers used a number of indicators for predicting weather and rainfall in a season (see questions d27 in Appendices 1 and 2). These include use of birds, plant phenology, animals, insects, wind direction, dust, moon structure, stars, stones and the sun to identify rainfall onset, and a good or bad year. Many farmers who believed that IK existed in the community, were concerned that it was disappearing with alarming speed. (See sections 5.8.2.1 and 5.8.2.2 for description of IK indicators used for weather forecasting). Section 5.8.3 describes IK methods to safeguard and preserve forecast weather.

5.8.2.1 Use of Indigenous Knowledge on Weather Prediction in Chibelela Village

As explained in the previous section 5.8.2, farmers use a number of local indicators to predict not only rainfall onset and quantity, but also for weather forecasting to predict a good or a bad year. Study findings from the FGD and semi-structured interviews conducted in Chibelela village showed that farmers used plant phenology attributes such as the emerging of tree leaves, flowering and plant growth size to predict rainfall onset and identify a good or bad year. When rainfall is about to come, tree species known as the plum fingerleaf tree (*Vitex ferruginea*), locally identified as Mfuru, blood wood tree/sealing-wax tree (*Pterocarpus angolensis*), locally known as Mninga, large-leaved dalbergia tree (*Dalbergia boehmii*), locally known as Mngooli (English name could not be identified), baobab tree (*Adansonia digitata*), locally known as Mbuyu, Mgole (English name could not be identified) and Acacia tree (*Acacia tortilis*), locally known as Mkunguu produce leaves and flowers which farmers used as indicators for forecasting the upcoming rainy season.

The outcomes of FGD and interviews revealed that farmers used morphological features of trees locally known as Mgole and Msonankanga (English names could not be identified) to predict weather. The Mgole tree, apart from being used to predict rainfall, was also used to signify a good or bad year. FGD findings indicated that the Mgole tree shows a unique feature signifying the rainfall onset by growing upright in dry seasons. When it bends it predicts imminent rainfall. Similarly, Msonankanga is a seasonal plant which has a unique

feature used to indicate the change of season. The plant grows tall during rainfall onset and becomes short when there is no rain.

Farmers stated that the Mnyinga tree, also known as the large-leaved Dalbergia (*Dalbergia boehmii*), was used to predict a good or bad rainfall season. When large-leaved Dalbergia tree partially shed leaves, followed by rainfall, this signifies a good year/season. Conversely, when large-leaved Dalbergia tree completely shed leaves and produces flowers before the rainy season commences, this indicates a bad year/season. Most large-leaved Dalbergia tree species produce and shed flowers partially before imminent rainfall showing a good season with sufficient rainfall. When most large-leaved Dalbergia trees produce and shed all of their flowers and the rain is delayed, it signifies a bad season, with scarce rainfall.

FGDs and semi-structured interviews indicated that bird species were used as local indicators to forecast weather. The four species used by farmers to identify a good or bad season are white-browed coucal (*Centropus superciliosus*), also known locally as Dudumizi, cattle egret (*Bubulcus ibis*), locally known as Yangeyange, wire-tailed swallow (*Hirundo smithii*), locally known as Samamba/Mbayuwayu and birds locally known as Yobwa. The study showed that the appearance of white-browed coucals signified rainfall onset. White-browed coucals, when they produce a certain noise at night in November, the indication is that there will be upcoming rainfall. It is believed that, in most incidences white-browed coucals appeared when rainfall resumed after it had stopped for a while. Frogs (various species) were used as local indicators for weather prediction. The appearance of frogs and the sound they produce signifies the onset of rainfall. Respondents indicated that if frogs delay making this noise, the rainfall is yet to start.

When Yobwa birds appeared moving from west to east during the month of October this signified a good year and if there is to be a bad year, Yobwa birds will delay appearing and pass in November. The appearance of cattle egret birds (*Bubulcus ibis*), in a village suggested a bad season, characterised by the death of cattle and the outbreak of livestock diseases. The appearance of wire-tailed swallows (*Hirundo smithii*) in large numbers in the sky signified rainfall onset predicted imminent heavy rainfall. The findings indicated that nowadays the appearance of these birds is becoming increasingly rare.

The interviews and FGDs further identified millipedes (various species), army worms (*Spodoptera exempta*), termites (*Ancistrotermes* sp.), butterflies (various species), grass-green

grasshoppers (*Hesperotettix* sp.) and insects locally known as Mbilazi as being used for weather prediction. The appearance of millipedes, grass-green grasshoppers and butterflies in great numbers in a season showed that rain is imminent. The appearance of grass-green grasshoppers abundantly signifies imminent rainfall and a good year. Conversely, the appearance of caterpillars in January or February after the rainfall season indicates an upcoming food famine in the village. The study found that although termites (*Ancistrotermes* sp.) were not used in rainfall prediction, their appearance after the rainfall season in large numbers signifies famine, as they destroy cultivated crops. In addition, it was learned that when Mbilazi insects are green in colour it predicts imminent heavy rainfall and their appearance in red signifies less rainfall in a season.

The study found that in the past farmers used stones to predict rainfall. The findings from both the interview and FGDs indicated that a few elderly farmers possessed knowledge on the special stones used in predicting weather. In the FGDs a farmer explained, “When the rainfall season was near, elders who were believed to be traditional healers took blood from a chicken and placed it on special stones which are round in shape”. “The elders left the special stones for one night and collected them in the morning. If the stones were covered with a significant quantity of water, it signified immense rainfall and if covered with less water this meant low rainfall in the coming season”. It was learned that these days the IK of using special stones in weather forecasting is being practised less.

The findings of the study showed that farmers use wind and dust direction to predict rainfall onset, the amount of rainfall and continuity of rainfall in a season. When there is strong wind and dust in October or November coming from east to west it signifies rainfall and a good year. However, when the wind/dust direction is from west to east, this signifies that there will be less rain that season and is regarded as predicting a bad year. In the focus group, it was stated that it was difficult to predict the amount of rainfall using wind/dust direction. Most farmers could forecast rainfall based on imminent rainfall, but were not able to predict the expected quantity of rainfall. Findings from the focus group were that wind direction is used to show rainfall resuming when it had stopped for a while.

Farmers also use the structure of the moon and stars to predict rainfall. The study ascertained that the structure of the moon is used to predict weather. When farmers observe a halo of light surrounding the moon, they believe the halo signifies that the moon is surrounded by

water and this predicts rainfall. When the moon is surrounded with clouds it signifies that rain will fall in small quantities, but will last for a long period in the forthcoming days. The consecutive appearance of a semi-circular moon positioned in the north predicts imminent rainfall.

The study found that the position and quantity of stars is used to predict rainfall in a particular season. The villagers use stars to predict the amount of rainfall and the onset of rain. Farmers use a particular type of star, they observe its movements and make inferences on the rainfall patterns for a specific season of the year. The study identified the early emerging of a star known as 'Nangakavuji' in mid-November. Its appearance in the west, moving from the east, signifies a good rainfall season. If the star delays appearing within its set time frame, it indicates a bad season, with less rainfall.

The FGD revealed that the appearance of a group of stars known as 'Nimila', which move from east to west, when in position in a particular referenced, location signifies the amount of rainfall in a season. Farmers identified the sun's position in the morning and compared its similar position with Nimila stars to signify that rainfall was expected in mid-December. The Nimila stars' movement is observed continuously from mid-November to mid-December. When Nimila stars reach a referenced position in the evening, farmers predict rainfall and a good season. If Nimila stars do not reach the referenced position during mid-December, it indicates a delay in the rainfall season. If Nimila stars pass the identified referenced position when viewed at night in mid-December, it means that the season is going to be a bad one, with scarce rainfall.

The sun is another indicator farmers use to predict weather. Farmers look at the sun's position to make presumptions about a season. Farmers have identified a specific position where they expect the sun to be prior to the rainfall season. They use a particular reference point such as the position of the sun in a hill or trees to predict a season. Thus, if the sun reaches that position and there is still no rain, it means there will be scarce rainfall. A heavy shower of rainfall is predicted if the sun reaches the referenced position and rainfall commences. Other farmers said that when they observe the position of the sun in the south in November, it signifies the onset of rain.

A summary of indicators in local, common and scientific names and signs used to signify presence of rainfall or rainfall scarcity for Chibelela is presented in tables below and the

glossary in Appendix 6. Table 5.18 describes knowledge of local indicators based on plant phenology. Table 5.19 shows local indicators based on insects. Moreover, table 5.20 indicates knowledge on local indicators based on the moon, sun, stars, stones and wind. Table 5.21 gives the knowledge of local indicators based on birds.

Table 5.11: Knowledge of Local Indicators Based on Plant Phenology: Chibelela Village

Local /Swahili name	English name	Scientific name	The sign used to relate to the rain
Mfuru	Plum fingerleaf tree	<i>Vitex ferruginea</i>	Flowering and shedding of leaves signify rainfall onset.
Mninga	Bloodwood tree/sealing-wax tree	<i>Pterocarpus angolensis</i>	Flowering and shedding of leaves signify rainfall onset.
Mnyinga	Large-leaved dalbergia tree	<i>Dalbergia boehmii</i>	When there is partial shedding of leaves and there is rainfall onset, it means a good year, while when there is complete flowering before rain commences, it indicates a bad year.
Ngooli	-	-	Flowering and shedding of leaves signifies rainfall onset.
Msonankanga	-	-	A seasonal leafless plant which grows tall during rainfall onset and becomes short when there is no rain.
Mkunguu	Acacia tree	<i>Acacia tortilis</i>	Flowering and shedding of leaves signify rainfall onset.
Mgole	-	-	Bends during rainfall onset.
Mbuyu	Baobab tree	<i>Adansonia digitata</i>	Flowering and shedding of leaves signify rainfall onset.

Note: A dash (-) sign on the table shows the English and/or scientific name could not be identified (**Source: Interview with UDSM Botanist 2013**).

**Table 5.19: Knowledge of Local Indicators of Rain Based on Insects and Animals:
Chibelela Village**

Local /Swahili name	English name	Scientific name	The sign used to relate to the rain
Vyura	Frogs	- <i>Anura/Pseudacris</i> sp. -Various species	-When frogs start to make a lot of noise it indicates rainfall onset. -Their continuous noise signifies more rainfall in that season.
Jongoo/Gingwili	Millipede	Various species	Appearance on the earth's surface during the expected rainfall season indicates the rain is about to fall.
Mchwa	Termites	<i>Ancistrotermes</i> sp.	Their appearance in large numbers after the rainfall season signifies famine.
Senene	Grass-green grasshopper	<i>Hesperotettix</i> sp.	Their abundant appearance signifies imminent rainfall and a good year.
Viwavi	Army worms	<i>Spodoptera</i> <i>exempta</i>	- Their appearance on trees before the rainfall season (October/November) signifies enough rain in the coming season. -Their appearance after rainfall season (January) predicts coming food scarcity.
Mapapa Ukwale/Vipepeo	Butterflies	Various species	Appearance in bulk moving from west to east shows a good season.
Mbilazi	-	-	Appearance of these insects in

			green predicts imminent heavy rainfall and their appearance in red signifies less rainfall.
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Note: A dash (-) sign on the table shows the English and/or scientific name could not be identified (Source: Chang'a and Yanda 2010).

Table 5.12: Knowledge of Local Indicators Based on the Moon, Sun, Temperature, Stars and Wind: Chibelela Village

Local /Swahili name	English name	Scientific name	The sign used to relate to the rain
Jua	Sun	-	<ul style="list-style-type: none"> - Positioning of the sun in a certain identified position prior to the rainfall season means there will be enough rain that season. - Positioning of the sun in the south in November signifies rainfall onset.
Mwezi	Moon	-	<ul style="list-style-type: none"> - When overcrowded by clouds it means the rainfall is imminent and predicts a heavy rainfall. - When there is a halo around the moon, it means rainfall in small quantities but for a long duration. - Consecutive appearance of a semi-circled moon positioned in the north predicts upcoming rainfall.
Nangakavuji	Star	-	<ul style="list-style-type: none"> - Appearance of 'Nangakavuji' in mid-November and moving from east to west shows a good year.

Nimila		-	- Appearance of ‘Nimila’ stars in mid-December, moving from the east to west and positioned in a particular referenced location, signifies quantity of rain in a season and hence a good or bad year.
Upepo	Wind	-	East to west means rainfall onset.
Mawe ya Uganga	Stones	-	Appearance of special stones in the morning covered with a significant quantity of water signifies immense rainfall and if stones are covered with small quantity of water low rainfall will occur in the coming season.

(Source: Field Data 2012)

Table 5.13: Knowledge of Local Indicators Based on Birds: Chibelela Village

Local /Swahili name	English name	Scientific name	The sign used to relate to the rain
Dudumizi/Mugulo	White-browed Coucal	<i>Centropus superciliosus</i>	- When the bird makes a loud noise during the night in November it indicates imminent rainfall. -When they appear it means rainfall onset after it has stopped for a while.
Yangayange	Cattle egret	<i>Bubulcus ibis</i>	The appearance of Yangayanga birds shows it will be a bad season characterised by death of cattle as a result of diseases.

Yobwa	Bird	Name could not be ascertained	Their movement from west to east during mid-October signifies a good year. Their late appearance signifies a bad year.
Samamba/Mbayuwayu	Wire-tailed swallow	<i>Hirundo smithii</i>	Appear in groups all over the sky showing imminent rainfall onset. Their appearance also predicts imminent heavy rainfall onset.

(Source: UDSM Zoologist 2013)

5.8.2.2 Use of Indigenous Knowledge on Weather Prediction in Maluga Village

With regard to the IK farmers use in weather prediction, the study found that in Maluga village farmers use plant phenology, birds, animals, insects, wind direction, sun/temperature, moon structure and stars as indicators to predict rainfall onset and for forecasting a good or bad year. Plants used were identified as large sour plum (*Ximenia caffra*), locally known as Mtuundwa, large-leaved false thorn (*Albizia versicolor*), locally identified as Mzuu, acacia trees (*Acacia tortilis*), locally known as Mguunga, Mtamba (English and scientific names could not be identified), large-leaved dalbergia (*Dalbergia boehmii*), locally known as Mpogolo, Christmas tree/flamboyant tree (*Delonix regia*) locally identified as Mkrismasi, Msunzu (English and scientific names could not be ascertained).

Other trees include the Myrr tree (*Commiphora* sp.) locally known as Msaghaa, Mlandala (English name could not be identified), wing pod tree (*Xeroderris stuhlmanni*), locally known as Munene, Mkuyu (English name and scientific names could not be identified), Mnkola (English and scientific names could not be identified), Msalumbi (English and scientific names could not be identified), Mtulu (English and scientific names could not be identified) and Baobab tree (*Adansonia digitata*), locally known as Mbuyu. Farmers use the emergence of tree leaves, flowers and fruit to predict rainfall onset. When the rainfall season is about to start, trees produce leaves and flowers and farmers use these local indicators to prepare their

farming activities. Msalumbi and Mtuundwa tree species produce fruits which ripen when rainfall is imminent.

Findings from the interviews and the FGDs indicate that the birds used as local indicators for weather predictions are white-browed coucal (*Centropus superciliosus*), also locally known as Dudumizi, wire-tailed swallow (*Hirundo smithii*), locally identified as Samamba, Nkuunguza (English and scientific names could not be identified), Nsiigu (English and scientific names could not be identified) and cattle egret (*Bubulcus ibis*), locally known as Nangenange and Kinkiingoma (English name could not be identified). These birds are used to predict the onset of rainfall and a good rainfall season. The appearance of white-browed coucals, moving and singing in groups early in the morning, around 05:00, in October and November signifies imminent rainfall and a good year. Wire-tailed swallows appear in groups during rainfall onset and their appearance predicts heavy rainfall. The appearance of another bird species, identified as Kinkiingoma, in November and producing a distinctive noise indicates rainfall onset and predicts heavy rainfall. It was similarly found that the appearance of Nkuunguza, cattle egrets and Nsiigu birds in large numbers predict rainfall onset and good harvests in a season.

In Maluga village farmers use hyenas and frogs (various species) for rainfall prediction. The noise produced by hyenas and frogs signifies the onset of rain. The noise of a hyena (*Crocuta crocuta*) predicts imminent rainfall in a season. The study ascertained that insects used for weather prediction in Maluga village are Mlilyanondoo (English and scientific names could not be identified), termites (*Ancistrotermes* sp.), Grass-green grasshoppers (*Hesperotettix* sp.) locally known as Senene, caterpillars/host larvae (*Melachaka jeseri*) and millipedes (various species). The appearance of termites (*Ancistrotermes* sp.) on the earth's surface indicates the beginning of the rainfall season. Particularly, when Mlilyanondo insects appear and make a noise, it shows the rain is about to start. The appearance of grass-green grasshoppers (*Hesperotettix* sp.) signifies both imminent rainfall and a good year. When caterpillars/host larvae appear after the rainfall season (January) food scarcity is imminent.

FGDs established that farmers use wind direction to predict rainfall onset and amount of rainfall in a season. Findings show when farmers observe strong winds moving from west to east from September to November it signifies imminent heavy rainfall in the upcoming season. When the wind direction is from east to west in July, it indicates that there will be

less rainfall in the upcoming season and is believed to predict a bad year. Farmers pointed out that when they observe heavy dust moving from south to north it signifies imminent rainfall.

FGD findings in Maluga village were that farmers use the structure of the moon and its colour to predict a season of sufficient rain or scarce rainfall. It was observed that farmers describe a good rainfall season when the moon's structure is oval with a small black spot in the middle and surrounded by clouds. When the moon is overcrowded by clouds appearing as a black spot surrounding the moon, it signifies rainfall onset and means heavy rainfall. When the moon is red it predicts high rainfall and when it is white low rainfall is the forecast.

Farmers in Maluga village use the sun and temperature to predict weather in a season. When there is a high temperature, strong sun rays and heat in September to November it signifies the onset of rainfall. When the sun is in a south-west direction during the rainfall season, it signifies imminent rain. When the sun is positioned in the north-west it indicates the beginning of a summer season in a year.

In Maluga village farmers use stars to predict weather. They use stars to predict amount of rainfall and rainfall. Farmers use the stars' positioning in a particular referenced location to signify the amount of rainfall in a season. The FGDs indicated that Nimila stars appear in November to December prior to the onset of rainfall. They move slowly from the east and when they reach a known position, recognised by farmers, it signifies rainfall onset. As the rainfall continues, the Nimila stars further move to a known position which informs farmers that the rain is about to end. Thus, when Nimila fail to reach an identified position, it signifies that the rain will stop early and it will be a season with scarce rainfall. Study findings in Maluga could not ascertain the use of stones in weather prediction, in contrast to Chibelela village.

The summary of indicators in local, common and scientific names and signs used to signify the presence of rainfall or rainfall scarcity for Maluga are shown in the tables that follow and the glossary in Appendix 6. Table 5.22 describes knowledge on local indicators based on plant phenology and Table 5.23 shows local indicators based on insects. Table 5.24 indicates knowledge on local indicators based on the moon, sun, stars and wind and Table 5.25 shows knowledge of local indicators based on birds.

Table 5.22: Knowledge of Local Indicators Based on Plant Phenology: Maluga Village

Local /Swahili name	English name	Scientific name	The sign used to relate to the rain
Mtuundwa	Large sourplum	<i>Ximenia caffra</i>	An abundance of flowering plants fruits from September signifies enough rain.
MzUU	Large-leaved false thorn	<i>Albizia versicolor</i>	Appearance of many flowers and leaves before the rainy season in November indicates imminent rainfall onset.
Miguunga	Acacia	<i>Acacia tortilis</i>	Appearance of many flowers and leaves before the rainy season in November indicates imminent rainfall onset.
Mtamba	-	-	Appearance of many flowers and leaves before the rain season in November indicates imminent rainfall onset.
Mpogolo	Large-leaved dalbergia	<i>Dalbergia boehmii</i>	Appearance of many flowers and leaves before the rainy season in November indicates imminent rainfall onset.
Mkrismasi	Christmas tree/flamboyant tree	<i>Delonix regia</i>	Appearance of many flowers and leaves before the rainy season in November indicates imminent rainfall onset.
Msunzu	-	-	Appearance of many flowers and leaves before the rainy season in November indicates imminent rainfall onset.
Msaghaa	Myrr tree	<i>Commiphora</i> sp.	Occurrence of many flowers and leaves before the rainy

			season in November indicates imminent rainfall onset.
Milandala	-	-	Occurrence of many flowers and leaves before the rainy season in November indicates imminent rainfall onset.
Munene	Wing pod tree	<i>Xeroderris stuhlmanni</i>	Flowering and shedding of leaves signifies imminent rainfall.
Msalumbi	-	-	Fruits ripen when rain is about to commence.
Mkuyu	-	-	Flowering and shedding of leaves signifies rainfall onset.
Mbuyu	Baobab tree	<i>Adansonia digitata</i>	Flowering and shedding of leaves signifies rainfall onset.
Mnkola	-	-	Flowering and shedding of leaves signifies rainfall onset.
Mtulu	-	-	Flowering signifies imminent rainfall.

Note: A dash (-) sign on the table shows the English and/or scientific name could not be identified (**Source: UDSM Botanist 2013**).

Table 5.14: Knowledge of Local Indicators Based on Insects and Animals: Maluga Village

Local /Swahili name	English name	Scientific name	The sign used to relate to the rain
Mlilyanondoo	Insect	Could not be identified	Its occurrence and noise shows the rain is about to start.
Viwavi	Caterpillars/ Host larvae	<i>Melachaka jeseri</i>	Their appearance after the rainfall season (January) predicts coming food scarcity.
Jongoo	Millipede	Various species	Appearance on the earth's

			surface during the expected rainfall season indicates that rain is about to fall.
Senene	Grass-green grasshopper	<i>Hesperotettix</i> sp.	Their abundant appearance signifies imminent rainfall and a good year.
Mchwa	Termites	<i>Ancistrotermes</i> sp.	Appearance of termites indicates the beginning of rainfall.
Vyura	Frogs	- <i>Anura/Pseudacris</i> sp. - <i>Various species</i>	-When frogs start to make a lot of noise, it indicates rainfall onset. -Their continuous noise signifies more rainfall in that season.
Fisi	Hyena	<i>Crocuta crocuta</i>	The noise they make predicts imminent rainfall.

(Source: Chang'a and Yanda 2010)

Table 5.15: Knowledge of Local Indicators Based on the Moon, Sun, Temperature, Stars and Wind

Local /Swahili name	English name	Scientific name	The sign used to relate to the rain
Mwezi	Moon	-	- When the moon is overshadowed by clouds and has a black spot in the middle it means the rainfall is about to come and it will be a good year. - When the moon is overcrowded by clouds it signifies the rainfall is about to come and predicts a heavy rainfall. -When the moon is red it predicts high rainfall and when it is white it signifies low rainfall.

Upepo	Wind	-	When there is a strong wind moving from east to west in July to September it means no rain. But when it moves from west to east from September to November it shows that rain is about to come and there will be heavy rainfall.
Vumbi	Dust	-	Moving from south to north signifies rainfall onset.
Joto/Jua	Temperature/ Sun	-	High temperatures and strong sun's rays in September to November predicts the imminent onset of rainfall.
Nimila	Stars	-	The positioning of these stars in an identified reference point signifies rainfall quantity, its onset and end of rainfall in a season.

(Source: Field Data 2012)

Table 5.16: Knowledge of Local Indicators Based on Birds

Local /Swahili name	English name	Scientific name	The sign used to relate to the rain
Kinkiingoma (big black)	-	-	When it makes a certain distinctive noise before the rainfall onset it indicates imminent rainfall.
Nsigu (small)	-	-	Their appearance signifies imminent rainfall.
Nkuunguza (black with white stripes)	-	-	Their appearance in large numbers predicts enough rain and good harvests.

Dudumizi	White-browed Coucal	<i>Centropus superciliosus</i>	Singing of the Dudumizi early in the morning around 05:00 in October and November is a sign of start of rainfall and a good rainfall season.
Samamba/Mbayuw ayu	Wire-tailed swallow	<i>Hirundo smithii</i>	Appear in groups when the onset of rainfall is near. Their appearance also predicts heavy rainfall.
Yangeyange	Cattle egret	<i>Bubulcus ibis</i>	The appearance of Nangenange birds signifies imminent rainfall.

Note: A dash (-) sign on the table shows the English and/or scientific name could not be identified (**Source: UDSM Zoologist, 2013**).

Findings from both semi-structured interviews and FGDs, indicated in sections 5.8.2.1 and 5.8.2.2, shows a slight difference between farmers' awareness of indigenous indicators used in weather and climate prediction. Results indicate more farmers possessed IK in Maluga village, compared to Chibeleda, where a few possessed IK. The study observed that farmers in Maluga village were aware of many more plant species for weather prediction than in Chibeleda village. Farmers in Maluga village, contrary to Chibeleda village, indicated the practice of interpreting the hyena's sound in forecasting rainfall.

In Chibeleda village, a few older farmers were more explicit in explaining their use of IK in predicting the weather. This was not so in Maluga village. For example, in Chibeleda farmers indicated using 'miraculous' stones in predicting rainfall. Bird species which were observed in both villages were wire-tailed swallow (*Hirundo smithii*), white-browed coucal (*Centropus superciliosus*) and cattle egret (*Bubulcus ibis*). It was observed in both villages that farmers possessed IK on weather forecasting, using stars called Nimila. Farmers in Chibeleda could identify other stars, known as Nangakavuji, which were also being used to predict rainfall onset. Other similarities observed in the two villages were using sun, wind, dust, moon, frogs, termites, grass-green grasshoppers and millipedes in weather prediction. Despite learning from respondents about their IK level of understanding, it was noted that most of the local indicators such as trees and birds have disappeared and climate change and variability is being named as a cause.

5.8.3 Indigenous Knowledge Preservation

Preserving IK for weather forecasting is of paramount importance for farmers in mitigating and adapting to climate change and variability. The findings explaining farmers' reliance on IK is described in section 5.8.2 and demonstrates that farmers perceive IK of weather forecasting as fading away and they need preservation strategies for such knowledge.

The study solicited views from respondents on ways of preserving IK for weather prediction in their localities (cf. questions d31 in Appendices 1 and 2). Analysis of the content of the semi-structured interviews showed that most respondents suggested that parents should teach and impart skills on using IK for weather prediction to youth people and children. This can be achieved through educating the youth and children through storytelling. They reiterated that this might ensure IK is not lost and can be transferred from one generation to another.

Other farmers proposed incorporating IK as a subject in the curriculum of schools as a means of ensuring its continuity from one generation to another. Respondents proposed that scholars collaborate with knowledgeable people in a community (opinion leaders) and publish information on IK in books for future reference. Findings highlight the need for proper record-keeping at village level about the way a particular society uses IK in weather prediction. These findings support those by Chang'a, Yanda, Ngana (2010) and Kangalawe, Mwakalila, Masolwa (2011), who found that documentation and incorporating IK were essential in local adaptation planning.

Despite the proposed ways to preserve IK, farmers identified challenges which they faced in preserving indigenous knowledge. The major challenge of IK preservation raised by farmers was generalising indigenous knowledge from people with different cultures. This challenge arises as each community has its own way of predicting rainfall using its local indicators, which differ across villages and regions.

The findings of the study show that deforestation, loss of elders and loss of animal and bird species in the study villages seem to be critical factors which hinder managing and preserving IK on weather prediction. This occurs as IK hinges on knowledge built up within people in a locality over a certain period, through interaction with their environment. The above-mentioned barriers are regarded as factors threatening the management and preservation of IK, which is, in turn, threatened by climate change and variability. The study found that

cultural change in the younger population was a crucial barrier in preserving the IK systems as younger people view these practises as traditional and outdated.

5.9 Mitigating the Impact of Climate Change and Variability

For more than a decade, the United Republic of Tanzania has implemented several government initiatives to lessen the effect of climate change and variability for farmers in Tanzania. Section 3.7.2 in Chapter Three discussed government strategies on mitigating climate change and variability in Tanzania.

The study findings from interviews with district agricultural officers show that farmers and their farming practices have been severely affected in the study villages as a result of climate change and variability. The effects include increased food insecurity from 60% to 80%, conflicts between farmers and pastoralists and farmers diverging to other economic activities to earn a living. Section 5.9.1 describes the government initiatives to mitigate the impacts of climate change at district and village levels. Section 5.9.2 of this chapter discusses methods farmers are applying to lessen the impact of climate change and variability on their livelihoods.

5.9.1 Government Initiatives at Local Level

The study findings from district agricultural officers revealed that, at local level, the district council has set aside a number of strategies to reduce the effects of climate change and variability. These include raising farmers' awareness on environmental conservation, using experts to provide education on the benefits and use of improved seeds (early-maturing and drought-resistant), tree planting, adopting beekeeping, reducing livestock and setting aside land for grazing.

The study found other measures which the government of Tanzania has embarked on to cope with climate change and variability, including tree planting, government subsidies for seeds, inorganic fertilizers and distributing farm implements. The government contributes 80%, while farmers contribute 20% of the price for agricultural inputs.

5.9.2 Methods Farmers Apply to Mitigate the Effects of Climate Change and Variability

This section explains strategies farmers use to mitigate the impacts of climate change and variability.

5.9.2.1 Farming Methods Applied

Respondents were asked to state methods which they thought could reduce impacts of climate change and variability (cf. questions d20 in Appendices 1 and 2). Findings from the semi-structured interviews content analysis indicated most farmers believed tree planting and reduced charcoal making as issues which ought to be addressed to mitigate the effects of climate change and variability. Findings from respondents indicate a need to change farming methods to cope with climate change and variability. Most farmers indicated that, in recent years, they have extensively changed their farming methods towards adopting new, more productive agricultural practices, as a result of unpredictable rainfall, increase in pests and increase in temperature. These findings concur with those by Rogers (1995) in his DOI model, which shows perceived need to change has an impact in knowledge acquisition and adaptation to climate change and variability.

The respondents were asked about methods they apply to mitigate the effects of climate change and variability (see questions d22, i70 and i72 in Appendices 1 and 2). Findings from the content analysis of interviews showed the methods farmers apply include early farm preparation, planting in rows, increased use of manure, improved seed growth, irrigation, late planting, use of drought-resistant seeds and early-maturing varieties. Other local adaptation indicators include participatory cultivation, use of improved varieties, deep soil cultivation, using ridges, use of more efficient farm implements such as ploughs and tractors, use of improved varieties and use of pesticides.

As ways to reduce the impacts of climate changes and variability, the study ascertained that farmers from both study villages had been practising a variety of farming activities indigenously (see questions d24 in Appendices 1 and 2). These include cultivating using ridges, crop rotation and selecting types of crops to grow depending on the soil type and structure. The study found that farmers in the past practised mono-cropping, mixed cropping and burnt cultivated plant residues on the farm when preparing their farms for cultivation. Burning plant residues was done to eradicate plant diseases and pests before starting the new

cultivation season. These findings agree with those of Lema and Majule (2009), who observed that farmers possess knowledge on methods such as mixed cropping, burning of plant residues and crop diversification as means to coping with risks in farming. The study found that farmers have changed their farming practices and are shifting towards practising inter-cropping and not burning cultivated farm residues.

Findings from the focus group discussions from both Chibelela and Maluga villages indicated that the challenges associated with climate change and variability have been a major factor in the farmers' adoption of new farming practices for them to ensure a harvest. A farmer, JM, from Chibelela stated, "Mr. Facilitator, these days rainfall is highly erratic, if you don't use new methods of planting you won't get anything [referring to harvest]". Another farmer, BY, from Maluga village added, "We have recently witnessed if a farmer does not use new improved seed varieties and apply deep cultivation, he/she cannot harvest well".

5.9.2.2 Food Preservation Methods Used

Through content analysis of the interviews and focus group discussions the study found that, despite the growing use of chemicals for food preservation, farmers still apply indigenous knowledge in food and grain preservation (cf. questions d24 in Appendices 1 and 2). The use of indigenous storage vessels to store food was observed by Liwenga (2003), who conducted her study on food insecurity in semi-arid Tanzania. In addition, these findings support Rogers' (2003:254) views on indigenous knowledge systems, which hold that when a new idea is introduced in a community, individuals tend to evaluate it based on existing values and experiences.

In Chibelela village, farmers preserve grain using smoke, ash and powder from ground and dried leaves of trees known as Neem tree (*Azadirachta indica*), also locally known as Mwarobaini, and another species locally known as Mkuhuni. These findings confirm those by Liwenga (2003) and Kangalawe, Mwakalila and Masolwa (2011). They noted that ground and dried leaves of the Neem tree are used in grain preservation in Tanzania. The current study findings indicate grains are preserved in locally made baskets and pots. In Chibelela village, the study found the grain baskets used in food preservation are called Kilindo/Chidongha and Nhoto, while pots were known as Nyungu and Nhungu. For details, see Figures 5.8-5.12.



Figure 5.8: Indigenous Food Preservation Equipment used by Farmers - Chidongha (side view) (Field Data 2012)



Figure 5.9: Indigenous Food Preservation Equipment used by Farmers - Chidongha (Upper view) (Field Data 2012)

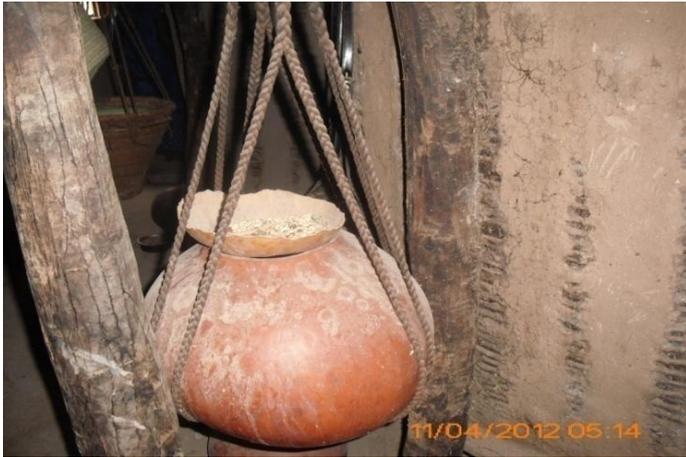


Figure 5.10: Indigenous Food Preservation Equipment used by Farmers – Nhungu (Field Data 2012)



Figure 5.4: Indigenous Food Preservation Equipment used by Farmers - Nhoto (Field Data 2012)



Figure 5.12: Indigenous Food Preservation Equipment used by Farmers - Nyungu (Field Data 2012)

In Maluga village, farmers have been adapting to climate change and variability through the use of indigenous methods. They use ash, smoke and powder from the ground and dried leaves of the Neem tree (*Azadirachta indica*) to preserve grains. Farmers in Maluga village use grain-preserving traditional baskets known as Shakasaka (see Figure 5.13), which are similar to Chidongha in Chibelela. The traditional pots and baskets used in Maluga village are known as Kyungu, Kiindi and Keo, which are similar to Nyungu, Nhungu and Nhoto in Chibelela village. Farmers use ash for killing insects in field-cultivated plants. Chidongha and Shakasaka traditional baskets are used to preserve grain, are being locally made from the product of trees and animal dung. The traditional baskets identified as Keo/Nhoto are made from special grass, while traditional pots known as Kyungu/Nyungu are made from clay. The study identified that the traditional storage pots known as Kiindi/Nhungu are also crafted from selective trees.



Figure 5.13: Indigenous Food Preservation Equipment used by Farmers - Shakasaka (upper view) (Field Data 2012)

5.9.2.3 Coping Strategies

The focus group discussions in the study villages revealed a growing shift towards use of irrigation farming as a method for mitigating the impact of climate change and variability. Group participants mentioned that farmers have been diversifying their farming activities

towards irrigation agriculture where they cultivate short duration maturing vegetables such as onions, tomatoes, cabbages, peas and grapes. Farmers have adopted other economic activities such as small trading of groundnuts, selling livestock and selling fish. Because of the negative impact of climate change on farming, they resort to charcoal making and selling firewood which in the long term constitute degradation of the environment. Mongi, Majule and Lyimo (2010) and Lyimo and Kangalawe's (2010) found that farmers have been adapting locally to the impact of climate change and variability and other environmental variables by expanding cultivation areas, to compensate for reduced crop yields during droughts, reducing fallows, switching to more drought-resistant crops, selling livestock, selling charcoal and engaging in small scale buying and selling in the shops that they established.

Other activities that farmers practise include building construction and tailoring. The emergence of small shops (viosk) for selling food, beverages and daily human needs was noted. To increase their income, farmers have diversified into salt-making industries, buying motorcycles, famously known as "bodaboda", which are hired by other people to facilitate public transportation. They also engage in selling solar power machines, beekeeping and wax production. The study found business activities such as grinding mill machines, growth of entrepreneurial activities (VICOBA), sunflower grinding machines, carpentry, casual labour and receiving contingency gifts from friends or relatives. These coping strategies of farmers in Tanzania were also observed by Lema and Majule (2009); Yanda and William (2010) and Kangalawe, Mwakalila and Masolwa (2011).

Through in-depth interviews with extension officers this study has identified the need for government to embark on measures that seek to reduce the adverse effects climate change and variability on farmers' livelihoods. These include the sustainable use of land for agriculture and livestock keeping, tree planting, water sources conservation and avoiding practising agriculture on water sources.

5.10 Attitudes to, and Perceptions of, Farmers of Climate Change and Variability

Farmers' attitudes to, and perceptions of, an innovation largely influences how they respond to other innovations (Rogers 2003). Therefore, innovation seems to influence how knowledge diffuses to farmers and is a critical factor in influencing the decision to embrace innovation. In this section, views of farmers and the district agricultural extension officers in Maluga and

Chibelela villages on their experience of dry spells, drought, rainfall and temperature and food security issues are presented in Section 5.10.1.

The results from the semi-structured focus group discussions and in-depth interviews with farmers and district agricultural officers, respectively, were further compared with data from the Tanzania Meteorological Agency (TMA), to ascertain any similarities or differences between the local perceptions from respondents and data from the meteorological stations. Section 5.10.2 presents farmers' attitudes and perceptions regarding food security.

5.10.1 Attitudes to, and Perceptions of, Farmers of Drought, Rainfall and Temperature

Farmers were requested to highlight their perceptions of the frequency and experience of drought and rainfall patterns when comparing the environment now with the last decade (cf. questions i64 and i66 in Appendices 1 and 2). Findings from the semi-structured interviews show that most farmers have observed frequent droughts, erratic rainfall patterns and a temperature increase. Studies by Slegers (2008), Gwimbi (2009) and Mengistu (2011) confirm these findings and these authors found that farmers in Tanzania, Zimbabwe and Ethiopia similarly perceive an increase in drought, reduced and erratic rainfall and increase in temperature in the last decade. Most (82 or 97.6%) respondents perceive an increase in erratic rainfall patterns, while only 2 (2.4%) respondents indicated that they had not witnessed any significant changes in rainfall pattern for the last decade, in both Chibelela and Maluga villages. These results confirm those of Rogers (2003:170), who regarded individuals' previous experience and perceptions as crucial in the adoption of innovations process.

With regard to respondents' perceptions concerning an increase in temperature from 2002-2011, findings from the semi-structured interviews indicate that most (69 or 82.1%) perceive an increase in temperature, while 15 (17.9%) do not perceive any increase in temperature for the last decade. Despite findings from the semi-structured interviews showing that farmers perceive and increase in temperature, findings from the focus group discussions show that few farmers believe there is a slight increase in temperature and increased wind intensity, compared to the previous decade. The farmers' comments were:

F1: "These days the temperature and wind have increased compared to the past".

F2: "... not only the temperature that has been observed to increase in this village, but also the wind intensity".

F3: “I think temperature has not changed, it is just the same...”

Findings from in-depth interviews with agricultural extension officers show they perceive a decrease in rainfall, increase in dry spells and an increase in temperature, with regard to the pattern of climate change and variability in the last decade. One district agricultural officer stated “These days we have observed dry spell, drought, less and erratic rainfall in the district when compared to the past”. Another district agricultural officer commented “recently the weather has changed and rainfall is scarce”. “Our farmers have witnessed climate change and variability impacts as they suffer from dry spells and food insecurity more frequently”. Table 5.26 summarises farmers’ perceptions of rainfall and temperature changes in the last decade.

Table 5.17: Farmers’ Perceptions of Changes of Rainfall and Temperature for the Last Decade

Response N=84	Rainfall Pattern		Response	Temperature	
	Frequency	Percentage		Frequency	Percentage
Yes	82	97.6	Yes	69	82.1
No	2	2.4	No	15	17.9
Total	84	100		84	100

Respondents were asked about their attitude to the frequency of observed drought and erratic rainfall pattern (see question i65). Most farmers indicated that they have often observed the incidence of drought, decreased rainfall, recurrent food shortage, dry spells and erratic rainfall while few respondents stated that they have rarely observed the phenomena.

Study findings from the semi-structured interviews illustrate that 34 (40%) respondents have observed drought and erratic rainfall very often, 27 (32%) respondents often and 9 (11%) respondents stated they have neither often nor not often observed the incidences of drought and erratic rainfall. Ten (12%) indicated that they have observed frequent drought and erratic rainfall rarely, while only 4 (5%) stated that they have very rarely experienced drought nor erratic rainfall in the villages. Figure 5.14 below illustrates the results.

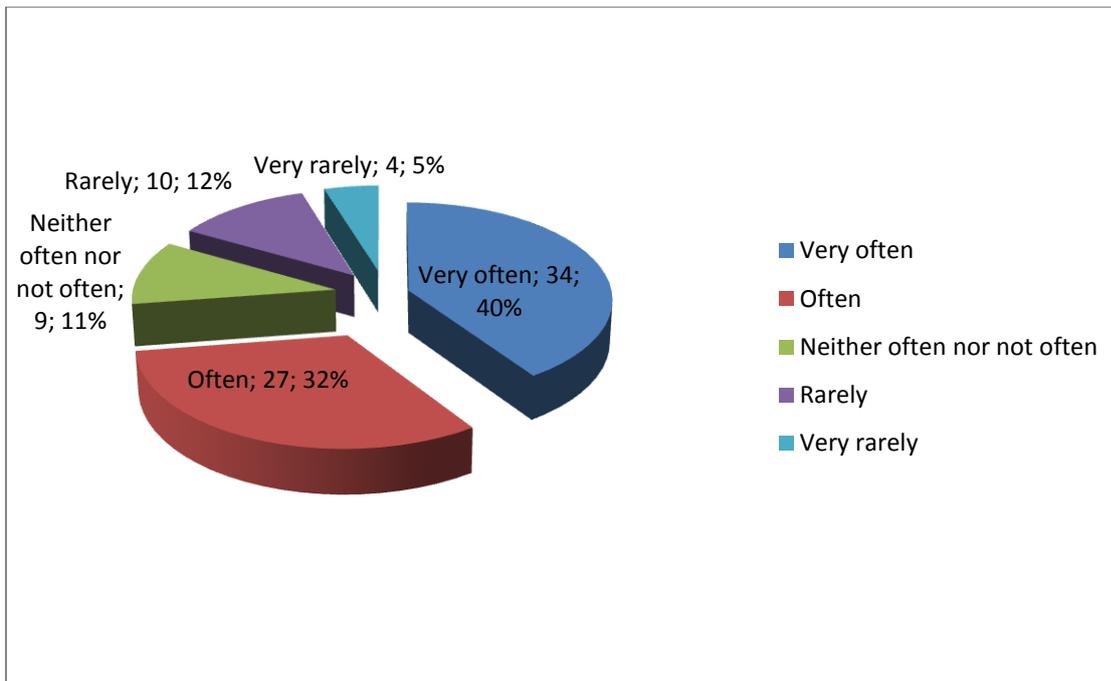


Figure 5.6: Farmers’ Perceptions of the Frequency of Drought and Erratic Rainfall Patterns

The findings from the focus group discussions and semi-structured interviews from Maluga and Chibeleda villages show that most farmers have recently observed a significant decrease in the amount of rainfall and its reliability in arrival is very erratic. Farmers pointed out that recently rainfall pattern has changed and it arrives much earlier and at times later than usual. The findings show that, in the past, rainfall onset used to delay for a long period of time compared to the patterns nowadays. A farmer in Chibeleda village stated, “In the past, rainfall used to commence between 15 and 20 December and did not stop till mid of June the following year. Nonetheless, the situation these days is different as the rain ends in February or March”.

A similar observation on change of rainfall dates was noted in Maluga village. A farmer stated “In the past rainfall would start on 15 November and end in May the following year. However the trend shows currently rainfall may end in March or early April in the subsequent year unlike the past observed trend”. He added “these days the rainy season has been shorter more unpredictable and dry spells have increased”.

Having solicited views from semi-structured focus group discussions and in-depth interviews from farmers and district agricultural officers, respectively, the findings were compared with

analysed data from the Tanzania Meteorological Agency (TMA). The aim was to ascertain any significant similarities or differences between the respondents' local perceptions of the rainfall pattern and temperature for the period of ten years and data from the meteorological stations.

The findings of the study show that there has been a decrease in rainfall and an increase in temperature for the last decade in Chibelega village. The graphs as depicted in Figure 5.15 and Figure 5.16, illustrate rainfall pattern and temperature variations in Chibelega village from 2002-2011.

Findings in Maluga village also indicate a decrease in rainfall and an increase in temperature for the last decade. Figure 5.17 and Figure 5.18, show rainfall patterns and temperature variation for the past decade. These findings confirm the perceptions of farmers with regard to increased temperature and decreased rainfall during the past 10 years.

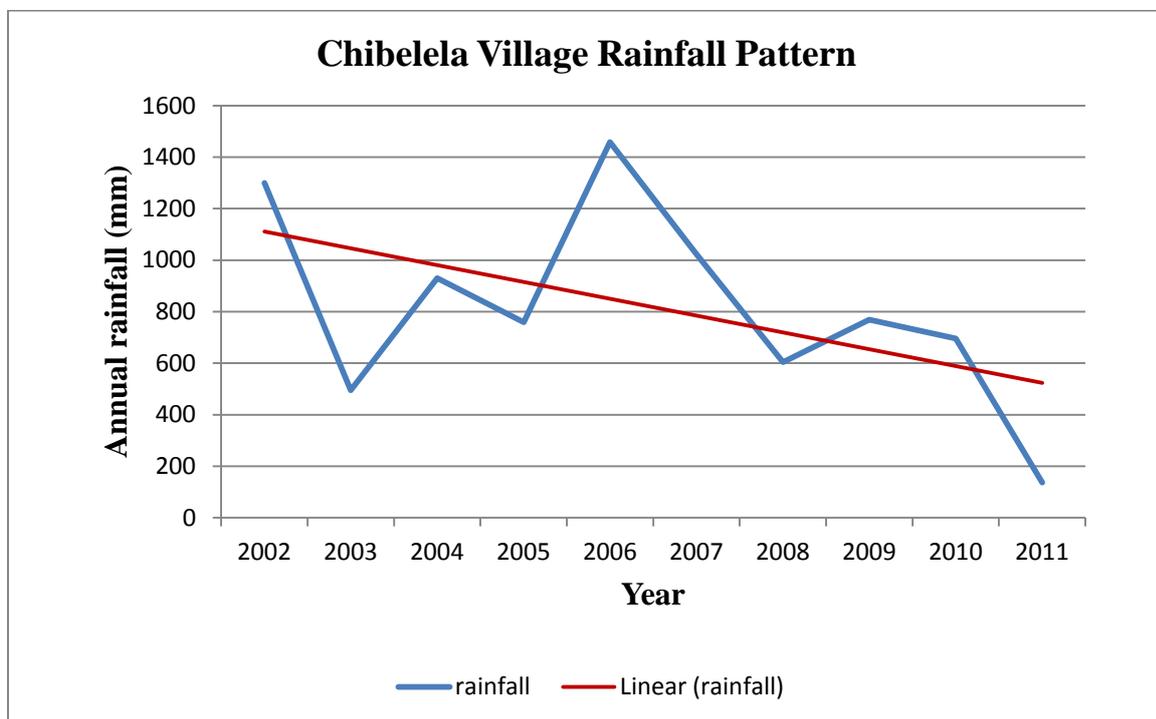


Figure 5.7: A Graphical Representation of Rainfall Patterns for the Last Decade in Chibelega Village (Source: TMA 2012 rainfall data)

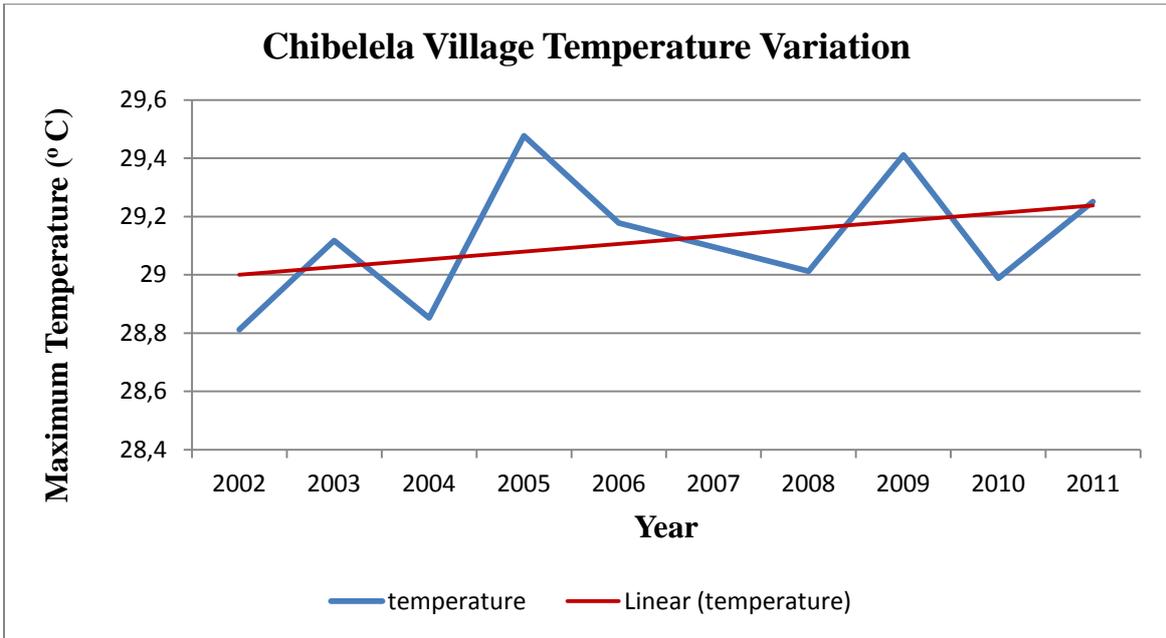


Figure 5.16: A Graphical Representation of Temperature Variations for the Last Decade Years in Chibelela Village (Source: TMA 2012 temperature data)

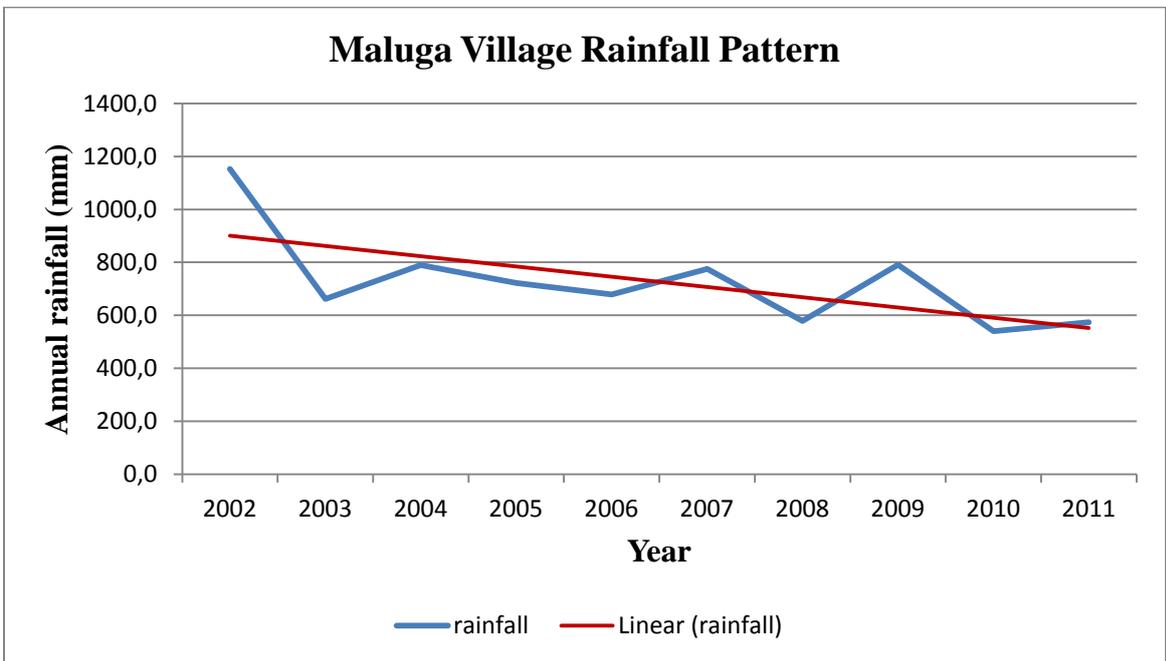


Figure 5.17: A Graphical Representation of Rainfall Patterns for the Last Decade in Maluga Village (Source: TMA 2012 rainfall data)

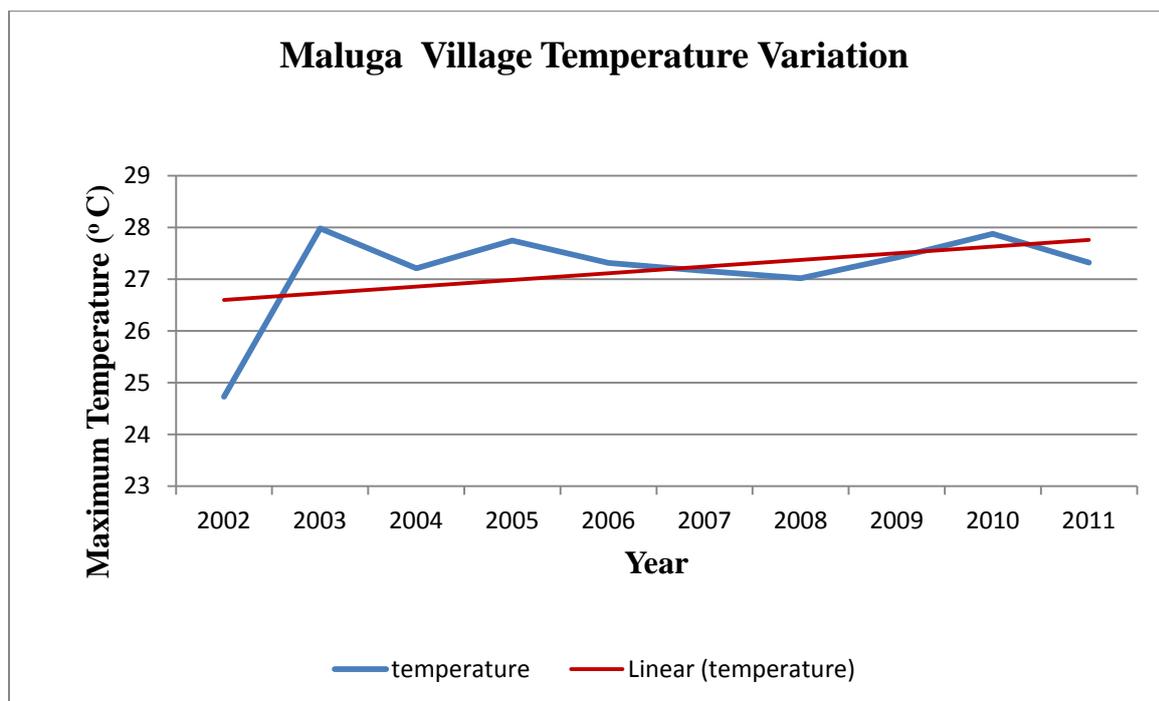


Figure 5.18: A Graphical Representation of Temperature Variations for the Last Decade in Maluga Village (Source: TMA 2012 temperature data)

5.10.2 Attitudes to, and Perceptions of, Farmers in Farming

Farmers were asked to explain the challenges they face in farming (cf. questions i68 and i70 in Appendices 1 and 2). Results from the focus group discussions showed that, despite awareness and education programmes to influence farmers' adoption and use of innovations, the study found that farmers have developed negative attitudes to industrial fertilizer and new improved seed varieties. This affected the use of these innovations. These results are in accordance with the findings by Rogers (2003:221), who observed that attitude to adopt an innovation is influenced by the perceived attributes of the innovation. The study found that most farmers have a negative perception of the newly introduced sorghum varieties, referred to as 'white' sorghum. They perceive white sorghum to be tasteless compared to the indigenous sorghum variety known as Lugugu. These findings are in line with those by Rogers (2003:168-200), who found that attitude influences users' decisions to adopt an innovation.

Findings indicate that farmers prefer more indigenous sorghum varieties than the new sorghum high-yield varieties, as the new varieties are attacked more by disease, insects and birds, compared to the indigenous varieties. These findings are supported by the DOI model

by Rogers, which explains that for an innovation to be accepted in a community, it should be compatible with the values, norms, beliefs, culture and meet the individuals needs of farmers (2003:240-246). Most farmers believe that they might end up having a very poor harvest, or fail to harvest, if he/she cultivates new sorghum varieties. These results reflect those of Rogers Diffusion of Innovations model, which indicates users choose an innovation based on its importance relative advantage, compatibility and complexity (2003:229-258).

Similar views emerged from farmers that new early-maturing maize varieties are not susceptible to drought but are more susceptible to being eaten by the grain borer insect, compared to indigenous maize variety. Nevertheless, the study found that, despite farmers' perception on new seed varieties, they have observed that new varieties produce larger harvests, in a shorter period of time. These findings conform to those by Mukhopadhyay (1994:99), who found that farmers' decisions to adopt the new High Yield Varieties (HYV) depended on discounted returns per unit cost and the added risk or uncertainty that HYVs entailed, compared with traditional varieties. The findings were supported by Rogers, in the Diffusion of Innovations model, which shows the relative advantages, observability, trialability and compatibility attributes to be critical in the adoption of an innovation (Rogers 2003).

Similar findings were noted from the focus group discussions on farmers' attitudes towards inorganic/industrial fertilizer usage. Despite the government's effort in subsidising agricultural inputs such as inorganic fertilizer, farmers prefer using organic fertilizer, namely manure. The study revealed that farmers have a negative attitude to the use of inorganic/industrial fertilizer, believing that it reduces soil fertility. These findings confirm those by Rogers, which show that the attitude to, and decision about, an innovation lies in the perceived characteristics of the innovation (Rogers 2003). The attributes of innovation-decision process, which explain farmers' rate of adoption, include relative advantage, observability, compatibility, and complexity (Rogers 2003).

The study found that farmers still perceived agricultural inputs such as fertilizers and pesticides to be expensive and prefer being given such inputs free. Findings also show that farmers perceive distance and cost to be factors affecting their ability to acquire agricultural inputs. These findings are in line with those Lema and Majule (2009), who discovered that lack of farm implements to be the major factor influencing farmers' agricultural production.

The findings from the FGDs indicate that farmers perceived a loss in soil fertility, a need for increased fertilizer usage, a lower water table and reduced soil water retention capacity. They have also observed an increase in usage of new farm implements and deep soil cultivation, compared to the past. These findings concur with Lema and Majule (2009), who found unpredictable rainfall, increased pests and diseases and low soil fertility to be the major factors influencing farmers' production capability. Through the FGDs farmers stated that in the past, they used to practise traditional cultivation by throwing seeds onto the soil in a small area, which would result in harvesting large quantities. The scenario is different nowadays, in that farmers need to apply new scientific methods to ensure yield. Supporting this finding, a farmer, JM, from Chibelela village represented most farmers' views, by explaining that, "Nowadays, if a farmer fails to apply fertilizer, pesticides and deep soil water preserving methods when cultivating, he/she is most likely going to have poor harvest".

With regard to attitudes to challenges in farming, the findings show that most farmers perceived poor extension services, changes of climate resulting in unreliable rainfall, increase in pests and diseases and inadequate farm inputs as major challenges hindering their agricultural activities. Similar findings, by Mutekwa (2009) and Mongi, Majule and Lyimo (2010), found that poor services by extension officers, as well as pests and diseases, climate variability and wealth were serious challenges affecting farmers in Zimbabwe and Tanzania. Other perceived barriers in farming indicated by farmers are inadequate farm implements and the poor quality of new improved seed varieties. These varieties mostly pointed to are maize varieties which are said not to be sustainable in drought and susceptible to diseases as well as easily destroyed by insects.

The present study shows that farmers have recently observed an increase in harmful insects such as the larger grain borer, locally known as Scania/Tembo, and perceive a spread of diseases in the villages. The insects are said to destroy grain and seed of maize and peas. During the focus group discussion, a farmer, DD, from Maluga village, stated "recently farmers have observed an increased number of insects which not only destroy grains in the field, but also destroy cultivated crops in the field". Another farmer commented, "These days there is also an increase in human diseases such as malaria and vector insects such as mosquitoes now when compared to the last decade".

The findings from the interviews and the focus group discussions from the farmers further suggest an increase not only in plant diseases, but also birds which feed on grains, in recent years. The increase in plant diseases has positively prompted farmers to use pesticides to ensure harvesting. They stated that in the past years, they were able to cultivate without using pesticides and yet they still get a good harvest. Another factor that affects their capacity to grow a new sorghum variety, referred to as white sorghum is the increase in the number of birds that eat their crops.

5.10.3 Attitudes to, and Perceptions of, Farmers Regarding Food Security

The study sought to deduce farmers' attitudes to food security and their preparedness at household level (cf. questions i71, i72 and i73, i74 in Appendices 1 and 2). The FGD showed that farmers perceive an increased incidence of food shortages as a result of a shortened growing season, reduced amount of rainfall and an increased incidence of drought and dry spells. These findings on farmers' attitudes to food security are supported by those of Liwenga (2003) and Mongi, Majule and Lyimo (2010). Therefore, when farmers were asked to explain their perceptions of food security at the level of household, the majority of farmers indicated that the food they produced was not adequate for consumption and sale. These findings confirm those by Rogers' DOI model, which asserts that recognising a problem or need was crucial in developing an attitude towards an innovation (2003:137, 171).

Results from the semi-structured interviews show that most (58 or 69.0%) respondents indicated that the food they produced was not enough to feed their family and still have a surplus to sell to the market. The study findings show that few (26 or 31.0%) respondents indicated that they produced sufficient food for their family to eat and for sale. In support of the above findings, farmers' focus group discussions indicated a decline in food security at the household level (see Figure 5.19.)

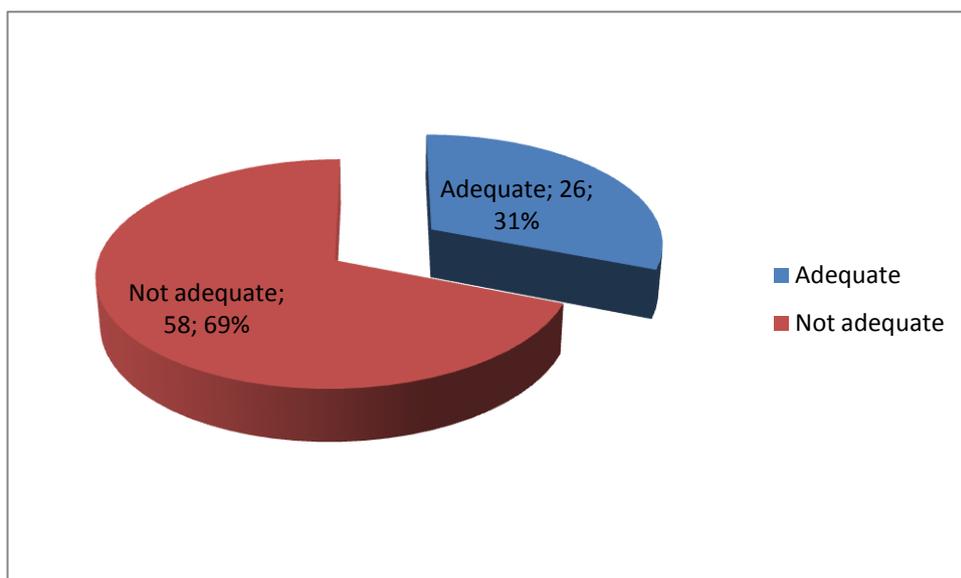


Figure 5.19: Farmers' Food Adequacy

The FGDs revealed that farmers were not producing sufficient food to feed their families. Respondents indicated that producing sufficient food was dependent on the condition of having timely and sufficient rainfall. Even those who said that they produced sufficient food to sell at the market also acknowledged that harvest was not enough to cover the need of their household and for sale at the market. These findings show that most farmers are not prepared for the possibility of drought or famine. Farmers' preparedness can be enhanced through the adoption of innovations. In this regard, new appropriate farming practices introduced to farmers can promote household food security and mitigate climate change and variability.

With regard to the farmers' level of preparedness, the results of the study show that farmers are not prepared for drought and floods. Figure 5.20 shows that 36 (42.9%) of the farmers are not prepared and 12 (14.3%) are least prepared. Twelve (14.3%) farmers said that they were neither prepared nor highly prepared for drought and floods. Seventeen (20.2%) of the farmers stated that they were prepared, while only 7 (8.3%) farmers said that they were highly prepared.

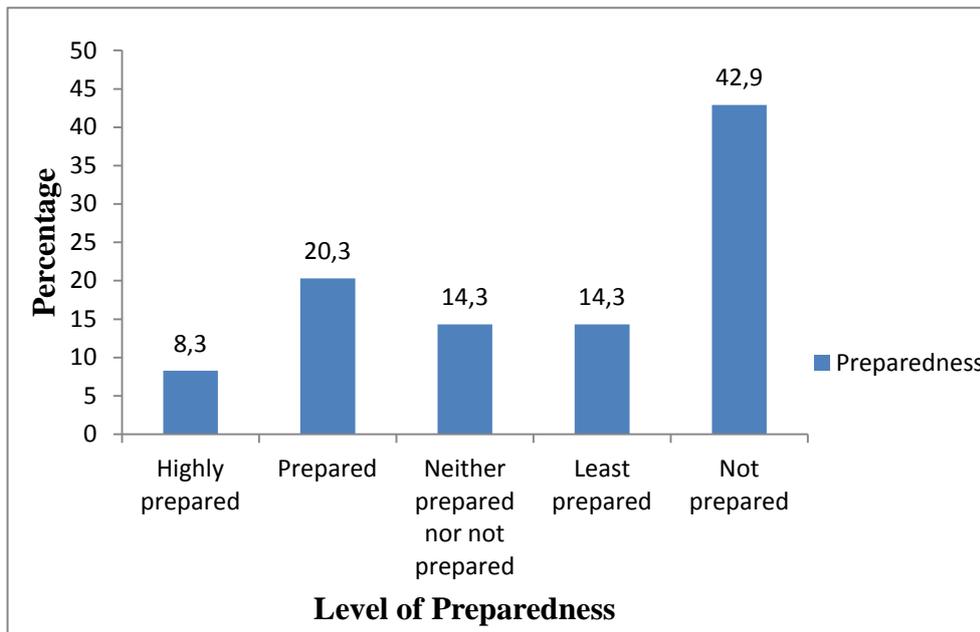


Figure 5.20: Farmers' Level of Preparedness for Drought and Floods

5.11 Farmers' Current Level of Adoption of Information on Adaptation

This section presents findings of farmers' level of adoption of information on adaptation to climate change and variability.

5.11.1 Types of Innovations Adopted

Farmers were asked about what innovations they have adopted based on information received from CCAA trainers (see questions f41 and f42 in Appendices 1 and 2). Results from semi-structured interviews indicate most (80 or 95.20%) respondents received and adopted innovations on improved farming methods, while 4 (4.80%) respondents did not adopt the information. Findings further show that 68 (81.0%) respondents had adopted and had the production of high-value crops and 16 (19.0%) had not adopted the production of high-value crops. The third category had 49 (58.3%) respondents who adopted growing improved seed and 35 (41.70%) who did not adopt growing improved seed.

The fourth category had 45 (53.6%) respondents who had adopted the use of new technology farm implements while 39 (46.40%) did not adopt the use of the implements. Similar findings were made during in-depth interviews from agricultural extension officers and the CCAA programme manager. The results shown in Figure 5.21 are that most farmers have adapted to the use of improved farming methods and high-value crops compared to other innovations. These findings confirm those by Rogers in the Diffusion of Innovations model, which

emphasises the role of attributes of innovations, such as relative advantage, compatibility, trialability and observability in enhancing the adoption of innovations (2003:15-16)

In-depth interviews with the two agricultural extension officers and a programme manager revealed increased awareness of climate change and variability by farmers, use of organic and inorganic fertilizer and improved seed usage. Farmers have also adopted the use of pesticides and significant use of improved farm implements such as tractors, power tillers, ploughs, Magoye rippers and Spring jembe. These results concur with those in the DOI model, which explains the fundamental role of communication channels in adoption of innovations (Rogers 2003). Disseminating information influences the innovation-decision process through creating awareness, imparting new knowledge, changing individuals' attitudes, influencing decision-making, using an innovation and fully adopting it (Rogers 2003:171-189).

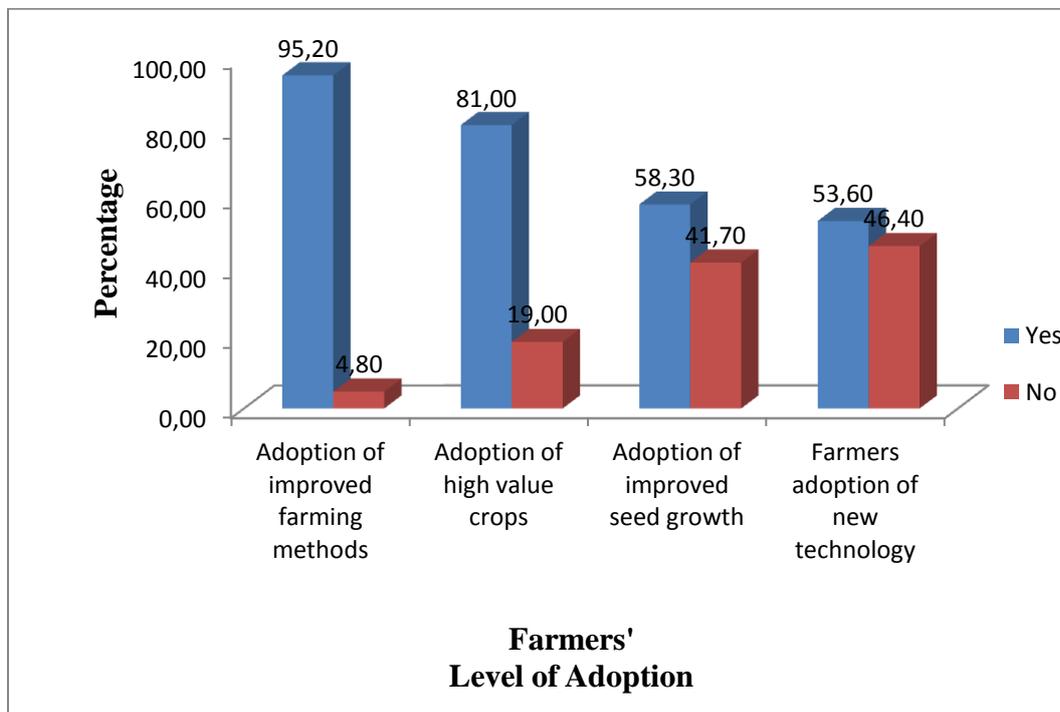


Figure 5.8: Farmers' Level of Adoption

5.11.2 The Level of Adoption of Innovations

The level of adoption by farmers was assessed. Respondents were asked to rate their level of adoption of innovations. The semi-structured interviews show that most respondents have adopted the innovations. Results show that 24 (28.6%) respondents have highly adopted and 38 (45.2%) respondents have adopted innovations. Fourteen (16.7%) respondents had neutrally adopted and only five (6.0%) respondents had least adopted the innovations. The

study ascertained that only three (3.6%) respondents did not adopt innovations. The observed findings confirm those of Rogers (2003:16), who explains that innovations which are perceived to be more observable, compatible, triable and with a greater relative advantage were adopted more rapidly than others. Refer to Figure 5.22 for more details.

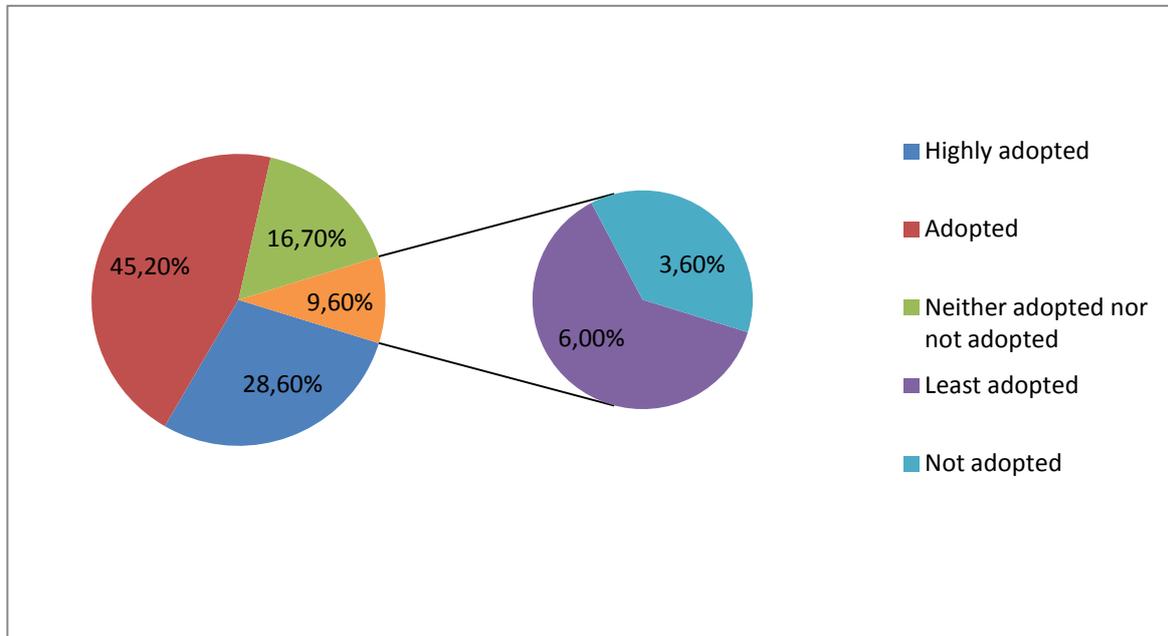


Figure 5.9: Farmers' Rate of Adoption of Innovations

5.11.3 Farmers' Variations in Adoption of Innovations

Respondents were asked whether there was any difference in the rate of adoption of information between farmers who did not receive training through the CCAA project and those who did (cf. questions d20 and e25 in Appendices 3 and 4). Findings from the in-depth interviews with the district agricultural officers of both Chibelela and Maluga villages and the CCAA programme manager indicate that there is a difference in adoption between farmers who had received training and those who did not receive training from the CCAA project. One agricultural officer stated, "Yes, there is a difference on adoption between trained and untrained information, as trained ones have seen and practised with experts in the field using Farmer Field Schools, unlike untrained farmers".

The other agricultural officer commented, "Yes, there is a difference on the adoption level between the trained and untrained farmers". Trained ones seek more consultation and ask more questions on ways of adopting to improve agricultural production as they have seen the positive impact of training". The CCAA programme manager stated "Yes, trained farmers are

more specific and focused in their agricultural activities than those who did not observe the practicals in the field". These findings are in line with those by Rogers (2003) in his DOI model, which stresses the role of awareness as a critical component in an innovation decision process. Trained farmers seem to have developed a positive attitude towards innovations. These results are consistent with those by Diederer, Meijl, Wolters and Bijak (2003) in the Netherlands, who observed that farmers who were innovators used extension services more and engaged more in improving agricultural innovations than early adopters.

Findings from the in-depth interviews with the extension officers and programme manager, observed a notable incidence of cases where farmers who did not receive training from CCAA experts had adopted innovations to a greater extent than trained farmers. Major reasons given for the observed variation in adoption are farmers' ability to seek consultations from extension officers, willingness to learn, farmers' income and their capacity to purchase farm inputs and farm implements. These findings confirm those observed in the Diffusion of Innovations model which ascertains the crucial role of socio-economic factors in determining the rate of adoption of an innovation (Rogers 2003:288).

Despite the findings from the agricultural officers and the programme manager showing trained farmers have adopted innovations more than untrained ones, the findings of this study have not detected any significant difference in adoption between farmers. The semi-structured interviews and the focus group discussions with farmers indicated most untrained farmers had also diffused and adopted new agricultural practices to adapt to climate change and variability, as they could apply the new knowledge they had received from their fellow farmers.

The qualitative data from the focus group discussions and the interviews, the study cross-tabulated between farmers' level of adoption and their respective villages, but hardly see any major difference between the Maluga and Chibelela villages. Results in Chibelela village indicate that 15 (31.2%) respondents had highly adopted innovations and 22 (45.8%) respondents had adopted.

Five (10.4%) respondents were neutral; 3 (6.2%) respondents had fairly adopted and 3 (6.2%) respondents did not adopt. In Maluga 9 (25.0%) respondents had highly adopted; 16 (44.4%) respondents had adopted and 9 (25.0%) respondents were neutral. Two (5.6%) respondents

had fairly adopted and none of the respondents in Maluga village had failed to adopt an innovation. See Table 5.27 for more details.

Table 5.18: Cross Tabulation Showing Farmers’ Adoption of Innovations in Maluga and Chibelela Villages

Farmers Level of Adoption N=84						
Village	Highly adopted (Frequency and Percentage)	Adopted (Frequency and Percentage)	Neutral (Frequency and Percentage)	Fairly adopted (Frequency and Percentage)	Havenot adopted (Frequency and Percentage)	Total (Frequency and Percentage)
Maluga	9 (25.0%)	16 (44.4%)	9 (25.0%)	2 (5.6%)	0 (0.0%)	36 (100%)
Chibelela	15 (31.2%)	22 (45.8%)	5 (10.4%)	3 (6.2%)	3 (6.2%)	48 (100%)
Total (Frequency and Percentage)	24 (28.6%)	38 (45.2%)	14 (16.7%)	5 (6.0%)	3 (3.6%)	84 (100%)

5.11.4 A Comparative Analysis of Farmers’ Level of Adoption of Innovations

The study sought to compare the level of adoption of information by farmers. The respondents were asked to explain farmers’ level of adoption of information on adaptation to climate change and variability at each village (see also questions d21 and e26 in Appendices 3 and 4). The findings from the programme manager indicated a slight difference between adoption of information in the two study villages, with results showing Chibelela village having adopted more than Maluga village.

Notable differences arose from the agricultural extension officers’ views in both villages. Findings from the agricultural extension officer in Chibelela indicated a slight adoption of information on adaptation to climate change and variability. The agricultural extension officer in Maluga indicated that the majority of farmers had adopted information on how to adapt to climate change and variability. The agricultural extension officer from Chibelela indicated resource constraints constituted the major factors that prevented farmers from fully adopting innovations.

Field observation by the researcher shows that in Chibeleda village the level of diffusion of information by farmers is greater, compared to Maluga village. This could be linked with the presence of more farmer groups in Chibeleda village than Maluga village. The findings on the farmers' difference in the level of adoption in the two study villages are supported by the Diffusion of Innovations model, which shows interpersonal communication channels which control farmer groups' communication are embedded as a variable which influences adoption of innovations (Rogers 2003).

5.11.5 Correlation Test between Adoption and Socio-Economic Variables

The study investigated if there is any correlation between age, gender, level of education, farmers' level of income and level of adoption of innovations. Findings from the cross-tabulation show a direct relationship between increase in age and level of adoption of innovations by farmers. The analysis shows the Pearson Chi-square value of 35.431 and the significance value is 0.018, at the 0.05 probability level of significance. With regard to gender, the study could not ascertain any direct association between gender and adoption of innovations. The cross tabulation between gender and adoption of innovations indicates a Pearson Chi-square value of 2.465 and the significance value of 0.651 at the 0.05 probability level of significance. Tables 5.28 and 5.29 summarise details.

Table 5.19: Cross-Tabulation between Age and Level of Adoption of Innovations

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	35.431 ^a	20	0.018
Likelihood Ratio	38.896	20	0.007
Linear-by-Linear Association	0.221	1	0.639
N of Valid Cases	84		

a. 25 cells (83.3%) have an expected count less than 5. The minimum expected count is 0.07.

Table 5.29: Cross-Tabulation between Gender and Level of Adoption of Innovations

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	2.465 ^a	4	0.651
Likelihood Ratio	2.445	4	0.655
Linear-by-Linear Association	0.427	1	0.513
N of Valid Cases	84		

a. 5 cells (50.0%) have an expected count less than 5. The minimum expected count is 0.93.

The findings ascertained a statistical significance between farmer income levels and adoption of innovations. Cross-tabulation shows a Pearson Chi-square of 37.282 and a significance value of 0.002, at the 0.05 probability significance level. These findings confirm those by Rogers (2003:288), which show that wealth enhances the adoption of innovations. This study found a direct correlation between level of education and the adoption of innovations. The study findings depict the Pearson Chi-square value of 41.624 and the value of significance of 0.000, at the 0.05 probability level significance. Tables 5.30 and 5.31 provide details.

Table 5.20: Cross-Tabulation between Income Level and Level of Adoption of Innovations

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	37.282 ^a	16	0.002
Likelihood Ratio	34.134	16	0.005
Linear-by-Linear Association	10.908	1	0.001
N of Valid Cases	84		

a. 21 cells (84.0%) have an expected count less than 5. The minimum expected count is 0.14.

Table 5.21: Cross-Tabulation between Level of Education and Level of Adoption of Innovations

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	41.624 ^a	12	0.000
Likelihood Ratio	24.277	12	0.019
Linear-by-Linear Association	1.721	1	0.190
N of Valid Cases	84		

a. 16 cells (80.0%) have an expected count less than 5. The minimum expected count is 0.04.

5.11.6 Attributes of Innovations

Farmers were tested on five attributes which influence the rate of adoption. The attributes are trialability, observability, complexity, compatibility and relative advantage. Respondents were asked if they had tried to apply an innovation from experts and failed (cf. questions f45 and f46 in Appendices 1 and 2). Findings from the farmers’ interviews show that few farmers (24 or 28.6%) had applied an innovation and failed, while most farmers (60 or 71.4%) indicated not having failed upon trying an innovation.

5.11.6.1 Trialability

Farmers were asked to explain how they responded when they tried innovations from other extension services and failed (cf. questions f46 and f47 in Appendices 1 and 2). Study findings show a low level of trialability and high level of observability from farmers. These findings corroborate those of Rogers, which showed the rate of adoption of an innovation to be influenced by trialability, or the degree to which a new idea can be tested in a new environment within a specific period of time (2003:16, 258). Figure 5.23 shows a low trialability level from farmers, as findings indicated that the majority (65 or 77.4%) of the respondents, if they failed to apply an innovation were not ready to return to the old technique unless they got guidance from an expert. The study findings also show that only 19 (22.6%) respondents indicated that, upon failing to introduce an innovation, they would be

sufficiently courageous to change the farming technique and return to the old technique or adopt a new technique without seeking guidance from an expert.

5.11.6.2 Observability

Observability findings, depicted in Figure 26, show that 72 (85.7%) respondents indicated that if they apply an innovation and fail, they will take time to observe the impact of an innovation introduced by seeking guidance from colleagues or an expert. These findings are consistent with those explained by the Diffusion of Innovations model, which indicates time to be crucial in the innovation-decision process individuals undergo in the adoption of an innovation. Time is a critical variable in adoption of innovations, as it enables an individual to acquire knowledge, develop an attitude, make a decision and use or reject a particular innovation (Rogers 2003:21). Twelve (14.3%) respondents were not ready to observe the impact of an applied innovation.

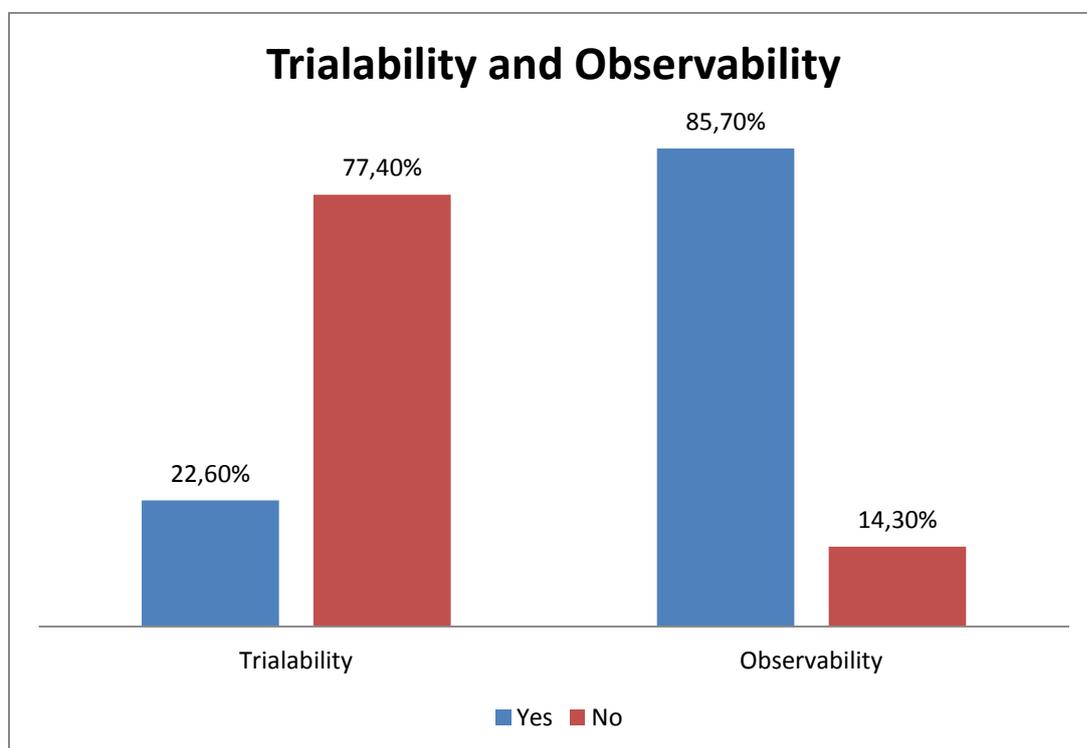


Figure 5.10: Trialability and Observability Attributes of Innovation

Findings show that 76 (90%) respondents who fail to apply an introduced innovation prefer to consult a source before trying again. These findings are consistent with those of Rogers (2003:258) and Agrawal (2008), who observed that trying out a new innovation in person enables an individual to minimise uncertainty about an innovation and expedite its adoption.

Only eight (10%) respondents were ready to repeat and observe the applied innovation without consulting an expert. Figure 5.24 elucidates the findings.

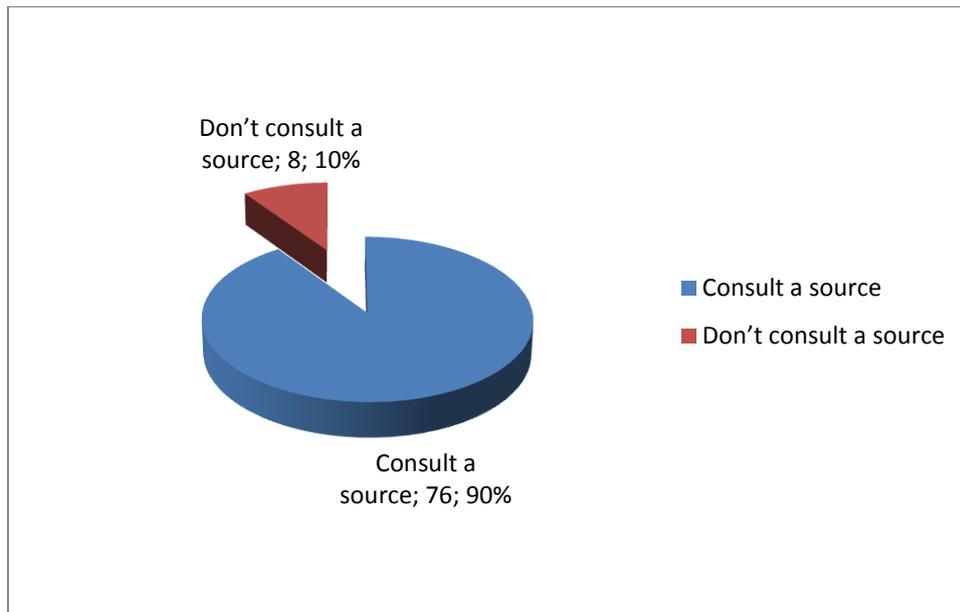


Figure 5.11: Farmers' Willingness to Consult a Source Prior to Repeating an Innovation

5.11.6.3 Complexity and Compatibility

Innovations and new technology introduced to farmers were measured to assess their level of complexity. Farmers were asked to compare their normal agricultural practices with the innovations they had received from CCAA experts (see questions f48 and f49 in Appendices 1 and 2). Findings from most farmers revealed that the innovations and new technology introduced to them were compatible. Results from the semi-structured interviews show that 21 (25.0%) respondents indicate that the innovations were very compatible and 51 (60.7%) said the innovations were compatible. The DOI model by Rogers explains that the more an innovation is considered consistent with the individuals' needs, past experience and present values the quicker it can be assimilated into a community (2003:240-241).

Only a few farmers found the introduced innovations to be neither compatible nor incompatible, while eight (9.5%) respondents found the innovations to be fairly compatible. The study findings could not identify any respondents with whom innovations were incompatible. Table 5.32 shows the results.

Table 5.22: Farmers' Perception of Innovations' Compatibility

Perception of innovations compatibility N=84	Frequency	Percentage
Very compatible	21	25.0
Compatible	51	60.7
Neutral	4	4.8
Fairly compatible	8	9.5
Total	84	100

With regard to the incompatibility of farm implements with the demands of the farmers' situations, the farmers' interviews revealed that despite their immense benefits, the newly introduced farm implements identified as the Magoye ripper and Spring hoe/(jembe), which are used for soil tillage, had disadvantages. The study revealed that the Magoye ripper takes too much time to cultivate a small area on a farm. The Spring jembe, which farmers use for deep soil tillage, appears to be heavy and requires much energy for cultivation. These results are consistent with Rogers' Diffusion of Innovations model, which indicates that individuals in a social system take more time to adopt an incompatible innovation which does not match the users' existing values and experiences (2003:15).

5.11.6.4 Relative Advantage

The study also found that the relative advantage as an attribute of innovations was implicitly measured through farmers' responses to the innovations received from the CCAA project. Section 5.6.1 of this chapter describes the usefulness of training which farmers had undergone. This section captures the Rogers' Diffusion of Innovation's relative advantage attribute. The section comprehensively indicates innovations that farmers have adopted in the course of training, showing that they are relatively better than the conventional farming methods. The Diffusion of Innovations model explains that users' perceptions of an innovation determine its adoption rate (2003:15).

5.12 Farmers' Access to, and Use of, Information on Climate Change and Variability

In this section, findings explain farmers' access to, and use of, climate change and variability information in Maluga and Chibelela villages. Section 5.12.1 identifies sources farmers use to access information on climate change and variability. Section 5.12.2 presents findings on

how farmers use Information on climate change and variability in practising agricultural activities.

5.12.1 Sources of Information Farmers Use to Access Information

Farmers were asked to state how they gained access to information on climate change and variability (cf. questions h56 and h57 in Appendices 1 and 2). Findings from the semi-structured interviews and focus group discussions show that farmers use radio, mobile phones, fliers, magazines, brochures and television as media for accessing information. However, the farmers predominantly use radio and mobile phones, rather than other media, to access this information. These findings confirm those of Ingram, Roncoli and Kirshen (2002), who observed that radio was preferred by the majority of farmers in Burkina Faso in disseminating forecast information. Rogers (2003: 205-206), in the DOI model, explains that mass media were effective in reaching a wider audience rapidly and were effective in creating knowledge. Findings from the FGDs indicate that, despite farmers indicating that they use radio and mobile phones to communicate information on climate change and variability, only a few accessed information from radio and television.

The in-depth interviews with agricultural extension officers also indicated that radio and mobile phones are the most used sourced by farmers. One extension officer stated “Farmers who have been trained seek more information on CCV from extension officers through mobile phones”.

The findings from interviews with farmers suggest that farmers mostly prefer, and depend on, direct and/or physically accessible interpersonal sources. Results, as explained in Section 5.40, show that farmers mostly depend on village leaders, influential and/or knowledgeable and/or trained people, village meetings and public gatherings in the village to access information on climate change and variability. The study found the reasons for preference of these sources by farmers to be easy access and the authoritativeness of information from the sources. These findings concur with those of Rogers (2003:205), who found users prefer interpersonal channels as they can seek clarification, feedback or secure more information about an innovation, compared to the mass media. Rogers adds that the interpersonal channels persuade an individual to change his or her attitude and adopt an innovation. Farmers also depend on researchers, NGOs, agricultural and extension officers and farmer-to-farmer sources for accessing information on climate change and variability.

Interviews with farmers and extension officers show that NGOs and research institutes, which farmers depend on to access information on climate change and variability in the Maluga and Chibelela villages, include World Vision Tanzania, Sustainable Environment Management Action (SEMA), International Crop Research in Semi-arid and Tropical (ICRISAT), HOPE and Rural Livelihood Development Company (RLDC).

Other institutions used by farmers include Small Enterprise Development Agency (SEDA), University of Dar es Salaam, Sokoine University of Agriculture, the District Council and Ilonga, Seliani and Hombolo research institutes. Information services disseminated through these sources include those related to sustainable agriculture, access to and use of hybrid seeds, education on and awareness of climate change and variability, food security, livestock keeping, entrepreneurship, forestation and crop and livestock diseases.

The study sought to discover how farmers perceived the extension officers' reliability as a source of information and knowledge for climate change and variability. Findings show that most respondents perceive extension officers to be unreliable. Thirty-eight (45.2%) respondents view extension officers as not reliable. Twenty-one (25.0%) found agricultural and extension officers to be least reliable.

The study ascertained that 18 (21.4%) respondents stated that extension officers were reliable, while four (4.8%) respondents indicated extension officers as being highly reliable in accessing information on climate change and variability. Only a few farmers (3 or 3.6%) were neutral, signifying that they perceive extension officers to be neither reliable nor unreliable. Figure 5.25 provides a summary of results.

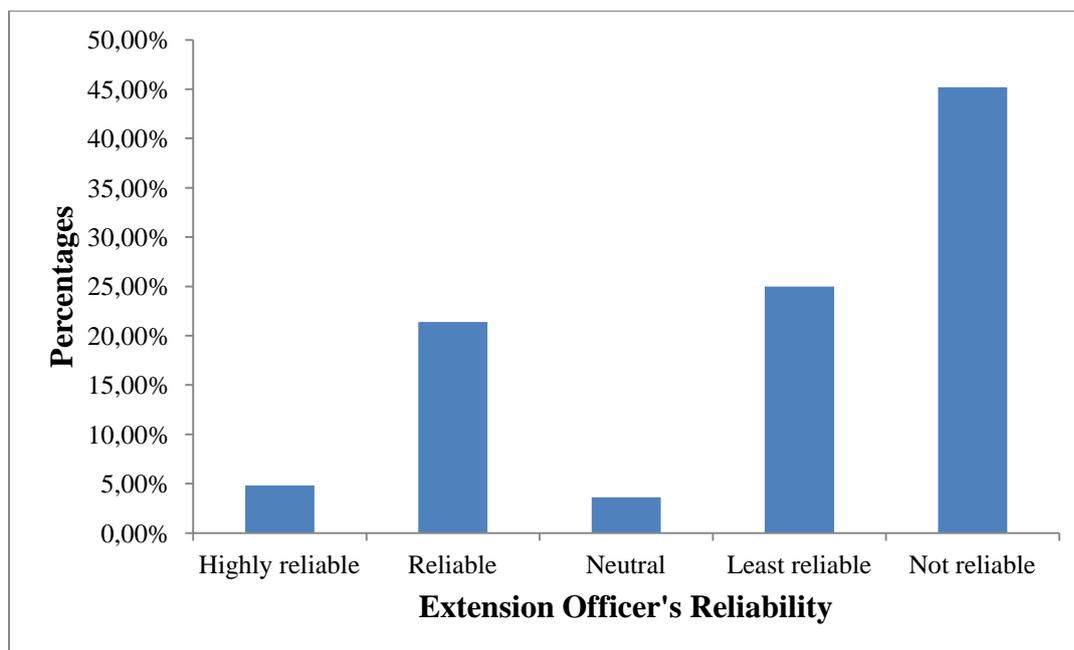


Figure 5.12: Reliability of Extension Officers for Farmers

Similar findings were noted from the focus group discussions which support the farmers' interview results. The findings indicate that extension officers are not reliable sources for providing information on climate change and variability to farmers, seemingly because farmers have limited access to them. Thus, despite their roles which are to develop a need for change, establish good rapport with users, diagnose problems and influence users' behaviour, the failure of these change agents to dedicate most of their time to contacting users has a negative impact on the adoption of an innovation (Rogers 2003: 369-373). Despite findings showing that farmers least rely on extension officers because of their unavailability, most farmers still find the content of information delivered by the extension officers to be reliable. These findings are supported by Diffusion of Innovations model, which shows that professional change agents such as extension officers are perceived as being credible and competent by farmers (Rogers 2003:385).

The study found that farmer groups are a fundamental source of information for farmers in accessing knowledge on climate change and variability. The study discovered that the presence of farmer groups in Maluga and Chibelela villages played a crucial role in improving farmers' livelihoods through transfer of knowledge (see questions c15, c16 and c17 in Appendices 1 and 2). The study by Munyua and Stilwell (2009), which observed the

critical roles of farmer groups in information transfer, exchange, adoption of an innovation and knowledge acquisition, that also supports these findings.

The existing farmer groups were Chiwona, Nazareti, Wazachi, Wapendanao, Uwazachi, Wapendanao, Tahadhari, Amkeni, Ushirika, Wajane, Zaeni matunda and Muungano in Chibelela village and Ufumbuzi in Maluga village. The study noted that farmer groups play a significant role in disseminating information, knowledge sharing and imparting technical skills to farmers. Farmer groups further contribute towards motivating change in farming practices, provided social assistance and enabled members to access loans and find markets.

Findings further indicate that farmer groups have been playing a crucial role in farmers' mitigation and adaptation to climate change and variability. It was learned that farmers use groups and networks to access and use information on improved seed varieties, drought-resistant crops and sharing farming experiences on best farming methods. Communication channels are said to be essential in the innovation-decision process in adoption, as they play a significant role in knowledge creation and change of individuals' attitude (Rogers 2003:205). Other roles played by farmer groups include access to, and use of, farm implements, timely knowledge-sharing on new farming techniques and providing awareness and education on the choice of type of crops to cultivate in a particular season to enhance agricultural production.

Despite farmers depending on various sources of information to enhance and update their knowledge on adaptation, the findings suggest that many farmers still believe in indigenous knowledge for weather prediction. The FGDs in the study villages revealed that, despite farmers accessing information on rainfall patterns and temperature variation through various sources, they still believe in local indicators, such as plant phenology, insects, animals, birds, the sun, stars and the wind as critical signs for forecasting rainfall onset, and as indicators of a good or bad year. Rogers (2003:254-255) explains that IK is, and has been, useful as new ideas/innovations emerge from, and build on, the existing experiences individuals possess.

5.12.2 Use of Information on Climate Change and Variability

Respondents were asked to explain if they were able to use the information and knowledge received from experts to adapt to climate change and variability. Findings indicate that information disseminated to farmers could be used for innovations introduced on climate change and variability to adapt to new farming methods. Results from semi-structured interviews show that 77 (91.7%) respondents were able to use new knowledge, while only 7

(8.3%) indicated not being able to use the new knowledge from experts. Figure 5.26 shows these findings.

These seven farmers sought to explain to the researcher that the factors contributing to poor utilisation of the new knowledge from agricultural experts were insufficient rain, financial constraints and their own advanced age.

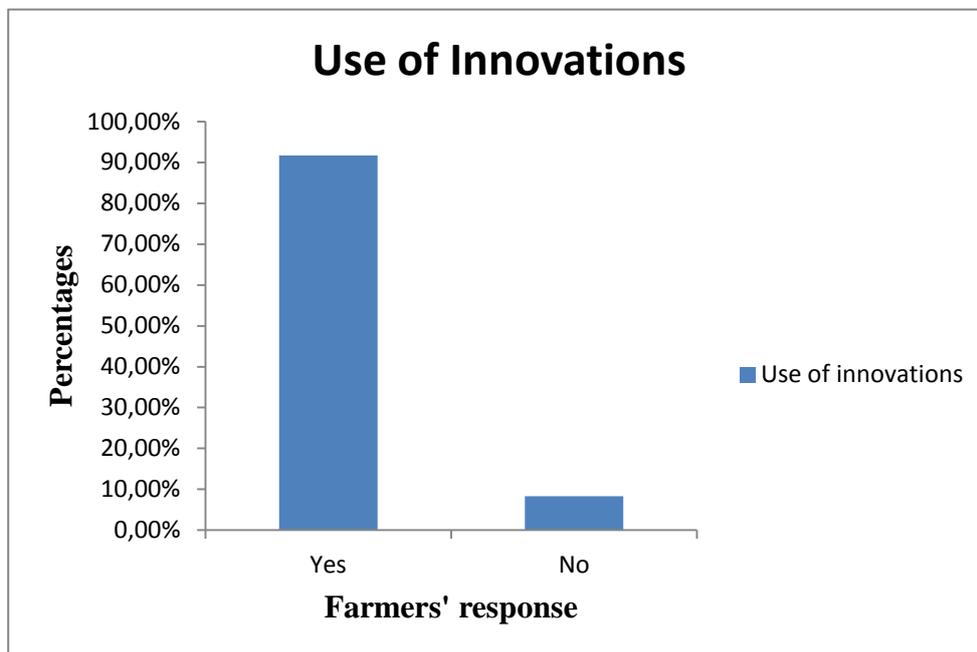


Figure 5.13: Farmers' Use of Innovations on Climate Change and Variability

Similar findings were observed when respondents were requested to rate how useful the disseminated innovations on climate change and variability were (cf. question h57 and h59 in Appendices 1 and 2). The findings from the semi-structured interviews from most (33 or 39.3%) respondents were that innovations received were very useful. Forty-three (51.2%) stated that the innovations were useful, while six (7.1%) said that the innovations were neither useful nor not useful. Only one (1.2%) respondent had indicated the innovations to be fairly useful and a further one (1.2%) respondent stated that the received innovations on climate change and variability were not useful. Refer to Table 5.33 for more details.

Table 5.23: Farmers’ Categories of Usefulness of Innovations on Climate Change and Variability

Level of usefulness of innovations N=84	Frequency	Percentage
Very useful	33	39.3
Useful	43	51.2
Neither useful nor not useful	6	7.1
Fairly useful	1	1.2
Not useful	1	1.2
Total	84	100

Findings show that information received on the use of the innovations was useful. More explicitly, findings from the semi-structured interview and focus group discussions content analysis indicate that most farmers have adapted by applying information on early farm preparation, choice of a crop to grow, use of early-maturity crops, drought-resistant crops and new scientific methods of planting such as space planting. Other adaptations include the use of rope, use of improved farm implements such as the Magoye ripper, plough and Spring hoe or jembe. The study found that farmers have adapted farm soil water conservation using tiered ridges, efficient use of land in cultivation, proper fertilizer usage and grain preservation. The adoption of innovations depends on the characteristic of innovations, as perceived by users (Rogers 2003:15). The more an innovation is perceived to have benefits, relative advantage and be compatible, the more users will tend to adopt the innovation.

According to the findings from the in-depth interviews with the two district agricultural extension officers, farmers have benefitted much from access to, and use of, information on adaptation to climate change and variability. The benefits include improved annual harvests, increases in food security at village level, choice of crops to plant in a season, increased usage of improved seeds and fertilizer. Other benefits include increased use of farm implements, access to information on plant diseases and knowledge concerning how to control grain-eating birds.

The in-depth interviews with the district agricultural extension officers indicate that both trained and untrained farmers make use of information disseminated on climate change and variability. From their observations, trained farmers have a much higher usage level of extension services unlike those who were not directly trained by experts or researchers. These research findings are in line with those of Rogers (2003), who found individuals' cosmopolitan outlook, also referred to as awareness, was crucial in access to and use of a communication source for adopting an innovation. They explained that trained farmers mostly seek consultation with experts more than farmers who did not receive direct training from agricultural experts/researchers. As explained in section 5.11 of this chapter, the study findings from the cross-tabulation of the semi-structured interviews in the two villages could not ascertain any significant variations in terms of the use of information dissemination on climate change and variability.

Findings from the in-depth interview with the programme manager indicated that there was a slight difference between adoption and use of information in the two study villages, with the results showing Chibelela village having adopted more than Maluga village. Different views were noted from the in-depth interviews with the agricultural extension officers in both villages. Findings from the agricultural extension officer in Chibelela indicated a slight adoption of information on adaptation to climate change and variability. The agricultural extension officer in Maluga indicated that the majority of farmers had adopted information on how to adapt to climate change and variability. The agricultural extension officer from Chibelela indicated that resource constraints were the major factor which prevents farmers from fully adopting innovations. These findings are in accordance with Rogers' diffusion model, which shows that wealth contributes to adoption of an innovation, as new innovations are costly and require a large initial capital outlay (Rogers 2003:288).

Despite information disseminated to farmers being useful, farmers still encountered barriers in their quest for knowledge acquisition and sharing for adapting to climate change and variability. More details of the factors which hamper effective access and usage of information disseminated to farmers will be described in section 5.13.

5.13 Factors Affecting Access to, and Use of, Information on Adaptation

Despite farmers accessing and using factors for the adoption of innovations, as indicated in section 5.12, there are still a number of challenges farmers face in meeting their information on climate change and variability needs to enhance their ability to adapt to climate change and variability. Farmers were asked to explain the barriers they encounter in getting access to, and using, information for adaptation to climate change and variability (cf. questions j74, j76). (See also questions i68 and i70 in Appendices 1 and 2.)

Content analysis results from semi-structured interviews and focus group discussions demonstrate a number of highly challenging factors affecting farmers' access to, and use of, information on climate change and variability. These are the inadequacies of the experts in disseminating information, improper co-ordination in collecting and storing weather forecasts at village and district levels, getting timely access to improved seeds, affording high seed prices and unreliable seasonal forecast information. With regard to unreliable seasonal forecast information, a farmer, DM, from Chibelela stated "... just to add on the weather forecasting, the Tanzania Meteorological Agency on September 2012 broadcasted through media that rainfall will commence on October but until end of November, we haven't seen rain".

Interviews with farmers further show that other factors affecting access to, and use of, information include income/wealth, poor and unreliable extension services, low level of literacy and inadequate knowledge of climate change and variability issues from both farmers and village/opinion leaders. It was revealed that opinion leaders misinform other farmers by feeding them with false information concerning government initiatives on adapting to climate change and variability.

The findings from FGDs indicated that climate change and variability through human activities, such as cutting of trees and deforestation, has affected farmers' access to, and use of, local indicators in predicting weather. Farmers recorded that they had recently observed trees being depleted at an alarming speed and the birds they have been using to forecast weather have disappeared.

Further barriers to access to, and use of, information on adaptation to climate change and variability outlined by farmers include cultural barriers (laggards, change in behaviour regarding change of crops, low risk level and ignorance), low level of education, inadequate

supply of seeds from seed banks and lack of information centres. The study found cultural barriers and ignorance to be critical factors affecting access to, and use of information on adaptation to climate change and variability. Findings from the interviews indicate that a lack of youth readiness to listen to radio broadcasts of agricultural issues acts as a barrier to their access to and use of, information for adaptation to climate change and variability. Results show that the youth prefer listening to other radio channels airing music and entertainment programmes. The study findings indicate that most young farmers are not willing to learn about agricultural innovations and dedicate most of their time to other economic activities. The Diffusion of Innovations model indicates that the norms and cultures of a society are critical social system components which affect diffusion of innovations (Rogers 2003:24).

The FGD findings and the semi-structured interviews with farmers ascertained that cheating on seed varieties and inadequate knowledge of stockists of agricultural inputs were serious threats to farmers' adaptation to climate change and variability. In this regard, farmers indicated that they fail to cope effectively with adaptation as a result of purchasing seed varieties not of their choice and buying expired agricultural products. Thus farmers fail to access and effectively use information on pesticides, seed varieties and fertilizer usage as a result of the inadequate knowledge of stockists. These findings are in line with those by Rogers (2003:24) and underscore the role of change agents such as extension officers, stockists and NGOs in influencing diffusion of innovations. The change agents may enhance or slow the adoption and diffusion, by failing to effectively assist farmers, thus leading to uncertainty in access and use of innovations (Rogers 2003:27).

Other factors mentioned by farmers affecting access to, and use of, information on adaptation to climate change and variability outlined by farmers include the following:

- inadequate education on the use of pesticides
- presence of a number of radio stations with entertaining programmes
- inappropriate broadcasting time of awareness programmes on radio
- inadequate government budget (accountability)
- lack of electricity, poor group leadership
- insufficient information on markets and the inadequate number of Agricultural Meteorological (AgroMet) stations at village/ward level.

These findings corroborate those by Agwu, Ekwueme and Anyanwu (2008); Agrawal (2008) and Mutekwa (2009), who observed that local institutions, limited access to information on climate change and inappropriate broadcasting time affected farmers' access to, and use of, information in performing their agricultural activities.

Results from the in-depth interviews with the agricultural extension officers indicated a number of other challenging issues which impinge low usage of information on adaptation to climate change and variability. The extension officers stated:

E2: "One challenge which ought to be addressed to enable farmers cope with climate change and variability is lack of information on marketing production and productivity and value addition to agricultural products".

E2: "... another challenge we face from farmers is their perception and belief that local sorghum and maize varieties are delicious and resistant to pests and diseases".

E1: "The majority of farmers we serve have not yet accepted using industrial fertilizers. Some believe the industrial fertilizers destroy their crops, while others perceive access to the fertilizers to be a major constraint".

E2: "Most farmers prefer less use of inorganic fertilizer as they believe it destroys the soil and reduces fertility".

E1: "Government's inadequate financial support in the agriculture is one of the major factor impeding access to and use of information by farmers as it affects our service provision to farmers".

E1: "We need more feedback and updates on climate change and variability at the district level".

With regard to farmers' change in farming behaviour, the agricultural extension officers' interviews show that farmers experience difficulties in shifting from cultivating crops they are used to and adopting new crops. One of the extension officers stated:

E2: "One of the challenges we as extension officers face nowadays in advocating coping strategies in this varying climate is changing farmers farming behaviour". Farmers become skeptical in shifting from growing the crops they have been cultivating such as maize or

groundnuts to adopting a new crop such as mangoes”. These findings are in line with those by Agrawal (2008:4), who found that for adaptation to be effective farmers should be given time for trialability, social learning and observing mistakes.

E2: “...farmers’ exposure is still a problem to many farmers as many haven’t witnessed ways of adapting to climate change and variability from other people”.

Findings from the interview with the extension officers show that in the course of service provision to farmers, they observe low participation when farmers are called upon to try new innovations. These results corroborate those of Rogers (2003:26), who observed that diffusion of innovations is influenced by both the individuals’ characteristics and the nature of the social system representing the individual. The extension officers comments were:

E1: “When we introduce new farming methods, most farmers tend to ignore the introduced research-based innovations and continue with their daily activities”.

E2: “Farmers are used to the culture of receiving subsidised agricultural inputs from the government and most farmers have not changed their behaviours, they prefer free agricultural inputs for their farming practices”.

The study sought to investigate heterophily which, in diffusion of innovations, refers to the difference in the level of education, social status or belief (s) between farmers and experts involved in disseminating information on climate change and variability (see questions j76 and j78 in Appendices 1 and 2). Specifically, the study findings inquired to see if heterophily could hamper farmers’ ability to access and use information, as described by Rogers’ Diffusion of Innovations theoretical framework. The semi-structured interviews revealed that 54 (64.3%) respondents were certain that heterophily between them and experts was not a factor which hampered their access to information on climate change and variability. Conversely, findings indicated that 30 (35.7%) respondents thought that heterophily contributed positively as a barrier towards accessing and using information on climate change and variability. These findings are consistent with Rogers (2003:305) Diffusion of Innovations model, which explains that exchange of information and human communication occurs between people who are alike also known as homophilous.

This study further argues that with regard to heterophily, the fundamental factor indicated by farmers as contributing to their inability to access and use information on climate change and

variability was low level of education. Farmers stated that the low level of education affected their ability to contextualise disseminated information on innovations from experts. However, the study revealed that farmers' negative perceptions on researchers could be a negative contributing factor in access to, and use of, information on climate change and variability. Farmers tend to believe that most researchers conduct research based on their need and not aimed at improving farmers' welfare. These findings are supported by the Diffusion of Innovations model, which found that attitudes and beliefs are crucial in determining the diffusion on an innovation by farmers (Rogers 2003:171).

The study inquired from farmers what the major barriers to adaptation to climate change and variability are apart from barriers related to access and use of information. The semi-structured interviews showed that farmers believe adaptation to climate change and variability is being slowed down by lack of timely access to, and use of, seed, lack of adequate financial resources to buy farm inputs, low levels of literacy, absence of water reservoirs, meagre extension services, inadequate local government services and accountability in implementing government policies. These findings are consistent with the variables described by the Sustainable Livelihoods Framework (SLF), which explains the role of policies, the government, institutions, financial capital, human capital, social capital, natural capital and physical capital in the adaptation of farmers (Carney, Drinkwater, Rusinow, Neefjes, Wanmali and Singh 1999).

The study found other barriers to farmers' adaptation that included lack of seasonal rainfall information, information about the types of birds which eat sorghum, low levels of education, poor access to markets, inadequate information on markets and high loan interest and inadequate budgets. Other barriers include the low number of extension officers, a bureaucratic government financial system and cultural barriers (laggards, change in behaviour on change of crops, low risk level, ignorance). These results align well with those by Carney *et al.* (1999) in the SLF model and Rogers (2003) DOI model, which explain financial capital, human capital, government's service provision, institutions, culture, knowledge, decision-making and inadequate information access, in adoption to innovations and adaptation to climate change and variability.

5.14 Summary

This chapter analysed and presented the findings of the study. It presented the research questions, methodology used, demographic variables and described the goal of the CCAA project, pinpointing its usefulness to farmers. The study further presented and described types of information on climate change and variability disseminated to farmers and discussed how information is being repackaged and disseminated to farmers.

The chapter presented knowledge on adaptation to climate change and variability by farmers, stressing farmers' awareness, indigenous knowledge possessed by farmers and means to preserve the IK concerning weather prediction.

The chapter then highlights global and national initiatives on mitigating effects of climate change and variability and present methods farmers use to mitigate effects of climate change and variability. The chapter describes farmers' attitudes and perceptions of climate change and variability. The findings illustrate the farmers' attitudes and perceptions of climate change and variability, using rainfall, temperature, wind, drought and food security as local indicators. The chapter presents the farmers' levels of preparedness for drought and floods.

The chapter presents findings on farmers' adoption of information on climate change and variability. The findings highlight farmers' types of adoption, rate of adoption and attributes of the adoption of innovations. The chapter also presents findings on farmers' access to, and use of, information by showing the sources farmers use and how they use information to adapt to climate change and variability. The chapter indicates factors which affect farmers' access to, and use of, information for adaptation to climate change and variability.

The chapter provides critical perspectives on access and use of climate change and variability information from the farmers, the CCAA programme manager and the extension officers. Chapter Six discusses the study findings.

CHAPTER SIX

DISCUSSION AND INTERPRETATION OF FINDINGS

6.1 Introduction

This chapter discusses and interprets the findings as presented in Chapter Five, using the literature analysed in Chapter Three. The section sub-themes were organised from research questions and data collection questions. The sections and sub-sections in this chapter that includes section 6.1, which introduces the chapter. Section 6.2 discusses the Climate Change Adaptation in Africa's goals of disseminating information to farmers on climate change and variability. Sub-section 6.2.1 discusses the role of access to information in reducing farmers' vulnerability. Sub-section 6.2.2 discusses the role of attitude in enhancing the use of Innovations. Sub-section 6.2.3 describes the role of needs assessment in adoption of innovations. Sub-section 6.2.4 discusses on the attributes affecting farmers' access to and use of information. Sub-section 6.2.5 explains the project constraints. Section 6.3 discusses farmers' training on impacts of climate change and variability. Section 6.4 covers types of information on climate change and variability disseminated to farmers. Section 6.5 deals with the specific channels employed in disseminating information on climate change and variability.

Section 6.6 discusses the methods applied by farmers to mitigate the effects of climate change and variability. Sub-section 6.6.1 focuses on ways of mitigating the Impacts of climate change and variability to improve food security. Section 6.7 discusses farmers' awareness and knowledge related to mitigating climate change and variability. Sub-section 6.7.1 explains farmers' awareness of climate change and variability. Sub-section 6.7.2 discusses farmers' knowledge of mitigating climate change and variability.

Sub-section 6.7.2.1 gives an overview of scientific and indigenous knowledge on adaptation. Sub-section 6.7.2.2 discusses the scientific knowledge used in mitigating and adapting to climate change and variability. Sub-section 6.7.2.3 discusses indigenous knowledge used for mitigating and adapting to climate change and variability. Section 6.8 gives an overview of farmers' level of adoption of information on adaptation to climate change and variability. Sub-section 6.8.1 discusses farmers' level of adoption and farm decision making for adaptation to climate change and variability. Sub-section 6.8.2 discusses factors influencing farmer's adoption of innovations for adaptation to climate change and variability.

Section 6.9 discusses access to, and use of, information on climate change and variability; sub-section 6.9.1 deals with farmers' level of access to information on climate change and variability. Sub-section 6.9.2 the dissemination and use of information on climate change and variability by farmers. Sub-section 6.9.2.1 the factors enhancing farmers' uptake of information on climate change and variability. Sub-section 6.9.3 discusses the role of packaging in access to, and use of, information on climate change and variability.

Other sections discussed and interpreted in this chapter include section 6.10 focuses on farmers' attitudes to and perceptions of climate change and variability; sub section 6.10.1 is on factors which influence farmers' attitudes and perceptions of climate change and variability adaptation; section 6.11 discusses limiting factors affecting access to, and use of, information on adaptation to climate change and variability by farmers. Finally, section 6.12 provides a summary of the chapter discussing and interpreting the findings.

6.2 Climate Change Adaptation in Africa's Goals of Disseminating Information to Farmers

The major aim of disseminating information on climate change and variability to farmers is to ensure maximum yield from their farming activities and to improve their livelihoods. Rogers (2003) explains the need to expose farmers to innovations. Most of the time farmers, as information users, are not aware of the existing information and its associated benefits. In this regard, the role of information disseminators is crucial in ensuring farmers' access and use of innovations.

The CCAA programme manager was asked to explain the goals of the dissemination of information on climate change and variability to farmers (cf. question b5 in Appendix 4). Chapter Five, section 5.4, shows that the goals of Climate Change Adaptation in Africa (CCAA) extension project to farmers were to:

- 1) build capacity in farmers, in their organisations and the private sector, to enable them to improve agricultural innovation systems in both the favoured and unfavoured agro-ecological areas of Tanzania and Malawi
- 2) reinforce farmers' ability to access and use quality information through training in order to improve their agricultural produce

3) involve public and private sector stakeholders in developing an efficient agricultural innovation system

4) enable farmers' learning and sharing of experiences for enhanced strategies to uplift individuals, organisations and systems capacity within the agricultural innovation systems.

The findings indicated that, despite challenges, most of the project's goals and intended innovations for farmers had been met. It was established that farmers' decisions to select and use the innovations of their choice might have been attributed to their positive attitudes to, and observed benefits of the innovations which they had introduced. In seeking to stimulate diffusion and the adoption of innovations to farmers, Rogers (2003) emphasises the importance of awareness of the role of relative advantage, compatibility, trialability, observability and complexity. In this regard, farmers use the disseminated information effectively based on their positive attitudes and the expected benefits of that innovation to their livelihoods. The more annual returns they receive, the less complex an innovation is, the more an innovation can be tried and observed over time, the more compatible it is with users and the more it can be adopted in a community.

6.2.1 Access to Information and Farmers' Vulnerability

The major goal of CCAA's information dissemination to farmers was reducing their vulnerability to climate change and variability. From the research findings, it appears that farmers' vulnerability was reduced. Farmers' willingness to use the knowledge received lessened their vulnerability. The study findings indicate that farmers had changed their farming practices as a result of training from CCAA experts. Supporting the role of information on climate in mitigating the effects of harsh climate conditions, Tumbo, Mbilinyi, Rwehumbiza and Mutabazi (2010) claimed that access to climate and weather information has the potential to reduce the vulnerability of resource-limited farmers. Ayers and Huq (2009) explained what the goal of information disseminated to farmers is, not only stating that farmers are vulnerable to climate change and variability, but rather identifying and addressing the causes of vulnerability by sharing experiences at local and national levels with them.

Increased annual crop production was another goal of disseminating information on climate change and variability to farmers. Adejuwon, Odekunle and Omotayo (2008:167) observed that farmers' prior knowledge of information on climate change and variability included the

timing of farm activities such as planting, tilling, land preparation, transplanting, thinning, weeding, irrigation and harvesting. Other benefits identified by the authors include application of pesticides and fertilizer, the type of innovation to adopt, the decision to adopt an innovation such as water conservation practices, and the choice of crops and crop varieties. Supporting the role of disseminated information in increasing annual crop production, Rao and Okwach (2005) found that the information on climate change and variability, which indicated rainfall quantity and distribution, disseminated to farmers, enhanced their choice of appropriate varieties, adjusting of cropping practices and looking for ways to minimise losses or maximise benefits and generally regulate their cultivation practices. These findings are confirmed by the Diffusion of Innovations (DOI) model, which stresses the role of information dissemination in determining farmers' knowledge and adoption of innovations (Rogers 2003). However, timely access to information promotes farmers adaptation by enabling them to make clear decisions on farming matters. Farmers' ability to make the right decision improves annual crop production and enhances their adaptation capacity.

6.2.2 The Role of Attitude in Enhancing Use of Innovations

Farmers' change of attitude was one of the central goals of information disseminated on climate change and variability. The study learned that in the study villages, attitude contributed to farmers' adoption of new farming practices related to adaptation. Dhaka, Chayal and Poonia's (2010) study of farmers in India used structured interviews and found that attitude to climate change and variability changed the farmers' agricultural management practices. The Indian study findings agree with those in the Diffusion of Innovations model, which recognises the role of attitude as an important factor in an innovation-decision process in the adoption of innovations (Rogers 2003:174-175).

Change of farmers' attitudes was highlighted in Nigeria by Adejuwon, Odekunle and Omotayo (2008:175), who highlighted the role of the effective communication of information on climate change and variability, taking into account people's perception and knowledge in ensuring information is used by farmers. Change of farming practices by farmers as a result of their exposure to such practices and to communication about them was noted by Dhaka, Chayal and Poonia (2010). Despite these findings (see Sections 5.4 and 5.7) indicating that farmers have changed their farming attitudes and strategies regarding new farming methods and practices, there are several factors which have been observed to contribute to farmers'

low pace of adoption, or failure to adopt information from information disseminators. These factors are discussed in subsequent sections 6.7.1, 6.8.2 and 6.10.1 of this chapter.

6.2.3 Role of Needs Assessment in Adoption of Innovations

Worth noting in this study is the need to assess farmers' requirements and overcome the barriers that might hinder their use of the information on climate change and variability. The Diffusion of Innovations (DOI) model underscores the point that, for effective adoption change, agents should inquire about users' needs and make sure that they are compatible with the needs of the programme (Rogers 2003:375). The study findings indicate that, despite the apparent usefulness of the information disseminated to farmers by extension officers, farmers expressed their most pressing need as timely access to information about the season's rainfall, the rainfall distribution, new seed varieties, proper use of fertilizer, both organic and inorganic, crop diseases, proper use of pesticides and types of crops to grow in a particular season. These findings concur those of Kadi, Njau, Mwikya and Kanga (2011), who observed the critical role of assessing farmers' needs in enhancing more speedy adoption of innovations in East Africa.

Findings depicted in Chapter Five, section 5.8, noted that only a few farmers articulated a need for information on soil characteristics, irrigation farming, pesticides and grain preservation (cf. questions g50 and g51). These findings confirm those by Mutekwa (2009) in Zimbabwe, who found that, despite farmers receiving information from extension officers and NGOs, few farmers were applying soil and water harvesting strategies. The fact that few farmers responded to requests for information about the need for such information might have contributed to an inadequate needs assessment and information being disseminated to them. Laizer (1999) explains that, despite vast research and information on agriculture being available, few farmers have access to it in a manner that leads to adoption, which suggests a gap in communication between researchers and farmers, including with regard to effective needs assessment. The other reason for low preference of the innovations might be high cost, inadequate knowledge and low levels of exposure to the benefits of irrigation farming, soil conservation farming and use of pesticides. Yanda and Mubaya (2011) reason that governments in most African countries should invest more in agriculture and build capacity in people and institutions to reduce the effects of climate change and variability.

6.2.4 Attributes Affecting Farmers' Access to and Use of Information

Access to, and use of, information aimed at improving farmers' crop production is crucial in ensuring that farmers adopt an innovation. Rogers (2003:204-205) viewed access to communication sources and channels as crucial in enhancing the usage of innovations. These arguments align well with those by Adejuwon, Odekunle and Omotayo (2008), who state that the use of information on climate change and variability depends highly on how weather forecast information is communicated. However, information communicated by senders is one aspect. The ability of senders to convince receivers about an innovation and receivers' perceived need for information plays a great role in accessing and using of disseminated information. Notwithstanding this notion, findings in Chapter Five, section 5.8, indicate that farmers experienced difficulties in timely access to weather information, accessing and purchasing agricultural inputs, such as new seed varieties and pesticides, from the service providers. Adejuwon, Odekunle and Omotayo (2008:174) noted that farmers were not receiving weather-related information from potential sources.

In spite of farmers' access to reliable and timely information during the CCAA project, the study found that access to timely, accurate and more general weather information to farmers was a problem. This was attributed to poor forecasts by climate change and variability prediction models that were used by the governments' meteorological office. In Zimbabwe, Mutekwa (2009) feels that the uncertainty about and failure to precisely forecast weather by these models has been a major factor in not facilitating farmers' use of information on climate change and variability. Mutekwa found that the inaccuracy of weather information caused agricultural extension officers and NGO staff to be hesitant in educating farmers with regard to changes in current climatic conditions and the predicted situation in the future. They attributed their hesitancy to uncertainty about the knowledge that was available and models for predicting the changes and impact at local levels. These findings concur with those of Adejuwon, Odekunle and Omotayo (2008:174), who stress that the forecasting tools currently in use predict at regional and general levels and fail to predict at local levels. This failure is being attributed to interzonal variability and poor spatial scales.

The other major factor contributing to only partially attaining the desired goals in terms of farmers' adoption of innovations in the villages could be limited project resources and funds. Limited funds were a constraint for both experts and extension officers in their efforts to communicate frequently with farmers. The current study noted that extension services were

inadequate in terms of contributing to farmers' accessing and using agricultural inputs such as new seed varieties and pesticides from the service providers (see section 5.13 of Chapter Five) (cf. questions j74, j76). Findings of the present study also show that 45.2% of farmers perceived extension services to be unreliable (see section 5.12.1) (cf. questions h62 and h64 in Appendices 1 and 2). This perceived inadequacy might have affected the project's ability to fully achieve its goals. This finding indicates an extension service problem, which results in limited knowledge of how to access and use farm inputs by farmers. A study by Rees, Momanyi, Wekundah, Ndungu, Odondi, Oyure, Andima, Kamau, Ndubi, Musembi, Mwaura and Joldersma (2000) in Kenya revealed that farmers were not satisfied with the extension services that were provided. Similar findings were noted by Sturges and Chimseu (1996a) in Malawi, who noted that farmers observed a slow or poor response to technical requests from extension officers, especially on initiatives which needed information back-up.

The current study's findings indicated that both farmers and extension officers expressed dissatisfaction with the quality of extension services being offered after the completion of the project (refer to Chapter Five section 5.13) (cf. question f31 and f34 in Appendix 4). The dissatisfaction might have been attributed to limited funds and human resources to meet farmers' needs adequately. Dissatisfaction was not expressed by farmers only, but also by the extension personnel, who indicated that they had inadequate interactions with farmers. Various scholars, such as Mutekwa (2009) and Kadi, Njau, Mwikya and Kamga (2011), conducted research on farmers' climate change and variability in Zimbabwe and East Africa, respectively. Mutekwa's study targeted respondents similar to those from the present study, namely farmers, extension officers and project officers. The study adopted interviews and administered questionnaires to seek views from farmers. Kadi, Njau, Mwikya and Kamga (2011) used questionnaires, interviews, consultations and website searches as data collection methods. These authors noted that inadequate extension services and limited farmers' exposure to research outputs from experts had contributed to inadequate service delivery to farmers. However, the difference between these studies and this study is that it has adopted more qualitative methods to collect data, unlike those of Mutekwa (2009) and Kadi, Njau, Mwikya and Kamga (2011).

The inadequate services encountered in the present study included lack of transport, inadequate information materials to farmers, as well as farmers' lack of interest and commitment and ignoring of experts' information. Inadequate government budgets and poor

infrastructure were other reasons stated by Sturges and Chimseu (1996a) and Rees *et al.* (2000). The factors contributing to dissatisfaction, as explained previously, are captured well in the Sustainable Livelihood Frameworks (SLF) (Carney, Drinkwater, Rusinow, Neefjes, Wanmali, and Singh 1999). The SLF describes human capital, financial capital and physical capital to be strong determinants of adaptation to climate change and variability (Carney *et al.* 1999). The SLF was discussed in Chapter Two of this study.

Despite the resource constraints, the current study noted farmers' readiness to participate in the project training, which positively affected the project fully achieving its goals. These findings agree with those in the DOI model, which emphasises individuals' attributes influencing the adoption of innovations (Rogers 2003). In Malawi, Mchombu (2002) found that farmers failed to apply extension knowledge as they could not communicate their farming needs to the extension system. Sturges and Chimseu (1996a) found that farmers' capability and readiness contributed to their adoption of the innovations targeted at them. These authors further reason that farmers shunned contact with experts and that this hindered information provision to farmers. Nevertheless, Rogers (2003) contends that farmers should be trained to become information-seekers and should not depend solely on receiving information from extension officers, but should rather develop social behaviour towards seeking information whenever they are in need.

The knowledge gap was another barrier which might have contributed to slowing down the scaling-up of climate change and variability innovations to farmers (refer section 5.8.1 of Chapter Five). Despite farmers receiving training from the CCAA project, few farmers could understand climate change and variability and how it affected their farming practices. Most farmers failed to associate the new knowledge received with climate change and variability. This view has been supported by Yanda and Mubaya (2011:118), who observed that knowledge gaps in adaptation and barriers to information and knowledge flow influence peoples' ability to adapt to climate change and variability in East Africa. These authors learned that limited understanding of climate change and variability issues can be highly attributed to farmers lacking relevant information and knowledge to make informed adaptation decisions.

Inadequate knowledge and understanding of climate change and variability formed negative attitudes and created skepticism in users of information. This study argues that, despite

extension officers' quest to impart new knowledge on climate change and variability to farmers, the farmers' inadequate knowledge of climate change and variability and the available adaptation strategies affected their knowledge acquisition. Mutekwa (2009) observed that a lack of understanding of information disseminated on climate change and variability in Zimbabwe, by farmers and extension officers, was a barrier towards farmers attaining the desired goals from the extension officers. Supporting the perception of an extant knowledge gap, Adejuwon, Odekunle and Omotayo (2008:174) explained that, despite extension personnel in Nigeria advising farmers about the timing of farming activities, the advice came from extension officers' existing climate knowledge of the area and not from meteorological services. Thus, despite current study findings showing that farmers were aware of climate change and variability, their knowledge and understanding of climate change and variability issues was limited.

One of the goals of the recent Kilimo Kwanza government initiative (URT 2009a) and the most recent climate change and variability projects such as CCAA project, was ensuring collaboration between government and the private sector in raising awareness and introducing innovations aimed at reducing the effects of climate change to farmers. Despite these initiatives, the study found weak collaboration and communication between farmers, extension officers, researchers and the private sector. The weak collaboration and communication between these agricultural stakeholders might have resulted from poor communication habits and practices among them. Strong collaboration depends on frequent communication among members involved. It also depends on users' perceive need of the collaboration. The other reason might be farmers having access to, and using, farm inputs which had expired. Despite farmers being the targets of disseminated information and being sensitised to use a variety of farm inputs, they were skeptical about using them, due to the previously observed bad experiences of other farmers. The barriers to farmers' access to and use of information on climate change and variability are discussed in section 6.11.

6.2.5 Project Constraints

Farmers' resource constraints might have been among the main reasons for the project to partly meet its goals. Despite farmers being provided with improved agricultural implements and weather equipment, findings from the extension officers showed that inadequate resources of farmers contributed largely to limiting the project's achievements (refer to Chapter Five section 5.11). Resource constraints undermined farmers' ability to acquire land,

purchase agricultural inputs and increase cultivation. This observation was also noted by Mukhala and Chavula (2007) and Yanda and Mubaya (2011). These authors found that the majority of rural farmers in developing countries were resource-poor farmers who had low incomes, limited adaptive capacity and relied on climate-sensitive sectors. In supporting this evidence of resource constraints, Salinger, Sivakumar and Motha (2005), and Sivakumar, Mannava, Motha (2007) found that high prices and the inaccessibility of farm inputs and implements largely affected farmers' adaptation to climate change and variability in developing countries. Despite resources being a major constraint to most farmers in Africa, Mukhala and Chavula (2007), noted that resource-poor farmers in sub-Saharan Africa were not aware of the accessibility of information which could be used to make farm decisions. In turn, access to, and use of, innovations can improve household food security levels (Gundu 2009).

The findings of this study indicated that the management of farm implements and weather equipment was observed to be among the factors which worked against the goals of the CCAA project of ensuring farmers adapt to climate change and variability (refer Chapter Five, section 5.13). Findings indicated in Chapter Five, section 5.4, showed that farmers had been supplied with new farm implements and weather forecasting equipment in the two study villages. It was found that the weather measuring tools were stored in a room which could not be accessed conveniently. Even when the people who were assigned the equipment could access the room, the people commissioned to take daily data from the weather instruments did not do so on a daily basis as required. Farmers expressed feelings of discouragement regarding the collection and sending of daily weather data, as they did not receive adequate support from the district extension office. These findings confirm those by Carney *et al.* (1999) and Agrawal (2008), who stress the fundamental role of strong institutions, laws, policies, culture and government support in adaptation to climate change and variability.

Use of the farm implements which had been bought by the CCAA project for the farmers to enhance their adaptation capacities seemed to cause many misunderstandings among farmers. Farmers who were assigned the farm implements misused their handling roles, such as using the CCAA project equipment for their own use. As a result, the study ascertained the presence of misunderstandings resulting from the poor management of resources in the farmer groups. This misunderstanding caused grievances and threatened the sustainability of farmer groups. In this regard, farmers' proper management and use of farm implements is

needed urgently if efforts to reduce adverse impacts of climate change and variability are to succeed. Despite the SLF emphasising the mutual role of private and government sectors in adaptation, a well developed institutional framework, as explained by Agrawal (2008), would have reduced the misunderstandings at local level.

Scaling-up the innovations to a wider community is believed by Lutkam, Shetto, Mahoo and Hatibu (2005), Shetto (2008) and Linn (2012) to be one of the best strategies to disseminate new ideas to farmers in rural areas. Effective design of measures for scaling-up agricultural innovations can contribute to reducing the impact of climate change and variability. However, despite the majority of farmers indicating that they had acquired new knowledge through training, the beneficial effect of the training was mainly noticed in only a few farmers in the study villages. The main reason for the failure to scale-up the innovations to other villages was inadequate funds. Funds were observed by the project manager to be a major challenge in adoption of innovations in attaining expected goals on information disseminated to farmers (refer to Chapter Five section 5.3). These findings confirm those by Tarhule (2007), who stressed that most African countries have inadequate resources and technical expertise to facilitate climate and environmental research. Tarhule further suggests that to enhance their adaptation capabilities, African countries should design innovative plans which make use of existing findings from climate research.

6.3 Training Farmers on the Impacts of Climate Change and Variability

Trained and untrained farmers were asked, respectively, if they were willing to learn from innovations each had received and share them with others (see question h59 and h61 in Appendices 1 and 2). Findings, as given in Chapter Five, section 5.5.6, showed that both trained and untrained farmers were willing to participate in and learn innovations on adaptation to climate change and variability through the CCAA project. Findings from the 50 trained farmers indicated that 30.0% of respondents were highly willing to learn innovations, 46.0% were willing to learn innovations and only 2.0% were not willing to learn innovations. In addition, findings from untrained farmers indicated that as few as 14.0% of respondents were fairly willing to learn, while 8.0% of respondents indicated that they were not willing to learn new knowledge on farming for adaptation to climate change and variability.

The study results from the 34 untrained farmers showed that 32.4% of respondents indicated trained farmers were highly willing to share new information, 44.1% were willing while only

5.9% indicated that trained farmers were not willing to share new knowledge with untrained farmers on adaptation to climate change and variability. A few (8.8%) of the respondents indicated that trained farmers were fairly willing to share new information with them, but 8.8% of the trained farmers stated that they were not willing to share new information with untrained farmers.

These findings confirm those by Sturges and Chimseu (1996a), who stressed the critical role played by farmers' willingness and ability in the diffusion and adoption of innovations. Sturges and Chimseu's study (1996a) was conducted in rural areas of Malawi and applied only qualitative methods such as interviews, observations and group discussions in collecting data. The study had three types of respondents, who were information providers, intermediaries and information users. The current research study differs from that of Sturges and Chimseu mostly in terms of the study population and partly in methodology. The Sturges and Chimseu study adopted more qualitative methods, but also used quantitative methods. It had three categories of respondents, as did the present study. Yanda and Mubaya (2011:138) observed that farmers' participation in training sessions had a positive influence on their choice of adaptation strategies. Ngigi (2009) also supported the notion of inviting participation by potential users prior to initiating a project, as it facilitates their involvement and the sustainability of the intended project.

The fundamental role of training has been described by the Rogers' Diffusion of Innovations' model, which explains that the attributes of an innovation such as observability, complexity, compatibility, trialability and relative advantage are critical in enhancing adoption (Rogers 2003). Elaborating on the role of training farmers, Rogers cautions that "most farmers tend to evaluate innovations not based on the scientific research by experts, but rather their fellows who have adopted the innovation" (2003:36). Nevertheless, farmer training and education does not necessarily prompt adoption, but creates community awareness and knowledge which could be applied by farmers in the future to cope and adapt to climate change and variability. The way farmers perceive the usefulness of training by innovators contributes to a great extent to how they adopt innovations.

The sharing of innovative information by farmers enables knowledge dissemination in the community. Even though the current study results indicated that both trained and untrained farmers were willing to share information on best farming practices, most trained farmers

were understandably more rigorous in seeking consultations with experts rather than with untrained peers. These results are supported by those of Rogers (2003:170) in the Diffusion of Innovations model, which shows that the characteristics of the decision-making unit, such as communication behaviour, influence one's ability to acquire new knowledge. According to the DOI, earlier adopters who, in this study are trained farmers, have been observed to have higher communication behaviour and personality attributes than later adopters. These innovation characteristics enabled trained farmers, who are innovators, to influence changes by untrained farmers, who are later adopters (Rogers 2003:289-290).

Despite the study not establishing any significant difference in the adoption of new knowledge between trained and untrained farmers (refer to section 5.11) (cf. questions d20 and e25 in Appendices 3 and 4), the study results confirmed that farmers' training held an important role in imparting skills to farmers to enhance adoption. These findings confirm those by Mukhala and Chavula (2007:44), who observed that in most southern African countries, farmers' training and awareness activities were highly needed, as most farmers who were deprived of resources were not aware of the available information on climate change and variability that could be used in farm decision-making. Farmers' access to relevant knowledge, their ability to observe how innovations can be effectively applied by their fellows and how they perceive the benefits of the innovations can promote the diffusion of innovations to farmers. The fundamental role of farmers' training was highlighted by Sivakumar and Hansen (2007:74) and Yanda and Mubaya (2011:119-120), who showed that appropriate training of users is important in reducing the communication barriers and gaps between information providers and users.

Understanding innovations as a result of training is a step towards knowledge application. The study established that most farmers understood and could apply new knowledge after receiving training from CCAA experts. The mode of farmers' training through farmer field schools and farmer learning groups demonstrates the effectiveness of using interpersonal communication channels and farmer groups in disseminating innovations. Shetto (2008) observed that farmers' adoption of rainwater harvesting technology in Tanzania was enhanced by the use of interpersonal sources. Use of proper existing institutional structures such as farmer groups and local non-governmental organisations as effective dissemination channels was emphasised by Garforth (1998). Garforth's study found that the use of interpersonal channels is effective in changing farmers' perceptions towards an innovation.

This finding confirms that of the Diffusion of Innovations model, which stresses the importance of using interpersonal communication channels in disseminating information and the adoption of innovations (Rogers 2003).

6.4 Types of Information on Climate Change and Variability Disseminated to Farmers

Farmers were asked to explain the type of information on climate change disseminated to them (cf. questions g49 and g50 in Appendices 1 and 2). Findings showed that farmers received information on planting time, use of improved seed varieties, drought-resistant seeds, early warning information, rainfall patterns, food preservation, fertilizer usage and type of crops to grow in a season.

Orindi and Murray (2005) stated that disseminating and imparting knowledge on crop management to farmers was important, as climate change and variability will result in changes in cropping systems and shift in agricultural zones. Kandji and Verchot (2007) are of the view that information on climate change and variability should be used as an intermediate variable promoting mitigation and adaptation through the application of improved crop management practices. The authors explain crop management practices to include the use of rainwater harvesting, soil conservation and agro-forestry, to enhance productivity among smallholder farming systems.

Timely access to accurate information and knowledge plays a major role in farmers' adaptation to climate change and variability and in reducing vulnerability (Ngigi 2009). However, despite findings indicating that farmers have increased their annual yields as a result of access to information received through the CCAA experts (refer to section 5.6.1), it was learned that after the project ended, farmers continued to lack apt and accurate information on climate change and variability. Kandji and Verchot (2007) and Gunasekera (2011) explain that, to enhance livelihoods, advanced access to information on climate change and variability to farmers is essential in ensuring efficient and effective adaptation through correct and expedient decision-making in agriculture. Tumbo, Mbilinyi, Rwehumbiza and Mutabazi (2010) recorded that 90% of Tanzanian farmers depend solely on rain-fed agriculture. In this regard timely and more focused climate and weather forecasts to end-users is of great significance. Kandji, Verchot and Mackensen (2006) state that

appropriate seasonal forecast information could help governments and local people cope with climate change and variability.

Ingram, Roncoli and Kirshen's (2002) study in Burkina Faso confirms the role of timely access to information in enhancing crop diversification and water preservation and harvesting. These authors used a variety of data collection methods such as open-ended and in-depth interviews, focus group discussions, together with observation. They stressed the need for well-timed information on climate change and variability, such as seasonal forecast information to make farmers aware of the coming season. Farmers' access to appropriate information will further enhance their adaptive capacity, through choice of what and when to cultivate and the proper use of water. These measures will mitigate some of the adverse effects of climate change and variability.

Tumbo, Mbilinyi, Rwehumbiza and Mutabazi (2010) explained that inaccurate and unreliable climate and weather information caused heavy losses to resource-limited farmers, resulting from planting an incorrect seed variety and investing in labour and time in circumstances that result in crop failure and food insecurity. Supporting Tumbo, Mbilinyi, Rwehumbiza and Mutabazi's (2010) findings, Kandji and Verchot (2007) explain that information on climate change and variability is crucial to farmers in making the right decisions, not only in agriculture but also in other socio-economic activities so as to enhance livelihoods. However this study, stresses that in order for the farmers to benefit from information on climate change and variability, including seasonal climate forecast information, appropriate interpretation and the effective communication of the information is required to build trust between producers and users. Gunasekera (2011) confirms findings by Kandji and Verchot (2007) and explains that disseminated information will be effective if the information reaches appropriate end-users in a reliable, user-friendly and comprehensible manner.

Mengistu (2011) also shares the view that the accessibility and availability of information on climate change and variability is a fundamental requirement for mitigating the adverse impact of climate change and variability. This author reasoned that timely information on climate change and variability would not only improve mitigation of the adverse effects of climate change and variability but also enable farmers to make use of the beneficial effects to improve their wellbeing. Salinger, Sivakumar and Motha (2005), Gwambene (2007) and Majule and Yanda (2009) supported the view that a lack of access to reliable information on

new technologies such as new seed varieties, drought-resistant varieties, improper use of proper communication channels and other agricultural innovations generated through research was hampering farmers' ability to adapt to climate change and variability.

Despite many barriers hindering access, to and use of, information on climate change and variability, as has been explained in section 6.11 of this chapter, Kandji, Verchot and Mackensen (2006) and Patt, Ogallo and Hellmuth (2008) reported that there has been progress in most African countries towards disseminating information on climate change and variability. This information, if effectively used, can reduce the adverse effects on farmers of climate change and variability. However the concern of Patt, Ogallo and Hellmuth (2008), which was also seriously considered in this current study, is that in most African countries farmers complain that the information they receive from the meteorological agencies come at the onset of the rainy season and fail to cater for farmers' information needs. The authors therefore underscore the need for information disseminators to provide earlier forecast services, to allow farmers to plan for their agricultural activities and allocation of their limited resources. The disseminated information on climate change and variability should be supplied as re-packaged information about farming resources that corresponds with farmers' needs.

6.5 Specific Channels Employed in Disseminating Information on Climate Change and Variability to Farmers

This research sought to discover which specific channels farmers used to access information on climate change and variability (cf. question g54 and g52 in Appendices 1 and 2). Findings in section 5.7 of Chapter Five indicated that the extension officers and village government leaders inform farmers on issues related to climate change and variability. The study by Shetto (2008) on the scaling-up of natural resources management showed that village government leaders were widely used to transfer information to farmers on new ways of using rainwater harvesting technologies. Village government leaders took directives from the extension officers and informed farmers on climate change and variability. The need to build capacity in the stakeholders involved in disseminating information on climate change and variability and the complexities arising in agricultural production are of paramount importance in the current observed variable climatic conditions.

Farmers were asked to state how they gained access to adaptation information related to climate change and variability (refer questions h56 and h57 in appendices 1 and 2). The research findings (refer to Chapter Five, section 5.12.1) indicate that farmers most commonly use radio and mobile phones rather than the other mass media to access information on climate change and variability (CCV). These findings confirm those by Tarhule and Lamb (2003) in West Africa and contradict those by Cartmell II, Orr and Kelemen (2004) in the USA, who observed that farmers used more television, email and magazines than radio and workshops. Cartmell II, Orr and Kelemen's applied a telephone interview survey to 707 farmers in Oklahoma State.

A study similar to this was conducted by Cherotich, Saiduand Bebe (2012) on farmers in semi-arid Kenya. The study used a snow balling sampling technique to identify respondents and administer structured questionnaires to respondents. The study found farmers in semi-arid environments of Kenya used mostly radio and interpersonal sources such as extension officers, village leaders and indigenous leaders as channels for accessing information on climate change and variability. A study by Ingram, Roncoli and Kirshen (2002) observed that radio was preferred by the majority of farmers in Burkina Faso in disseminating information on climate change and variability. Ingram, Roncoli and Kirshen (2002) used qualitative methods, such as in-depth interviews, focus group discussions and observation, to collect data from farmers. The findings from the USA and those from Africa show a difference in the sources used most by farmers from developed and developing countries. These findings are consistent with those in South Africa by Meyer (2000), who found that the ways in which agricultural information is communicated in the rural developing world differs from that in the developed world. Developed countries have a much more advanced infrastructure and easily accessible communication channels than developing countries.

In Zimbabwe, Mutekwa (2009) found that media channels such as radio, but also newspapers and Television were used most by farmers to access forecast information. Despite these studies and this research confirming that radio was preferred by most farmers in many countries of Africa, the study by Shetto (2008) in Tanzania had different findings. Shetto's study found that, despite the majority of farmers having radio there were problems in the effective use of the radio, to access information. Ying, Das, Dawei, Vega, Viet Van Nguyen, Bakheit and Abdullahi (2007:182) confirmed the current study's research finding, when they observed that mobile phones have recently become the obvious choice of medium to inform

farmers on agro-meteorological services. In East Africa, Orindi and Murray (2005) described the major sources of communicating information on climate change and variability provision to farmers to be the government and private and civil societies.

Despite the results of the current study showing that farmers preferred and used radio to access information on climate change and variability, this study also found that interpersonal communication was highly used (refer to Chapter Five, sections 5.7 and 5.12.1). Many studies in Africa, such as those by Sturges and Chimseu (1996a, 1996b), Meyer (2000), Shetto (2008) and Cherotich, Saiduand Bebe (2012) were consistent with the present study's finding indicating that interpersonal communication sources were found to be effective in communicating information to farmers. The preference for these sources by farmers might be due to the ease with which they were accessed and the authoritativeness of the information from the sources. Meyer (2000) researched ways to enhance the effective transfer of agricultural information to farmers in Phokoane, Mpumalanga Province, in South Africa. Her case study targeted farmers who underwent training and it highlighted the need for farmers' training to enhance the transfer of agricultural innovations to rural farmers. Her study used documentation, interviews, audio-visual and direct observation methods in collecting data. Meyer found that farmers in Africa are used to accessing information orally, as it has been widely used in communication for many years. Preference for interpersonal communication by farmers is also be explained by Rogers (2003:205) and Cherotich, Saidu and Bebe (2012), who found that users preferred interpersonal channels, as they could seek clarification, feedback or secure more information about an innovation, which was different from using the mass media. Rogers believes that the interpersonal channels persuade an individual to change his/her attitude and adopt an innovation. DOI model explains, however, that the mass media are effective in rapidly reaching a wider audience and are effective in creating knowledge (2003: 205-206).

Kandji, Verchot and Mackensen (2006) were of the opinion that information is best delivered and shared with remote areas when transmitted through rural radios, community gatherings such as churches, local brew drinking ceremonies, farmer field days and mobile telephones. Tumbo, Mbilinyi, Rwehumbiza and Mutabazi (2010) reported that in semi-arid Tanzania information on climate change and variability was disseminated through village offices, religious and social gatherings, village meetings and at markets. Supporting this view, Slegers (2008) and Tumbo, Mbilinyi, Rwehumbiza and Mutabazi (2010) observed that in

semi-arid Tanzania, farmers use the District Agricultural Office and the radio to access forecast information. Mutekwa (2009) found farmers shared knowledge with other distant farmers, learning from past experience, based on indigenous knowledge systems, farmer field days and advice from agricultural extension officers and NGOs in communicating adaptation strategies.

The use of informal networks as sources and channels for communicating and accessing information on climate change and variability was supported by Rees *et al.* (2000), Mchombu (2002) and Tumbo, Mbilinyi, Rwehumbiza and Mutabazi (2010). These authors suggested that the use of networks and village extension workers was appropriate in disseminating new research, agricultural extension information and climate and weather information, as they were effective in information delivery. Rees *et al.* (2000) found that many farmers in Kenya depended on interpersonal local sources of information such as neighbours, friends, relatives; organisation and institutions such as community meetings, churches, women's groups, community based organizations, NGOs; media such as radio; agricultural companies, stockists, and markets as their major sources of knowledge. The use of farmer groups has been identified by Mchombu (2002) and Rogers (2003) as being effective in information-sharing for new research innovations. The use of groups is supported by Munyua and Stilwell (2009), who observed that farmer groups were effective in information transfer, exchange and adoption of an innovation. Knowledge acquisition supports these findings.

In spite of the current study's findings that only a few individuals were able to attend training workshops on climate change and variability, the results confirmed the individuals were more aware of climate change and variability than others who did not attend. Scholars such as Mchombu (2002) have observed that training workshops are effective in communicating information, especially for those who are literate. Mchombu (2002) noted that short training workshops and seminars were effective in rapid social learning and imparting skills and knowledge to farmers. Mchombu (2002) and Shetto (2008) observed that farmer field visits were essential in making farmers self-dependent and becoming knowledge seekers. These arguments are in line with the present study findings which showed farmer field visits by researchers and extension officers improved farmers' confidence in making farm decisions. However, a study in Oklahoma State by Cartmell II, Orr and Kelemen (2004) indicated that farmers preferred workshops less as a communication source.

A study by Sivakumar and Hansen (2007:74) supported appropriate training for users as an important channel in reducing the communication barriers and gaps between information providers and users. The study in West Africa by Tarhule (2007) suggests the need to use appropriate communication channels such as the village information flow network to facilitate users to receive and share information from information disseminators. The proper choice of medium for channelling and communicating information on climate change and variability to farmers is crucial. In Tanzania, Tumbo, Mbilinyi, Rwehumbiza and Mutabazi (2010) noted that informal sources were used most in disseminating indigenous knowledge, while a scientific weather forecast was disseminated through TV, radio and newspapers. These findings confirm those of Rogers (2003), who observed that informal sources were effective in changing peoples' strong attitudes, beliefs and norms, while formal sources were good at influencing weaker attitudes, beliefs and norms.

Farmers were asked to state better ways to make information on climate change and variability understandable and available (cf. question g52 and g55 in Appendices 1 and 2). Research findings, as shown in Chapter Five, section 5.4, indicated that farmers preferred audio-visual tools in learning farm innovations. The use of audio-visual materials as sources of information to farmers has received attention from a number of authors, including Mchombu (2002) who supported the use of audio-visual materials and publications to inform farmers about innovations. This author stresses, however, that it was not enough to use audio-visual sources only, but rather to ensure that the information communicated to end users is repackaged in an understandable manner, which can be utilised by farmers. The need to repackage information for rural farmers in an audio-visual format lies in the observed trend that such channels are most effective when accessed by semi-literate persons. Findings show that farmers use a number of sources to access information on climate change and variability. This observation has also been noted by Stigter *et al.* (2007:178), who found that farmers prefer combining interpersonal with mass media communication as they can select and evaluate information which is of importance to them.

This study sought to find out how farmers perceived extension officers as a source of information for climate change and variability (cf. research question h61 and h63 in Appendices 1 and 2, respectively). The findings indicated that 45.2% of farmers perceived that extension officers and services were not reliable in providing information on climate change and variability. Thus, despite their roles in changing farmers' attitudes, influencing

users' behaviour, establishing good rapport with users and diagnosing problems, the failure of these change agents to dedicate most of their time to consultations with farmers has been observed to have a negative impact on the adoption of innovations (Rogers 2003: 369-373). However, in spite of findings illustrating that farmers rely least on the extension officers, still most farmers find the content of information delivered by the extension officers to be reliable.

Despite being unreliable as providers, findings from the focus group discussions showed that farmers trusted extension officers' information. These results were supported by those of Cherotich, Saidu and Bebe (2012) in semi-arid Kenya. These authors used structured questionnaires to collect data on access to climate change information for vulnerable groups. They found that extension officers delivered information on climate change and variability and provided support services to farmers, unlike other communication channels. Not only in Africa, where farmers tend to rely on extension officers services but also in the USA, as was observed by Cartmell II, Dwayne, Orr and Kelemen (2004). The most interesting finding was that, despite farmers in USA and their counterparts in developing countries differing with regard to the communication channels used to access information, the study by Cartmell II, Orr and Kelemen (2004) showed that farmers preferred and relied mostly on information from extension officers. The finding in USA confirms this study's findings which showed farmers trusted information from extension officers, in spite of their inaccessibility. The Diffusion of Innovations model shows that professional change agents such as extension officers are perceived to be more credible and competent compared to other sources (Rogers 2003:385).

6.6 Methods Applied by Farmers to Mitigate the Effects of Climate Change and Variability

Yanda and Mubaya (2011:122) reported that the projected impact and evidence of climate change and variability on crop mitigation and adaptation plans have been well recorded in East Africa. Despite being well documented, mitigation and adaptation strategies in East Africa are poorly understood in the context of climate change. These authors believe that mitigation and adaptation strategies are not well described. Section 6.6 discusses farmers awareness and knowledge as critical components in farmers mitigating impacts of climate change and variability.

The study findings, presented in section 5.9.2, showed that farmers apply a number of coping and adaptation strategies such as:

- early farm preparation
- planting in rows
- increased use of manure
- improved seed growth
- irrigation
- late planting
- use of drought-resistant seeds and early-maturing varieties

Other local adaptation indicators include participatory cultivation, use of improved varieties, deep soil cultivation, using ridges, use of more efficient farm implements, such as the plough and tractor, use of improved varieties and use of pesticides. The study noted that farmers are shifting towards other economic activities to subsidise their income and losses which might result from food insecurity.

A number of authors had observed similar results to those of the current study. In Zimbabwe, Mutekwa (2009) found that the most used adaptation strategies were crop diversification, changing planting dates, planting short season varieties, growing legumes, soil and water conservation strategies and applying more fertilizer where excessive volumes of nutrients were being leached from the soils. Studies by Yanda and William (2010) and Kangalawe, Mwakalila and Masolwa (2011) in Tanzania found that the rural people engaged in farming had adapted by switching to other economic activities such as selling charcoal, establishing restaurants (viosk), switching to more drought-resistant crops such as sorghum and cassava, brick production and the use of casual labour.

A study by Majule and Yanda (2009) and Yanda and Mubaya (2011) in central Tanzania found farmers adapting to climate change through the adoption of early-maturing crops, drought-resistant crops, new crops, timing agricultural activities such as initial rain planting and water-harvesting methods. Studies by Mongi, Majule and Lyimo (2010) and Lema and Majule (2009) in semi-arid Tanzania showed farmers were applying a number of methods for mitigating the effects of climate change and variability. These studies used both qualitative and quantitative methods, such as focus group discussions, semi-structured interviews, questionnaires, key informants and open-ended discussions to collect data from farmers.

These results from central semi-arid areas of Tanzania contradicted those from Kenya and Tanzania by Eriksen, Brown and Kelly (2005), who found that farmers were hesitant to adopt drought-resistant crops due to limited access to information and skills, low consumption and market values. The inconsistency of the results might be attributed to three factors:

- Maluga and Chibelela villages underwent CCAA training to sensitise farmers on the best farming methods to adapt to climate change and variability unlike their counterparts in Mbitini, Kenya, and Same, Tanzania.
- The disparity in time because as this study was done more than 10 years after the one by Eriksen, Brown and Kelly.
- Availability of a number of initiatives and policy interventions plans with two major ones being the National Environmental Policy (1997) and the National Adaptation Programme of Action (URT 2007).

These policies have stimulated awareness on adaptation to climate change and variability options to farmers.

Reiterating findings on sub-section 6.8.2 of this chapter, farmers adopted new adaptation strategies and made farm decisions mostly based on their previous experience, attitudes, compatibility, relative advantage of the newly introduced method and the associated risks. These observations were noted by Slegers (2008) in Kondoa, Tanzania, where it was found that farmers used crop rotation method in adapting to climate change and variability, as they perceived crop rotation to be important in protecting the land from overuse. Orindi and Murray (2005) observed the role of farmers' experience in mitigating impacts of climate change and variability. These authors found communities have managed to identify and develop various local coping strategies as a result of living in that area for a long period of time. However, the authors noted that the coping strategies could only sustain households in the short term.

Risk, reward and compatibility are adoption attributes which have been explained by Rogers (2003) and Orindi and Murray (2005). These authors described adoption of agricultural innovations as depending on the perceived risks or benefits associated with the innovation. The authors are of the view that acknowledging and reducing this sort of risk is imperative for mitigation. In this regard, Orindi and Murray (2005) urge researchers to understand, utilise and document existing local livelihood coping strategies used by farmers, instead of

imposing complex and high-tech climate change adaptation strategies. Orindi and Murray (2005), Slegers (2008) and Mutekwa (2009) noted that farmers preferred crop diversification as one of the land management methods in mitigating the adverse impacts of climate change and variability. The authors found that crop diversification was adapted widely, as it has a number of benefits to farmers which, include minimising crop failure losses by spreading the risk, increasing food security, ensuring availability of food at household level and enabling farmers to increase their income. Thus, adaptation strategies should seriously take on board these factors to make adaptation measures effective.

Despite several similar studies in semi-arid regions like those by Slegers (2005); Lema and Majule (2009) and Mongi, Majule and Lyimo (2010), showing that poor farmers sell their labour to rich farmers as a way to cope with adverse effects of climate change and variability to ensure their livelihood, this study could not ascertain the existence of this phenomenon. Similarly, this study's findings on coping strategies (refer to section 5.9.2 of Chapter Five) reject those by Slegers (2008); Lema and Majule (2009); Lyimo and Kangalawe (2010); Yanda and William (2010) in Tanzania, who found farmers in semi-arid regions of Shinyanga, Singida, Dodoma and Simanjiro respectively, depended on the selling of charcoal and locally brewed beer as a coping mechanism to mitigate the effects of climate change and variability. However, there are two major reasons which might explain why this study's findings were inconsistent with those of the authors above. First, it might be that farmers are only gradually shifting towards other income generating sources to earn a living and are not depending solely on agriculture. This was observed in Maluga and Chibelela villages, where farmers were observed selling groundnuts and livestock across the road to earn more income. Second, farmers might have been hesitant to mention these coping and adaptation strategies, as they are perceived as malpractices in the community where people are aware that selling charcoal is not encouraged because of its negative impact on trees and the environment. Another factor is that people through their religions are also conscious that using or selling local brew is not a good way of generating money or taking care of their health.

6.6.1 Mitigating the Impacts of Climate Change and Variability to Improve Food Security

The study sought to identify farmers' attitudes to food security and their preparedness at household level (cf. questions i71, i72 and i73, i74 in Appendices 1 and 2). O'Kefee and Wisner (1975) noted that the extent of loss or damage associated with a disaster is influenced

by the people's level of preparedness. The results of this study indicated that the majority (69.0%) of respondents acknowledged that the food they produced was not sufficient to feed their family and remain with surplus for sale. The study findings showed that few (31.0%) of respondents could produce adequate food for their household needs and also for sale. Farmers perceive increased incidences of food shortages and low levels of preparedness to be caused by climate change and variability (refer to Chapter Five, section 5.10.3). Farmers revealed that increased food insecurity was a result of the reduced amount of rainfall, shortened growing season and increased incidences of drought and dry spells. Supporting the reasons for food insecurity in the semi-arid regions in Tanzania, Majule and Yanda (2009) and Lema and Majule (2009) found unpredictable rainfall, increased pests and diseases, low soil fertility and lack of farm implements to be major factors influencing farmers' production capability. These findings on farmers' perceptions of food insecurity in the central regions of Tanzania are supported by Liwenga (2003) and Mongi, Majule and Lyimo (2010).

In order to increase food production and mitigate the impacts of climate change and variability, an ability to recognise the problem is a fundamental step in the process of designing mitigation strategies. These findings confirm those in Rogers' DOI model, which asserts that recognising a problem or need was crucial in developing an attitude towards an innovation (Rogers 2003:137, 171). Therefore training and imparting knowledge to farmers on the best adaptation strategies such as grain storage and preservation would be of great value to seeking to reduce farmers' vulnerability on climate change and variability, if farmers have recognized the food insecurity problem. Supporting the role of farmer training, Yanda and Mubaya (2011:120) found that farmers in central Tanzania had increased growth of crops such as maize, bambara nuts, cowpeas and groundnuts as a result of training on improving storage for economic reasons which farmers had received.

Sivakumar and Hansen (2007:74) explain that under the current increasingly variable conditions conducting appropriate training for users of information on climate change and variability is prudent in order to facilitate quick understanding and to identify and address the communication barriers and gaps between information providers and users to enhance adaptation. Ngigi (2009) is of the view that training and demonstrations should be used to build capacity, not only in farmers, but also in other agricultural stakeholders in all aspects pertaining to adaptation to climate change and variability to enhance food productivity. Meyer (2000) views training as crucial in transferring agricultural knowledge from experts

who are literate to farmers who are mostly illiterate. Gundu (2009) found that inadequate training and lack of access to information and illiteracy levels affected farmers' household food security levels and the way they utilised agricultural resources.

Respondents were asked about the indigenous knowledge which they possessed with regard to adaptation to the adverse impacts of climate change and variability (see questions d24 in Appendices 1 and 2). The study findings, as presented in Chapter Five, section 5.9.2 showed that farmers still use indigenous storage tools to store food for future usage. The use of indigenous vessels to store food was also observed by Liwenga (2003), who researched farmers in the semi-arid areas of Tanzania. Kangalawe, Mwakalila and Masolwa (2011) conducted their study on farmers in the southern highlands of Tanzania. These findings support Rogers' (2003:254) views on IK systems, which explain that when a new idea is introduced in a community, individuals tend to evaluate it based on existing values and experiences. However, it is of great concern that the use of indigenous grain storage tools is fading away in Maluga and Chibelega villages. This observation could be explained by the societal changes as a result of globalisation and development. Development facilitates farmers' access to more easily accessed technologies, which simplify grain storage. The other factor explaining the low usage of indigenous grain storage tools might be the loss of old people who had skills on how to design the tools. As the study observed, with no documentation and preservation of indigenous knowledge, loss of elders signifies a loss of skills and technical knowledge on making these tools. To enhance the use of IK in mitigating climate change and variability, timely access to, and availability of, IK tools by farmers would be of great help. The next section, 6.7, discusses farmers' awareness and knowledge as crucial components in mitigating climate change and variability impacts on farmers.

6.7 Farmers' Awareness and Knowledge in Mitigating Climate Change and Variability

Todd (2005) explains that education has an important role to play in dealing with the problem of climate change and variability as it provides awareness which is critical to the individuals' adoption of innovations. Awareness motivates users to engage more in an information-seeking process to acquire new knowledge which is critical in decision-making under a changing Climate (Rogers 2003:173; Todd 2005:312). Effective decision making hinges on farmers' access to timely and accurate information and their ability to make use of this knowledge (Rogers 2003; Todd 2005). Farmers' knowledge on climate change and variability

was categorised into scientific and indigenous knowledge, to show farmers adoption of both scientific (explicit) and indigenous (tacit) external and local and knowledge and how they make use of the knowledge in the mitigation and adaptation to climate change and variability.

6.7.1 Farmers' Awareness of Climate Change and Variability

Farmers were asked to state their awareness regarding climate change and variability (cf. questions d18 in Appendices 1 and 2 and 1 in Appendix 5). Findings indicated that as many as 93% of farmers were aware of climate change and variability and only 7% were not aware. These findings confirm those by Jonge (2010), who found that farmers were aware of climate change and variability. Jonges' study investigated farmers' perceptions of adaptation to climate change in South Australia. The study employed telephone interviews and workshops in data collection. Mataki, Koshy and Nair's (2008) study in the Pacific Islands and Corner's (2011) in Uganda found awareness and knowledge on climate change to be crucial in determining how people respond to climate change and variability. These scholars noted that limited awareness of climate change and variability has resulted in the observed low level of mainstreaming of climate change and variability issues in development plans.

Mukhala and Chavula (2007) recorded that in Africa the majority of resource-poor farmers were not aware of the availability of information that could be used in their decision-making. Deressa *et al.* (2008) noted farmers' limited awareness of climate change and variability in Ethiopia. Deressa *et al.*'s study, which used a survey method, showed that the majority (42%) of farmers were not adapting as a consequence of not having adequate information. The present study's findings indicating that the majority of farmers being aware of climate change and variability might have been contributed to the CCAA training and sensitisation which exposed them to experts and extension officers. These findings confirm those by Sivakumar and Hansen (2007), who found training to be important in creating awareness and understanding of climate change and variability. These findings align well with those in the DOI model of Rogers (2003), which shows that awareness on climate change and variability is highly influenced by communication channels.

When creating awareness, there are a number of sources which are used to disseminate information on climate change and variability (refer to section 6.5). The mass media have been found to be effective in creating awareness and reaching wider audience than other sources (Rogers 2003). Confirming the role of mass media in creating awareness, the study

by Boykoff (2008) in developed countries found that mass media such as radio, television, newspapers and the Internet have played a crucial role in creating awareness, influencing social learning and constructing peoples' knowledge. These findings were inconsistent with those of Corner (2011), in Uganda, who observed that the mass media were not fully engaged in covering climate change and variability information. These findings indicate a discrepancy on the effectiveness of mass media networking in informing the community on these issues. Boykoff (2008) and Corner (2011) argued that factors such as journalism, packaging, culture, politics, economic standards and uncertainty greatly influence discourses on, and awareness of, climate change and variability. Despite mass media being acknowledged by Rogers (2003) and Boykoff (2008) to be effective in creating awareness, Rogers (2003), Deressa *et al.* (2008) and Nisbet (2009) stated that interpersonal communication sources were more effective in changing peoples' strong attitudes while weak attitudes were better influenced by sources of information in the mass media.

The findings by Deressa *et al.* (2008) and Nisbet (2009) have been well explained by the Diffusion of Innovations model of Rogers. Rogers (2003) who argues that the mass media effectively change weak attitudes, while interpersonal sources of communication are effective in changing peoples' strongly embedded attitudes, which are mostly culture-related. However, despite Rogers (2003), Deressa *et al.* and Nisbet (2009) indicating the role of the mass media in creating awareness and changing peoples' attitude, Mataki, Koshy and Nair (2008) cautioned that limited understanding of climate change and variability documented in the mass media in the Pacific Islands has resulted in producing inaccurate information for readers and viewers. The most pressing issue is that most people rely on the mass media to access information on climate change and variability. In this regard, awareness raising of climate change and variability issues by media is of immense significance in the adaptation of farmers, as was indicated by Dhaka, Chayal and Poonia (2010).

In the USA, Nisbet (2009) found that, despite the mass media greatly ensuring that the audience receives information, much of the information reached only a small proportion of the targeted audience. Nisbet learned that the packaging of the information content related to climate change and variability had caused low receptivity, influencing people's level of awareness. Other obstacles identified by Nisbet, were the nature of the media system, which had a variety of content choices. The complexity associated with climate change and variability which did not reveal the impacts on people directly. These findings confirm those

by Rogers (2003), who stressed compatibility, less complexity and more advantageous features for an innovation to be adopted.

Awareness of information on climate change and variability is affected by the limited amount of information available at international level (Corner 2011). This could be caused by the international mass media, which highly influence awareness in developing countries being monopolised by the developed countries. Gwimbi (2009) and Mutekwa (2009) observed that, despite the availability of information at regional, continental and global levels, most farmers in Zimbabwe still have inadequate awareness and knowledge of climate change and variability impacts and adaptation strategies. Phillips and Orlove (2004); Marx, Weber, Orlove, Leiserowitz, Krantz, Roncoli and Phillips (2007) and Roncoli, Orlove, Kabugo and Waiswa (2011) observed that farmers' awareness and knowledge of scientific climate forecast information greatly enhanced their participation in adaptation to climate change and variability activities. Thus, to enhance usage of the information on climate change and variability, Hisali, Birungi and Buyinza (2011) suggested that information sources promoting awareness on climate change and variability should include innovative information needed by farmers, such as pest resistant varieties and weather forecasts.

The findings presented in section 5.8.1 of Chapter Five, revealed that the study could not ascertain any significant relationship between awareness on climate change and variability and other variables such as gender, level of education, age and wealth. Findings from the cross-tabulation between gender and climate change and variability awareness showed a Pearson Chi-square value of 0.617 and a significance value of 0.661 at the 0.05 probability level. Cross-tabulation between age and climate change and variability indicated a Pearson Chi-square value of 9.812 and a significance value of 0.081 at the 0.05 probability level. Findings of cross-tabulation between level of education and climate change and variability awareness showed the Pearson Chi-square value of 0.509 and a significance value of 0.917 at the 0.05 probability level of significance. Findings of cross-tabulation between income levels and farmers' climate change and variability awareness illustrated a Pearson Chi-square value of 8.346 and significance value of 0.08 at the 0.05 probability level of significance. The study findings could not determine any significant difference in awareness between Maluga and Chibelela villages. The findings from cross-tabulation on awareness between the two study villages indicated a Pearson Chi-square value of 0.239 and a significance value of 0.696, at the 0.05 probability level significance.

These findings contradict those by Deressa *et al.* (2008) and Jonge (2010), who observed that age, information, credit and educational level tend to influence farmers' awareness of climate change and variability. Deressa *et al.*'s study used survey and random selection methods to collect views from respondents in Ethiopia. The study by Jonge (2010) in Australia used telephone interviews and selected respondents purposively. The observed inconsistency in findings between this study and those by Deressa *et al.* (2008) and Jonge (2010) could be attributed to three main reasons. First, this study focused on farmers who were purposively selected and were linked to a project, while that by Deressa *et al.* (2008) randomly selected respondents. Farmers in this study had undergone training and mostly were in farmer groups, unlike those in Ethiopia studied by Deressa *et al.* (2008). The difference in location and economic difference might also have contributed to this study's results being different from those by Jonge. Jonge's study was conducted in a developed country, while location and economic factors in this study were those of a developing country. Despite the study by Jonge (2010) similarly utilising purposive sampling to select farmers, the findings were inconsistent with those of this study.

Despite this study's findings not indicating a link between awareness, wealth and level of education, the qualitative study findings showed a correlation between farmers' exposure, access to information and change agents, level of literacy and farmers' awareness of climate change and variability. These findings confirm those by Rogers (2003: 171,172, 222,288-291) and Apata, Samuel and Adeola (2009), who observed that awareness and socio-economic factors affect an individual's awareness and ability to acquire knowledge. This further confirms findings in the Diffusion of Innovations model by Rogers, which shows wealth is not the major factor which influences awareness in the adoption of innovations (2003).

6.7.2 Farmers' Knowledge of Climate Change and Variability

Understanding of climate change and variability holds an important role in farmers' mitigation and adaptation. The climate change knowledge which farmers possess helps them to easily adopt innovations and advice from experts (Mutekwa 2009). This is because, as pointed out by Mchombu (2002), users tend to critically investigate and compare their local knowledge with the new knowledge before making use of knowledge that is introduced from outside their community.

This study sought to investigate farmers' understanding of climate change and variability (cf. question d19 in Appendices 1 and 2) and results confirmed that, despite farmers being aware of climate change and variability issues, there is still inadequate understanding and knowledge by farmers (see section 5.8.1). These results confirm those of Mertz, Mbow, Reenberg and Diouf (2008) in rural Sahel, who learned that, despite their awareness of issues of climate change and variability farmers had limited understanding of this concept. Farmers tended to associate climate change and variability issues with economic, social and political challenges that were not caused by human activities. Nonetheless, it is not only in Africa that understanding of these issues is a challenge. In Australia, Jonge (2010), who explored farmers' perceptions of adaptation to climate change and used telephone interviews and workshops in data collection, found that, despite farmers' being aware of climate change and variability, they lacked adequate knowledge because they associated the phenomenon with natural climatic variability and did not view it as human-induced. Mataka, Koshy and Nair (2008) similarly noted that in Pacific Island townships the majority of people did not understand the existing link between human activities and how they exacerbate climate change and variability.

Such limited understanding not only affected farmers, but also other agricultural stakeholders, namely public extension officers and private extension officers who are involved in transferring knowledge to farmers (refer to sections 6.2 and 6.11 of this chapter). Mutekwa (2009) in Zimbabwe and Corner (2011) in Uganda were among the investigators who found an existing knowledge gap among extension officers. Mutekwa (2009) found that Zimbabwean extension officers and non-governmental officers commissioned to impart knowledge on climate change and variability to farmers failed to educate farmers effectively on the current and projected changing climatic conditions.

Corner (2011) collected data through focus groups and interviews from government, private sector, media and community organisations. The author explored challenges and opportunities associated with communicating climate change and found that, despite the availability of education and awareness programmes, still most people had a limited understanding. Corners' (2011) study, similar to Mutekwas' (2009), found an existing gap of knowledge in mass media, researchers, extension officers, NGOs, civil society, and community based organisations on their understanding of climate change and variability. This limited knowledge, according to Corner, was attributed to lack of knowledge by information

disseminators and skepticism about information concerning climate change and variability. Corner's study had remarkable findings which this present study had also observed.

Eriksen, Brown and Kelly (2005) and Deressa *et al.* (2008), despite revealing that farmers' lacked adequate knowledge on potential adaptation methods, found that farmers also lacked alternative ways to adapt. These findings align well with those of Gwimbi (2009) in Zimbabwe, who found that although farmers were aware and prepared to adapt to climate changes, their knowledge on adaptation options were meagre. In a similar, yet slightly different, vein, Yanda and Mubaya (2011:25) explained that despite stakeholders in the agricultural sector being aware and having knowledge of projected changes in climate in coming years, there was a paucity of knowledge on expected changes in climate variability and the probabilities of extreme events.

There is a problem in communicating the science of climate change and variability to users (refer to section 6.10), which leads to a lack of understanding in the targeted users of the information. McBean and Hengeveld (2000) explored the challenges of communicating the science of climate change in Canada. The study discovered a communication gap between the scientists involved in climate science debates and other users of information. The study observed that a lack of scientists' effective communication skills, lack of correct information provided by climate change and variability contrarians and lack of scientific knowledge by public media editors and journalists were factors contributing to the people's confusion and acted as impediments to access and usage of information on climate change and variability.

These results agree with those of Corner (2011) in Uganda, demonstrating that the communication problem is global and is mainly attributed to inadequate understanding of the community. Indeed, a journalist's state of awareness has been noted by Anderson (2009) and Corner (2011), who observed that journalists are faced with various challenges in covering news on climate change and variability, including their inadequate knowledge of these issues and structural barriers in the media industry. The study by McBean and Hengeveld (2000) advocates for access to credible and quality information which is understandable to the public. This is of paramount importance if awareness is to be raised in different categories of people.

The level of understanding of climate change and variability and adaptation could be attributed to the people's perception that it is a distant problem. In East Africa, Orindi and

Murray (2005) observed that farmers perceive climate change and variability as a distant and not an immediate challenge affecting their livelihoods. Confirming these findings, Orindi and Murray, Mataki, Koshy and Nair (2008:274) feel that individuals and decision-makers mostly perceive climate change adaptation as a futuristic incident. This results in limited funding and institutional support, as adaptation plans are not considered as urgent or as having the same priority as other basic needs. As a consequence, most adaptation plans advocate future action and are not aimed at lessening the current adverse impacts.

Prior knowledge of individuals affects awareness and knowledge of a person. Lorenzoni, Nicholso-Cole and Whitmarsh (2007) described the individual's state of knowledge on the awareness of climate change and variability as being comprised of three categories, which are cognitive, affective and behavioural components. Despite these knowledge acquisition stages being more advanced in developed countries Nicholso-Cole and Whitmarsh (2007) noted that in the United Kingdom there is still a problem with peoples' understanding of climate change and variability issues. In this regard, the authors suggested the constant provision of information to people in order to raise awareness and change peoples' attitude and improve knowledge. Subsequent to individuals' knowledge, farmers' willingness and supporting learning environment are critical in facilitating the understanding and knowledge acquisition of farmers. Mutekwa (2009) observed that in Zimbabwe, despite some farmers confessing to a lack of knowledge about climate change and its impact on farming activities, most had adopted at least one strategy to cope with climate variability.

As a way to encourage farmers to change their attitudes and adopt new knowledge, regular information provision and the allocation of more time to such efforts is crucial. This has been emphasised by Lorenzoni, Nicholso-Cole and Whitmarsh (2007), who explained that in increasing the level of understanding and knowledge on climate change and variability, people should be engaged in dialogue and ample time should be provided for people to accommodate and accept the changes. These findings concur with those of Rogers (2003), in the Diffusion of Innovations model, which describes time as an important element in diffusion and adoption of innovations in a community. Time is crucial as it allows farmers to assess an innovation, to observe it, see how complex, compatible, advantageous and triable it is as compared to the knowledge they have been applying in order to improve their livelihoods. These adoption attributes have been described by the Diffusion of Innovations model (Rogers 2003).

To enhance farmers' knowledge, they should be exposed to field practices in order to learn from other early adopters. Deressa *et al.* (2008) supported this notion by explaining that farmers are more likely to be motivated when they have observed others and should try new innovations on their own farms. Deressa *et al.*'s study further underscores the role of assessing compatibility and benefits of introduced varieties to the new environment as an effective way of ensuring knowledge on innovations such as crop varieties are adopted by farmers. These findings by Deressa *et al.* (2008) confirms those in the Diffusion of Innovations, which stresses trialability, compatibility, relative advantage and observability as attributes which influence farmers knowledge diffusion and adoption of innovations. Sub-section 6.7.2.1 describes the scientific and indigenous knowledge farmers have acquired as critical aspects in mitigation and adaptation to climate change and variability.

6.7.2.1 An Overview of Farmers' Scientific Knowledge and Indigenous Knowledge on Adaptation to Climate Change and Variability

Sections 6.6.2.2 and 6.6.2.3 focussed on elucidating two major types of knowledge used by farmers in adaptation to climate change and variability. Section 3.10 identified gaps in the literature where it was unclear how farmers had acquired their knowledge and whether they applied their local/indigenous knowledge or adopted scientific information packaged and disseminated by information disseminators. Sections 6.7.2.2 and 6.7.2.3 drew on farmers' experiences and explored the indigenous methods that they use and adapt in response to the challenges of climate change and variability.

6.7.2.2 Farmers' Scientific Knowledge on Adaptation to Climate Change and Variability

Ziervogel and Opere (2010) explain that information on climate change and variability in sub-Saharan Africa is accessible from two main sources, meteorological seasonal climate forecasts (SCFs) and indigenous knowledge-based seasonal forecasts (IKFs). The scientific knowledge (SK) incorporates both SCFs and experimental-based knowledge from research institutions which farmers use to increase agricultural production and mitigate the adverse impacts of climate change and variability. Todd (2005:313) points out that formal education which enhances SK presents an opportunity to introduce people to various ways of doing things. The scholar reasons that formal education aims at creating awareness to individuals of the availability of other options and not merely discarding traditional practices.

This study indicated in sections 5.6.1 and 5.12.2, showed that farmers have gained understanding of climate change and variability issues and have adopted new farming practices as a result of education and awareness imparted by agricultural experts. Farmers' decisions to adopt new farming practices was influenced by their perceptions of new innovations being compatible, less complex and more advantageous compared to the existing knowledge, as has been described by the Diffusion of Innovations model (Rogers 2003). Farmers' use of the agricultural implements provided by the project enhanced their adaptation and improved their food security levels.

A number of authors have shown that scientific knowledge has enabled farmers to adapt to climate change and variability. Mukhala and Chavula (2007) observed that in sub-Saharan Africa, despite only 10% of the arable land being irrigated, there is evidence that farmers themselves are attempting to adopt strategies to cope with climate change and variability. The scholars observed that the strategies being adopted by farmers include the use of drought-tolerant varieties, crop diversification, adoption of reduced tillage methods and an increase in off-farm income-generating activities.

In Uganda, Erbaugh, Donnermeyer and Amujal (2007) investigated the impact of farmer field school (FFS) participation in integrated pest management (IPM) adoption and found that the new knowledge that farmers had acquired from agricultural experts was a major factor which promoted adoption of new farming methods. In Ghana, Boahene, Snijders and Folmer (1999) similarly found that farmers' access to new knowledge from extension officers augmented their adoption of a new cocoa variety which was more productive and resistant to diseases. In Burkina Faso, Barbier, Yacouba, Karambiri, Zorome and Some (2009) explored farmers' adaptation strategies and found that farmers' had changed their farming practices during the past decade as a result of the new knowledge that they had received from agricultural experts. Barbier *et al.* (2009) indicated that farmers' newly adopted farming practices increased their crop production. Innovations which farmers have adapted include micro-water harvesting, use of soil conservation practices, storage of hay and sorghum residues and growing dry season vegetables. The findings indicated that farmers were shifting from dependency on rain-fed agriculture to irrigation schemes. Barbier *et al.s'* findings on the role of scientific knowledge, confirms those by Lema and Majule (2009) and Yanda and Majule (2009) in Tanzania, which showed farmers have increased and improved the use of high-value crops. Nonetheless, the studies note a need for more awareness and education as use is still low.

A study by Matthews-Njoku, Adesope and Iruba (2009) on the acceptability of improved crop production practices among rural women in Nigeria indicated that rural farmers had a low adoption rate of improved farming practices. The study learned that low adoption rate was a result of inadequate technical information and knowledge from extension officers. The role of scientific knowledge was confirmed by Dimelu and Saingbe (2006), who explained that adoption and utilisation of appropriate agricultural technology by rural farmers was largely dependent on the new knowledge received by farmers. Another case study was in South Africa, where Jewitt and Lorentz (2008) observed that farmers adopted new farming knowledge as a result of knowledge they had received from researchers. The findings explain that the innovation they received had significantly enhanced their farming practices through frequent on-farm experiments.

Findings from a study in Malawi on the factors influencing farmers' adoption of a new variety of beans by Masangano and Miles (2004) established that the SK farmers had received enabled them to change their negative perceptions towards use of new Kalima bean variety. The authors indicated that farmers sometimes failed to adopt new farming practices as a result of low literacy levels and stressed the repackaging of new knowledge to encourage its use. Similar findings were obtained by Gundu (2009) in Zimbabwe. In Kenya, Goldberger (2008), studying the diffusion and adoption of organic agriculture in Makeni district, noticed that farmers adopted the use of fertilizers after receiving knowledge from government extension officers and NGOs. Goldberger found that farmers' decisions to adopt an innovation was to a greater extent influenced by their personal preferences, knowledge level and perceived needs. These findings confirm those by Rogers (2003), who found user perceived needs, knowledge and socio-economic factors enhanced the adoption of innovations. Dhaka, Chayal and Poonia (2010) recorded that scientific knowledge on adaptation to climate change and variability would possibly not have been adopted if farmers had not noticed that the climate had changed.

Arellanes and Lee's (2003) study in Honduras established that farmers had changed their farming practices to adopt sustainable agricultural technologies. These authors found that the knowledge farmers had received reduced their expenditure, as the innovations introduced were cheaper and compatible with their farming needs. The scholars' findings indicated that following new knowledge, farmers could apply fertilizer, grow leguminous crops and shift to

commercial vegetation production. In Tanzania, Kaliba, Verkuijl and Mwangi (2000) assessed farmers' adoption of inorganic fertilizers and new maize varieties and learned that low usage of farm inputs was attributed to the inadequate extension services offered by extension officers. To affect speedier adoption of scientific knowledge by farmers, there is a need to foster a close collaboration between experts, NGOs, private and government extension officers and farmers. This argument is supported by Kaliba, Verkuijl and Mwangi, (2000) and Sturdy, Jewitt and Lorentz (2008), who advocated much closer collaboration and communication between partners, to meet farmers' information needs on climate change and variability in their specific surroundings.

Researchers who observed farmers' application of new knowledge for adapting to climate change and variability in Tanzania include Majule and Yanda (2009) in Dodoma region, Lema and Majule (2009) in Singida region, Mongi, Majule and Lyimo (2010) in Tabora region and Lyimo and Kangalawe (2010) in Shinyanga region. Similar observations were made by Ingram, Roncoli and Kirshen (2002) in Burkina Faso. They learned that the new knowledge which farmers received enhanced crop diversification, water preservation and harvesting. These authors found that farmers applied new farming methods, such as the use of drought resistant varieties, space planting, introducing new varieties and the use of water harvesting technologies as adaptation strategies to cope with climate change and variability. Despite these results indicating that farmers are applying new farming knowledge to mitigate adverse effects associated with climate change and variability, frequent meetings with farmers are still of immense importance in order to sustain the innovations that have been introduced.

The findings of this study, given in section 5.8.1 established that the majority of farmers had knowledge that their surrounding environment was changing. Some of their views, which signified their local understanding of the changing environment was that the amount of rainfall was minimal and had become erratic, the temperature had risen pests and diseases and new farming method were unavoidable. These findings confirm those in other African countries by Maddison (2007), Deressa *et al.* (2008), Slegers (2008), Lema and Majule (2009), Mongi, Majule and Lyimo (2010), Mensah-Fosu, Vleck, Manschadi (2010), Jonge (2010) and Corner (2011, Mengistu (2011), who had similar observations to those of the study.

The study's qualitative findings indicated that the majority of farmers stated that tree cutting and deforestation were major factors propagating the changes in environment which have recently been observed. These results are in line with those by Slegers (2008), who indicated that farmers in Tanzania were aware of the scientific discourse that growing trees facilitates rainfall and those human-induced activities contributed to climate change and variability. However, Jonge (2010) found farmers in Australia were aware of the changing climate, but could not associate it with human activities and attributed them to natural causes. The major contentious issue emerging is failure of farmers to interpret and contextualise the meaning and major causes of climate change and variability. Corner (2011) observed, that while respondents knew that the climate was changing, very few could explain why. The study by Corner concluded that peoples' awareness and understanding of the main causes of global warming was tremendously low.

Tarhule (2007) and Tumbo, Mbilinyi, Rwehumbiza and Mutabazi (2010) explained that, in order to reduce the vulnerability and enhance the capability of communities to effectively adapt to climate change and variability, there was a need for the scientific community to enhance people' awareness and understanding of the magnitude of the problem. The authors reasoned that farmers' understanding would not suffice if there were not properly designed options to respond to the adverse effects of climate changes and variability.

Slegers (2008) noted that farmers in Goima, Tanzania, were turning to scientific weather forecasts as local indicators seemed to have lost accuracy in recent years. Roncoli and Kirshen (2002) observed that farmers' perceptions of the lack of dependability of local indicators used in predicting the season contributed to their turning to scientific weather forecasts even though that method can sometimes offer inaccurate information.

While Yanda and Mubaya (2011:139) found a positive significant relationship between farmers who access weather information and the growing of drought-tolerant crops, the present study found that few farmers used scientific weather forecasts in farming decisions. These findings are consistent with those of Tarhule and Lamb (2003) who found that the majority (two-thirds) of farmers in West Africa were using traditional farming and IK in weather forecasting. It has been documented that, despite improvements in scientific knowledge on adaptation to climate change and variability, still very few farmers in developing countries use this information to make their farm decisions (Tarhule and Lamb

2003 and Sivakumar, Mannava and Motha 2007). These findings concur with those by Kandji, Verchot and Mackensen (2006), who said that, despite the challenges in the output, the current developments in weather forecasting which they had observed were sufficient to be of benefit to farmers. Major reasons for the slow use of scientific weather forecasts are inadequate strategies to ensure information reaches farmers and the low level of preparedness by farmers. These findings concur with those by Sivakumar, Mannava, Motha (2007) and Mutekwa (2009), who claimed that farmers' low awareness and uncertainty of seasonal weather information were the major production risks encountered by farmers. Their studies suggested that agricultural extension officers need to design response strategies by explaining to, and training farmers on, the importance of seasonal climate forecast information and how they can use it to make efficient use of their limited resources, through informed investment decisions.

The other reason contributing to the low use of scientific weather forecast information is distrust of scientific weather forecasts. This distrust still prevails and is noticeable among farmers. Supporting this statement, Mchombu (2002) points out that in recent years most developed countries have turned to indigenous knowledge as they have found that scientific knowledge has failed to adequately address some of the human problems. In this regard, distrust of scientific knowledge in weather forecasts might be associated with farmers past experience of relying on scientific weather prediction. The next section, 6.7.2.3, discusses farmers' indigenous knowledge used in adaptation to climate change and variability.

6.7.2.3 Indigenous Knowledge on Adaptation to Climate Change and Variability

Respondents were requested to identify the indigenous knowledge they had been using to combat drought, floods and grain preservation in their farming activities (cf. question d24 in Appendices 1, 2 and question 6 in Appendix 5). Findings, as described in Chapter Five, section 5.8.2, showed that farmers used mixed cropping, drought-resistant crops, crop diversification, using ridge farming methods, burning farm residues, using ash to kill pests and contour farming as indigenous methods to cope with adverse climatic factors.

Slegers (2008) found farmers in semi-arid Tanzania were practicing indigenous methods such as ridge cultivation for preventing soil erosion. Slegers' study employed in-depth interviews, focus group discussion and questionnaires and field visits in collecting data to collect views and data from farmers. Lema and Majule (2009) in Tanzania recorded that farmers had been

applying mixed cropping, ridge farming, preparation of land for planting, staggered seed cropping and burning and preparation of land for planting as methods of enhancing their crop productivity. Lema and Majules' adopted both qualitative and quantitative methods and used focus group discussions, data from Tanzania Meteorological Agency, interviews, questionnaires and wealth-ranking, to collect data from farmers.

Magombo, Phiri, Kanthiti, Kachulu and Kabuli (2011) studied indigenous and innovative climate change adaptation practices of farmers in Malawi. Unlike the current study and others previously described, Magombo *et al.* applied only quantitative research methods, employing a household survey and administered questionnaires to 300 families, selected using random sampling. The study found indigenous climate change and variability strategies farmers used were mixed cropping farming methods, crop diversification, small-scale irrigation and organic manure.

Adejuwon, Odekunle and Omotayo (2008:166) explained that farmers in Nigeria had been using shallow wells as water storage facilities, applying mulching to protect seedlings from dry spells and the use of wetlands as means to cope and adapt to climate change and variability. On farmers' grain preservation, similar findings were noted by Kangalawe, Mwakalila and Masolwa (2011), who observed that farmers use ground tree leaves as grain preservation materials. These findings show that farmers have been coping with climate change and variability for many years using local methods. The most pressing issue, as indicated by Yanda and Mubaya (2011:25), is that, despite coping strategies for climate change and variability not being new to African farmers, the available coping methods may not be effective to offset the challenges brought by the climate changes that are expected. Thus, since adaptation is a long-term process which changes according to the weather and patterns, use of indigenous and scientific farming knowledge should complement other approaches and not be substituted for them. In fact, scientific knowledge should build on effective indigenous knowledge coping strategies.

This study further sought to establish whether IK on seasonal weather prediction existed in their community and whether the respondents possessed it (see questions d25 and 26 in Appendices 1 and 2). Despite findings by Green and Raygorodetsky (2010), showing that researchers perceived scientific knowledge to be superior to indigenous knowledge, the present study findings, as indicated in section 5.8.2 of Chapter Five, established that IK exists

and was mostly relied on and widely used in the community to plan for agricultural activities. Findings indicated that the majority (92.9%) of respondents possessed IK on weather forecasting and many (76.2%) relied on IK for weather prediction. Adejuwon, Odekunle and Omotayo (2008:166) recorded that in Nigeria, prior to scientific weather forecast information becoming available, farmers used traditional agricultural practices to mitigate the adverse impacts of weather and climate. The authors explained that even the farming methods recently adopted by farmers in most African countries, such as intercropping, multiple and relay planting, were not new to farmers, as they possessed salient features of indigenous farming practices that had been used by farmers for years. The authors reasoned that these farming methods and others generally aimed at ensuring food for farmers when a crop fails due to harsh climatic conditions.

This study sought to reveal what types of IK farmers possess with regard to weather forecasting (cf. questions d27 in Appendices 1 and 2). Findings in section 5.8.2.1 established that farmers use local indicators such as plant phenology, birds, animals, insects, wind direction, moon structure, stars, stones and sun to forecast weather. Slegers (2008), Chang'a, Yanda and Ngana (2010), Tumbo, Mbilinyi, Rwehumbiza and Mutabazi (2010) and Kangalawe, Mwakalila and Masolwa (2011) in Tanzania revealed that farmers use plant phenology, animals, birds, insects and astronomical indicators to predict weather and climate. For these studies the methodologies used were similar to those of this current study. The studies mostly applied qualitative rather than quantitative methods, such as structured interviews, semi-structured interviews and focus group discussions, to collect data from farmers. A study by Mengistu (2011) in Ethiopia explored farmers' perceptions and knowledge of climate change and their coping strategies. Contrary to the methodology used by Slegers (2008), Chang'a, Yanda and Ngana (2010), Tumbo, Mbilinyi, Rwehumbiza and Mutabazi (2010) and Kangalawe, Mwakalila and Masolwa (2011), Mengistu's study applied only qualitative research methods where focus group discussions were used to collect data from farmers. Key findings of the study showed that farmers use clouds, wind direction, sky colour, animal behaviour and plants to forecast rainfall in a season. Mengistu's findings concurs those of Tarhule and Lamb (2003) in West Africa who found farmers use stars, clouds cover, sky colour, wind and temperature to forecast weather.

The findings on the existence of IK farming practices in Africa by Adejuwon, Odekunle and Omotayo (2008) were supported by those of Slegers (2008) and Tumbo, Mbilinyi,

Rwehumbiza and Mutabazi (2010), who noted that farmers in Tanzania use their accumulated experience on observed natural phenomena to predict weather in a season in planning for their agricultural calendar. This is due to the fact that for a number of years rural communities have applied their indigenous knowledge on weather and climate prediction. Stigter *et al.* (2007:214) and Mutekwa (2009) observed that farmers in most poor and rural communities make farm and other production decisions based on their IK systems such as perceived indicators and previous experience. The major attributes explained by authors with regard to increased IK usage were observability and trialability characteristics which farmers had developed from years of observation, experiences and experimentation with weather pattern predictions. These attributes have been fully described in the Diffusion of Innovations model by Rogers (2003).

Despite the previously described studies indicating that farmers used IK in predicting weather, the findings of the current study were that in recent years the majority of farmers had said that the use of IK based on local indicators has lost accuracy in weather and climate forecasts (refer section 5.8.2) (cf. question d30 in Appendices 1 and 2). As a result, farmers blamed climate change and variability as the major cause of the lack of efficacy of these IK methods. Farmers perceived the indigenous knowledge on local indicators to be unreliable in predicting weather patterns and this threatens the perishing of IK, in general, in the near future. Studies by Ingram, Roncoli and Kirshen (2002) in Burkina Faso and Chang'a, Yanda and Ngana (2010) and Slegers (2008) in Tanzania found that increased climate variability has reduced the accuracy and reliability of local indicators in season predictions of the season.

The results from cross-tabulation analysis between age and indigenous knowledge could not establish any significant relationship between age of farmers and possession of indigenous knowledge. Findings showed a Pearson Chi-square value of 1.752 and the significance value of 0.882 at the 0.05 level significance. However, qualitative results of this study had indicated that elderly farmers possessed more IK than young ones. The qualitative results are consistent with those by Chan'ga, Yanda and Ngana (2010) and Kangalawe, Mwakalila and Masolwa (2011), indicating that aged farmers tend to be more aware of IK compared to young ones.

In Kenya Cherotich, Saidu, Bebe (2012) argued that the majority (83%) of elderly farmers mostly preferred IK to radio, extension officers and village leaders in accessing information on climate change and variability. The study implies that the elders, who mostly possess IK,

prefer IK sources to other sources to access information on climate change and variability. Farmers' awareness and knowledge acquired through many years of interacting with the environment tended to improve as time goes. Since elderly farmers were accustomed to predicting the weather using indigenous ways, this developed into a habit, which eventually led to preference of an information source to use to access information on climate change and variability.

Farmers possessing and relying on IK does not guarantee that farmers will use the knowledge in responding to the adverse impacts of climate change and variability. A study in Kenya by Speranza *et al.* (2010) learned that, despite farmers possessing indigenous knowledge on indicators of rainfall variability, they were not applying that knowledge adequately to changing their farming practices. These findings indicate that farmers were using scientific knowledge to make on-farm decisions. The study asserts that farmers used both IK and scientific knowledge to make their farming decisions. Their study found that IK was used by farmers as the basic knowledge to interpret and compare with scientific weather forecasts from meteorological stations to make farm decisions. Results by Speranza *et al.* (2010) were consistent with those of Munyua and Stilwell (2013). Munyua and Stilwell used interviews and focus group discussions to collect data from farmers in the Kirinyaga district of Kenya. The key findings indicated that the majority of farmers used scientific knowledge to make farm decisions. The study revealed that a substantial number of farmers use both scientific and indigenous knowledge systems in farming. These findings demonstrated a paradigm shift of farmers from exclusively using indigenous knowledge in farming practises to more reliance on scientific knowledge from extension officers, to manage farm activities.

IK and SK in most developing countries like Tanzania cannot work in isolation. The main reason is that that rural people are used to indigenous knowledge being embedded in their community to predict weather. The two types of knowledge should rather complement than compete with one another, as they both have their strengths and weaknesses. Therefore in order to foster the use of scientific knowledge in adaptation, there is need for scientists and local forecasters to collaborate. Murray and Orindi (2005) stressed the need for collaboration between agricultural experts and researchers to facilitate the provision of information on climate change and variability to farmers. These authors are of the view that SK should build on traditional knowledge.

Mutekwa (2009) argues for the use of both indigenous and scientific knowledge in adaptation to climate change and variability. He suggests that newly designed adaptation strategies should include the use of both existing indigenous knowledge and scientific practices to enhance farmers' capacity to effectively respond to climate change and variability. These findings confirm those by Shetto (2008), who emphasised that farmers who possessed IK adapted effectively to rain-water harvesting innovations. Ziervogel and Opere (2010), Green and Raygorodetsky (2010), Hisali, Birungi and Buyinza (2011), Corner (2011) and Mahoo and Mpetta (2011), observed a need for researchers to accept and incorporate both indigenous and scientific knowledge to enhance effective mitigation and adaptation strategies.

Stigter *et al.* (2007:487) supports the synergising of new scientific-based knowledge on weather forecasting which, in their view, provides accurate and reliable information, compatible with and blending with, the cultural system of the community (Rogers (2003:254-257). This blending might be of great help to produce innovations which are compatible with the values of the community and can easily be adopted by farmers. Ziervogel and Opere (2010) support integrating meteorological forecasts (explicit) and indigenous knowledge (tacit). These authors are of the view that farmers should be provided with the specific meteorological information they would use, such as onset of rainfall, total rainfall expected in the season, ending of rainfall, intra-seasonal variations which inform farmers' decisions on when to plant, what crops to plant, types of technologies to be applied and when to start harvesting. This knowledge should take the local IK possessed largely as tacit knowledge into account.

This study sought to investigate factors which reduced farmers' reliability and use of IK for weather forecasting (cf. questions d30 in Appendices 1 and 2). The findings, as explained in section 5.8.3, indicated that indigenous knowledge is fading away in the community and climate change and variability, loss of elders and scientific knowledge as major factors being blamed for the cause. Corner (2011) warns that climate change is a serious threat to indigenous indicators used to predict weather and calls upon the meteorological agencies to provide reliable and timely information to the community through local radios to enhance usage. One major reason for farmers to shun IK is the poor accuracy of local signs in weather prediction, as well as a loss of interest in IK by younger members of the community. Slegers (2008) found that most young farmers in developing countries have recently lost interest in making use of local signs in weather prediction, as they fail to predict weather. Supporting

the above argument, Mutekwa (2009) found that farmers have recently failed to forecast the time of the onset of seasonal rainfall. With regard to farmers' concern that scientific knowledge is contributing to the loss of IK, a study by Sturges and Chimseu (1996a) supports this notion and explains that scientific knowledge erodes the confidence of communities in using their traditional knowledge systems.

Speranza *et al.* (2010) felt that IK is threatened with perishing in the long term in society, as there is a limited transfer from generation to generation. Problems in the documentation and preservation of IK were explained by Chan'ga, Yanda and Ngana (2010) as the cause. The study by Chan'ga, Yanda and Ngana was conducted in the South-Western Highlands of Tanzania and used key informant semi-structured interviews and focus group discussions to collect data from crop farmers, pastoralists and agro-pastoralists. Key findings were that the loss of elders was a threat to accessing and using this knowledge, as the knowledge is neither documented nor preserved. This might be aggravated by the communication gap between elders who possess IK and young ones who have limited knowledge of it (see section 5.13). Mchombu (2002) asserts that this gap is a result of barriers in transferring knowledge from elders to the younger generation. This author feels that the reason for the existing gap was criticism of the IK by dominant cultures, which resulted in low usage of traditional knowledge channels of communication, which farmers mostly relied on in the past to access traditional information. Mchombu further argues that IK is fading away in the community, as the younger generation does not have IK on the environment and agriculture being imparted to them. Studies by Mchombu (2002), Chang'a, Yanda, Ngana (2010) and Kangalawe, Mwakalila, Masolwa (2011) emphasise the documentation, preservation and incorporation of IK in local adaptation planning strategies.

Farmers were asked to advise about the best methods to preserve/store the indigenous knowledge (refer to question d31 in Appendices 1 and 2). The findings indicated that storytelling and incorporating indigenous knowledge as a subject in the curriculum in schools, and collaboration with knowledgeable people in a community (opinion leaders) were critical for preservation. IK should be converted to readable formats such as print and digitised for future reference and wider sharing (Munyua and Stilwell 2013). Speranza *et al.* (2010) suggested that a way to ensure indigenous knowledge was preserved and used is to incorporate it in the education curriculum and link it with formal climate change and variability research, by involving the local people. The critical departure of this study is the

need to document and preserve indigenous knowledge in semi-arid regions to foster adaptation to climate change and variability. These regions are geographically challenged and prone to the adverse effects of climate change and variability due to the minimal amount of annual rainfall received. The next step should be designing ways of how to incorporate IK and SK to reduce farmers' vulnerability and promote adaptation at the local levels where most resource-poor farmers are living. One way should be providing farmers with the scientific information they might need to adapt to climate change and variability. The other way should be documenting farmers' success stories of using IK and SK to reduce the adverse impacts of climate change and variability.

6.8 Farmers' Levels of Adoption of Information on Adaptation to Climate Change and Variability

Adoption of innovation is of great value to farmers' adaptation to climate change and variability, as it exposes farmers to new knowledge on improving agricultural production. Section 6.8.1 introduces farmers' adoption practices and section 6.8.2 discusses access to, and the adoption of, innovations. Sivakumar, Mannava, Motha (2007) are of the view that the generation of technology, innovation and adoption in many developing countries was too slow to adequately offset the increasing adverse effects of climate change and variability adequately. In this regard, the role of farmers' access to timely information is urgently needed. However, the diffusion and adoption of innovations has been described in the Diffusion of Innovations model to have a series of steps. Rogers (2003) described these steps pertaining to the diffusion and adoption of innovations to involve a series of decision processes, which are the perceived need of an innovation, awareness, knowledge acquisition, decision-making and adoption or rejection of an innovation.

Mchombu (2002) had similar views to those of Rogers and explained that innovative ideas in a community constitute four steps, which are the awareness stage, the interest stage, the examination and testing stage and finally the adoption or rejection stage. In a nutshell, these scholars' findings explain that information is a pre-requisite in the adoption of innovations and farm decision-making. With regard to the level of adoption of information on climate change and variability for adaptation to climate change and variability, Tumbo, Mbilinyi, Rwehumbiza and Mutabazi (2010) found that, despite having a number of potential mitigation strategies in Tanzania, there is still minimal adoption. Their study envisages that

for most proposed adaptation strategies to be adopted there is need for scaling-up of these strategies to a wider community.

6.8.1 Farmers' Levels of Adoption and Farm Decision-Making for Adaptation to Climate Change and Variability

Farmers were asked about the types of innovations which they had adapted based on information received from CCAA trainers (see questions f41 and f42 in Appendices 1 and 2). Findings presented in section 5.11, indicate that most farmers (95.2%) have adopted innovations on improved farming methods and 81.0% grow high value crops, compared to 58.3% who grow improved seeds and 53.6% who use new technology and farm implements. Farmers indicated that they had adopted these innovations as a result of access to information disseminated to them through CCAA experts. These findings agree with those of Meyer (2000), who showed that agricultural innovations to rural farmers were effectively transferred to farmers through training. The study used documentation, interviews, audio-visual and direct observation methods to collect data. Meyers also mostly applied qualitative methods, similar to the present study. The role of information in adoption has been stressed by Rousan (2007), who found that farmers in Jordan perceived a positive correlation between the ability to share information, communication capability and adoption rate, as major factors determining farmers' adoption levels and farm decision-making, enhancing adaptation. Rousans used simple random sampling to select 160 women and a structured interview schedule to collect data. Rousan's study utilised mostly qualitative methods to collect data, while the present study used both qualitative and quantitative methods.

The study findings indicated that innovation least adopted by farmers was improved seed growth. There could be several reasons for this. One is the cultural barriers which have been mentioned by Rogers (2003) to contribute to the adoption rate of an innovation. Supporting the study's observation, results by Rousan (2007) and Sturdy, Jewitt and Lorentz (2008) indicated that for an innovation to be adopted by farmers a number of attributes need to be taken into account. These include farmers' needs, beliefs, norms and taboos and not the researchers' beliefs. Scientific arguments about agricultural innovation as norms greatly influence adoption. Slegers (2008) observed that a culture of laziness and sticking to their existing knowledge was a reason affecting farmers' adoption of innovations. The other factor explaining the minimal adoption of improved seed growth might be lower return and motivation from the process of growing seeds. Thus, as has been argued by Rogers (2003),

farmers' perceptions of an innovation are mostly influenced by the relative advantage, observability, complexity and trialability of that innovation.

This study sought to find farmers' rate of adoption of innovations subsequent to the training they had undergone (see questions f42 and f43 in Appendices 1 and 2). The findings indicated that 73.8% of the farmers had adopted innovations, while some 3.6% did not adopt the innovations. A similar study to this by Meyer (2000) in South Africa revealed that farmers' training was crucial in the transferring of agricultural knowledge from scientists to farmers. The study emphasised the compatibility between the information disseminator and receiver as an important aspect in facilitating farmers' adoption of innovations. The compatibility involves use of proper dissemination tools, format and language to farmers. Rogers (2003) regards compatibility as an important aspect for diffusion to, and adoption of innovations by farmers.

Extension officers and the programme manager were asked whether there was any difference in rate of adoption of information between farmers who had received and those who had not received training through the CCAA project (cf. questions d20 and e25 in Appendices 3 and 4). Despite the study findings not establishing any major difference between these groups, findings from the in-depth interviews with the district agricultural officers of both Chibelela and Maluga villages and the CCAA programme manager indicated that there was a difference in adoption between farmers who had received training and those who had not received training from CCAA project. The major reasons for the observed variation in adoption could be the trained farmers' possibly having an enhanced ability to seek consultations from extension officers. Other likely factors are their demonstrated willingness to learn, differences in farmers' incomes and, consequently, in their capacity to purchase farm inputs and implements.

These findings confirm those in the Diffusion of Innovations model, which depict the crucial role of socio-economic factors in determining the rate of adoption of an innovation (Rogers 2003:288). The results concur with those in Nigeria of Matthews-Njoku, Adesope and Iruba (2009). These authors used quantitative methods and mainly a structured questionnaire to collect data from respondents. Unlike this study, where the researcher collected data from farmers, Matthews-Njoku, Adesope and Iruba used extension officers to administer the questionnaire. The Nigerian study discovered that farmers were not receiving adequate

technical information from extension officers who were intended to be the key communication channels to enhance information dissemination. Inadequate receipt of technical information by farmers contributed to the low usage of improved crop production practices which, in turn, hindered agricultural production by women.

Despite the study establishing that access to training by farmers had an impact on the adoption of innovation and farm decision-making, it also found that there were several other factors which could be contributing to influencing farmers' adoption of innovations. These factors are discussed and interpreted in the next section, 6.8.2.

6.8.2 Factors Influencing Farmers' Adoption of Innovations for Adaptation to Climate Change and Variability

Sivakumar, Mannava and Motha (2007) proclaimed that agricultural production decision-making was complex, as farmers are faced with many challenges, including climate change and variability. Their study tested the five attributes which influence the rate of adoption of innovations: trialability, observability, complexity, compatibility and relative advantage. The study found these adoption attributes, as described in the Diffusion of Innovations model, to be extremely critical in enhancing farmers' adaptation to climate change and variability. The complexity attribute was tested when farmers were requested to state whether or not they had tried to apply an innovation from an expert and had failed to do so (see questions f45 and f46 in Appendices 1 and 2, respectively).

The findings indicated that most farmers (71.4%) had not failed when trying out an innovation. This could be attributed to farmers' access to technical information from CCAA project experts. Despite farmers indicating they had not failed upon trying an innovation, the current study showed a low level of trialability (22.6%) for farmers who tried innovations from other extension services and failed (refer to question f46 and f47 in Appendices 1 and 2). Low levels of trialability could be associated with perceived farming risks and low risk tolerance levels by farmers. The perceived risk might be contributed by climate change and variability, among other factors. Farmers' perceived that risks are not only observed in developing countries, but also in developed ones. Coles and Scott's (2009) study on farmers in the USA similarly found that farmers had low levels of risk tolerance. Observability was probed when respondents were requested to indicate if they take time to observe the impact of applying an innovation to improve their agricultural practices (cf. questions f47 and f48 in

Appendices 1 and 2). The results showed a high level of observability (85.7%) from farmers (refer to section 5.11).

These findings corroborate those of Rogers, who showed the rate of adoption of an innovation to be influenced by complexity, observability and trialability (Rogers 2003). Drechsel *et al.* (2006) and Ngigi (2009) agreed that the adoption of new information by farmers' heavily depends on an innovation not being complex (complexity), trialable and being observable within a specific period of time (observability). Rogers elaborated that an innovation should be trialable in other settings (trialability) and compatible with the needs, values and culture of a community. Supporting the notion of attributes in the adoption of innovations, a study in Honduras by Arellanes and Lee (2003) found that despite other factors contributing to farmers' adoption of innovations, the simplicity of the innovation, affordability and the availability of new adaptation practices significantly influenced farmers' behavioural change towards use of that innovation. Arellanes and Lees employed household interviews in collecting data to study farmers' adoption of sustainable agricultural technologies.

The major contending issue emerging from the current study findings farmers' low trialability and high observability is how farmers can effectively mitigate climate change and variability with difficulties in accessing timely information from extension officers. Results have shown that extension officers are not reliable for farmers (refer to section 6.2). Despite evidence from section 6.4 of this chapter showing farmers adapt locally to changes in climate, improving food security at household level will be a challenge if farmers' risks are not reduced. One of the best ways will be to improve farmers' access to timely and reliable information on climate change and variability, to enhance adaptation and improve farmers' risk tolerance levels (Apata, Samuel and Adenola 2009; Gwimbi 2009 and Mengistu 2011).

Farmers' adoption and understanding would be less likely take place if the innovations presented to farmers were in a format which is complex and incompatible with cultural farming values of farmers (Garforth 1998). Mchombu (2002) and Rogers (2003), despite learning that understanding was critical in adoption and decision-making regarding innovations noted that the format and language in which this information was presented to users highly determined the way they clearly understood the innovation. Simple and well-understood formats promoted the adoption of innovations more than complex ones. These

findings have been supported by Kandji, Verchot and Mackensen (2006), who noted that the complexity and probabilistic nature of seasonal forecasts affected farmers' adoption of information on climate change and variability. For effective adoption of innovations, agricultural researchers and experts need to strengthen their understanding and communication capabilities for them to convince users and meet their needs.

Furthermore, as the current study findings from farmers' showed high observability (see section 5.11) it implies that farmers' observation time is an important component in promoting the adoption of innovations by individuals in a community. If farmers are not provided with adequate time to observe, try and diffuse new information, it is likely to reduce their ability to adopt an innovation. These findings are consistent with those explained by the Diffusion of Innovations' model, which indicates that time is crucial in the innovation-decision process which individuals undergo in the adoption of an innovation. Time is a critical variable in the adoption of innovations, as it enables an individual to acquire knowledge, develop an attitude, make a decision and use or reject a particular innovation (Rogers 2003:21). Rees *et al.* (2000), Drechsel *et al.* (2006) and Lorenzoni, Nicholso-Cole and Whitmarsh (2007) emphasise the need for farmers to be provided with sufficient time to assimilate new knowledge. The authors stress the need for researchers, farmers and extension officers to conduct frequent participatory learning sessions and use social networks such as farmer groups in order to enhance the flow of information for quicker adoption through observability and trialability of research outputs. The Diffusion of Innovations model (Rogers 2003) also emphasises the role of social networks in the adoption of innovations.

Several authors have observed that attitude influences trialability. Rogers (2003), through the Diffusion of Innovations model explains that users' perceptions of an innovation determine its adoption rate (2003:15). Drechsel *et al.* (2006) found that attitude towards trialability of an innovation is important for adoption. Similar findings on innovation attributes were also observed by Mchombu (2002). Ngigi (2009) mentioned demonstrations and field exchange visits as critical in the adoption of innovations, as through them, farmers can form positive attitudes towards innovations.

The compatibility attribute of innovations was tested on farmers as they were asked how compatible the innovations introduced by trainers were when compared with their normal agricultural practices (cf. questions f48 and f49 in Appendices 1 and 2). Results from the

semi-structured interviews showed that the majority (60.7%) of respondents indicated that the innovations were compatible. The DOI model by Rogers explains that the more an innovation is considered consistent with the individuals' needs, past experience and present values the quicker it can be assimilated in a community (2003:240-241). Garforth (1998) noted that, for innovation products to be appropriately assimilated into a community, they must be relevant, compatible and affordable.

The study results on relative advantage were measured through farmers' responses to the innovations received from the CCAA project, as observed in section 5.6.1 of the thesis. The section describes the usefulness of the training which farmers had undergone and comprehensively covers the relative advantage of adoption attribute. It captures and indicates that the innovations farmers had adopted in the course of training. It shows that the innovations are far better than the conventional methods. Arellanes and Lee (2003) and Drechsel *et al.* (2009) observed that an innovation is easily diffused and adopted if it is perceived as beneficial and relatively advantageous. Kaliba, Verkuijl and Mwangi (2000) in Tanzania and Mutekwa (2009) in Zimbabwe found that farmers had adopted growing improved varieties such as drought-resistant and short-season crop varieties as a result of perceived benefits of the new varieties over the others. The findings established farmers' attitudes to hybrid varieties were relatively advantageous as they were capable of increasing annual yields and maturing in a shorter period of time, compared with traditional varieties.

The study investigated whether or not there was correlation between age, gender, level of education, farmers' level of income and level of adoption of innovations (see section 5.11). Findings from the cross-tabulation showed a direct relationship between an increase in age and the level of adoption of innovations by farmers. The analysis shows the Pearson Chi-square value of 35.431 and the significance value is 0.018, at the 0.05 level of significance. These results are inconsistent with those of Akudugu, Guo and Dadzie's (2012) adoption study in Ghana. These researchers applied probability multistage and simple random sampling to identify respondents and interviewed the respondents using a household questionnaire. Unlike this study, which applied both purposive and snowballing sampling procedure and qualitative and quantitative methods to collect data, the study by Akudugu, Guo and Dadzie used quantitative research methods and random sampling to select respondents. The present this study had the majority of respondents (31%) between the ages of 36 and 45 years while those in Akudugu, Guo and Dadzie's study mostly (93%) covered a

longer age span, of 18 to 60 years. The present study found age to be one of the social factors which affects adoption of innovations by farmers. The greater the age the greater the chance of a farmer adopting the innovation. A similar study in Ghana by Mensah-Fosu, Vleck, Manschadi (2010) found age not to be a factor influencing adaptation to climate change and variability. The Ghanaian study applied structured and unstructured interviews to collect data from 180 randomly selected farmers.

With regard to gender, the current study could not ascertain any direct association between gender and adoption of innovations. The cross-tabulation between gender and adoption of innovations indicates a Pearson Chi-square value of 2.465 and a significance value of 0.651, at a 0.05 level of significance. The present study could not ascertain any significant relationship between gender and adoption of information on climate change and variability. These findings confirm those by Arellanes and Lee (2003) in Honduras, who explored the determinants of adoption of low-input sustainable agriculture technologies on hillsides. The Honduras study applied household interviews to collect data from respondents. The study found that the adoption of innovations in Honduras were significantly influenced by the simplicity of the innovation, affordability and the availability of water through irrigation practices, land ownership and soil quality. Studies by Masangano and Miles (2004) and Akudugu, Guo and Dadzie (2012), contrary to the current findings, noted gender to be a factor enhancing the adoption of information on climate change and variability. Despite many scholars describing various determinants of adoption of innovations, as have been discussed in previous sections, a correlation test done by Rousan (2007) indicated that information sources' credibility and competency, cost, land tenure, capability to be shared, communication ability and relative advantage have positive and significant relationships with the adoption of innovations.

This study determined a statistical association between farmers' income levels and the adoption of innovations. This could be contributed by the composition of farmers, which indicated that there were wealthier farmers in both villages (see section 5.1.4). Cross-tabulation findings show a Pearson Chi-square of 37.282 and a significance value of 0.002, at the 0.05 level of significance. These findings confirm those by Rogers (2003:288), which show that wealth enhances the adoption of innovations. Lyimo and Kangalawe (2010) assessed vulnerability and adaptive strategies to the impact of climate change and variability in semi-arid Tanzania and collected data from farmers through focus group discussions, key

informants and structured household interviews. These authors' key finding showed that adoption of new farming practices to respond to climate change and variability is heavily influenced by wealth status, which enhanced their adaptive capacities. Similar results were found in Malawi by Magombo *et al.* (2011) and indicated household income to be a strong determinant in adoption of innovations on adaptation to climate change and variability.

Despite Lyimo and Kangalawes' study in Tanzania, showing that income is correlated with adoption, a study in Ghana by Boahene, Snijders and Folmer (1999) found that income was not a factor influencing the adoption of innovations. The research used simple random and purposive sampling and interviews to collect data from 103 farmers involved in cultivating cocoa. The study noted that wealthier farmers had better access to loans than small scale farmers. Findings from India by Mukhopadhyay were inconsistent with the present study's findings and found wealth not to be a strong determinant in adoption, but rather access to information, knowledge, skills and irrigation. The study noted that income was not an influencing factor in least developing countries like Tanzania, but also in highly developed countries such as the USA and China. Studies by Prokopy, Floress, Klotthor-Weinkauff, and Baumgart-Getz (2008) in the USA and by Stigter *et al.* (2007) in China found farmers' level of income to influence adoption of innovations in these countries.

This study found a direct correlation between level of education and adoption of innovations. The study findings depict the Pearson Chi-square value of 41.624 and the value of significance of 0.000, at the 0.05 level of significance. A study by Erbaugh, Donnermeyer and Amujal (2007) in Uganda found the level of education to influence the adoption of innovations. The authors used probability sampling to select samples and applied structured interviews in data collection. Other authors who observed that education was important in adoption of innovations were Masangano and Miles (2004), Erbaugh, Donnermeyer, Amujal (2007), Rousan (2007) and Deressa *et al.* (2008) and Gundu (2009) in Malawi, Uganda, Jordan, Ethiopia and Zimbabwe, respectively. The findings of a study by Arellanes and Lee (2003) were inconsistent with the current study's findings, in that level of education did not significantly influence adoption of minimum tillage, which was a low-input sustainable agricultural technology.

Perceived risk was another factor which influenced farmers' adoption of innovations (Rogers 2003). Sivakumar, Mannava and Motha (2007) and Coles and Scott (2009) noted agricultural

production decision-making to be complex, as farmers face many types of risks related to production, social, marketing, human and legal aspects. The current study results showed when farmers failed to apply an introduced innovation, the majority (90%) preferred to then consult a source before repeating an innovation. These findings were consistent with those of Rogers (2003:258) and Agrawal (2008), who observed that personal trial of a new innovation enables an individual to minimise uncertainty about an innovation and enhance adoption. Mukhala and Chavula (2007) stated that most farmers in African countries are resource constrained. Poor decision-making by a farmer results in poor production and food insecurity in the next season. Based on the findings above, showing that farmers prefer consulting a source before repeating a failed innovation, the inference is that they are restrained by the risks associated with the innovation. These findings confirm those by Kandji, Verchot and Mackensen (2006), who observed that the uncertainty emanating from crop failure makes farmers hesitant to adopt information on climate change and variability. The authors observed that farmers in most African countries fail to adopt innovations such as industrial fertilizers and high-yielding crop varieties as they are not certain whether the rainfall will be adequate or not.

Farmers' risks have also been observed by Kaliba, Verkuijl and Mwangi, (2000) in Tanzania and Coles and Scott (2009) in the United States. These authors found that low adoption of information on climate change and variability was highly affected by, among other things, low levels of risk tolerance and uncertainty about seasonal forecast information. Sivakumar, Mannava and Motha (2007) observed that weather and climate have been among the major factors which increase uncertainty and production risks in agricultural systems management. Scandizzo and Savastano (2010) recorded that, despite its economic returns, low adoption of modern genetically modified crops arose from farmers' skepticism about the risks for the environment and for human beings. Contributing to the literature on farmers' risk, Mchombu (2002) and Rogers (2003) reason that, despite farmers' low adoption rate being associated with expected risks, risk is mostly associated with either lack of adequate information on a new idea or inadequate finance.

In order to strengthen farmers' risks' tolerance in adapting to climate change, Kaliba, Verkuijl and Mwangi (2000) found that more farmer field trials and the effective utilisation of extension officers played a significant role. The authors advocated a less complex innovation, which took into account the cultural values of a community. These findings

confirm those by the DOI model by Rogers, which explains that the more an innovation is considered consistent with the individuals' needs, past experience and present values, the quicker it can be assimilated in a community (Rogers 2003:240-241). Akudugu, Guo and Dadzie (2012) agree that farmers' adoption has contributed to the expected benefits of the new technology and reliability of the extension services.

It is important to accept that with most innovations some risk associated with that innovation is inevitable. What is essential is enhancing farmers' ability to tolerate risks through access to relevant information and provision of adequate resources, which improve their adaptation capacity. This notion was raised by Drechsel *et al.* (2006), who found that farmers risk tolerance is crucial in adopting innovations. In this regard, high preparedness, prior knowledge of the timing and magnitude of weather events and climatic anomalies, resource availability and effective recovery plans will be of great significance to reduce farmers' risks and vulnerability to climate change and variability (Sivakumar, Mannava and Motha 2007:1).

Notable differences arose from the agricultural extension officers' views, with regard to the current level of adoption of farmers in both villages (cf. question d21 in Appendix 3). Information obtained from the agricultural extension officer in Chibelela indicated only a slight adoption of information on adaptation to climate change and variability. In contrast, the agricultural extension officer in Maluga indicated that the majority of farmers had adopted information on how to adapt to climate change and variability. The agricultural extension officer from Chibelela named resource constraints as the major factor which prevented farmers from fully adopting innovations. However, field observation from the researcher showed that in Chibelela village the level of diffusion of information by farmers is greater, compared to Maluga village. This difference could be linked to the presence of more farmer groups in Chibelela village than Maluga village. These findings on the farmers' differences in the level of adoption in the two study villages are supported by the Diffusion of Innovations model, which shows interpersonal communication channels which control farmer groups' communication are embedded as a variable which influences adoption of innovations (Rogers 2003).

The study findings in section 5.11, were that access to farm inputs is fundamental in farmers' adoption of innovations. The study indicated a low usage of new technology and farm implements by farmers. It was established that despite farmers changing their attitudes to the

use of new farm implements to adapt to climate change and variability, many explained that access to these facilities was a major obstacle to their adaptation. These findings corroborate those of Salinger, Sivakumar and Motha (2005), Gwambene (2007) and Slegers (2008). These authors ruled out the view that limited use of technology, having poor farm implements and low adaptive capacities in developing countries, contribute to the low adoption capability and adverse effects of climate change and variability. This study found that limited access to farm implements by farmers was caused by distance to the agricultural farm input shops and the high prices of the farm inputs.

It is not only the nations of Africa where farm input prices are of a concern to farmers. High input and farm implement prices and low output prices were noted by Stigter *et al.* (2007:177-178) in China. They found farmers' income levels determined their ability to access and use innovations. In some areas of Africa, Eriksen, Brown and Kelly (2005), Kandji, Verchot and Mackensen (2006) and Akudugu, Guo and Dadzie (2012) found that farmers low capacity to adopt information on climate change and variability was influenced by low consumption and market values and high prices of farm implements and farm inputs. Notably, Roncoli (2006) observed that flexibility and ease of use of innovations such as labour saving technologies and access to credit, allowed a farmer to respond rapidly to climate change and variability.

In Tanzania a study by Slegers (2008) revealed that poor access to farm implements and underutilization of chemical fertilizers by farmers in semi-arid Tanzania was a result of high purchasing prices and inaccessibility. Access to credit has been observed by Slegers (2008) and Drechsel *et al.* (2006) to play a huge role in farmers' access to agricultural inputs. Other factors stated by the scholars as affecting adoption of innovations include limited resources, inadequate income, soil type, availability of food at household level and health status. Regarding the role of household assets and capital, as described in the Sustainable Livelihood Framework, Mukhopadhyay (1994) stated that the presence of agricultural implements alone did not foster adoption. The study indicated that farmers' adoption in India was enhanced by the value of land owned and accessibility of sources for irrigation.

Access to farm inputs which strengthen farmers' ability to adapt to climate change and variability cannot be achieved if farmers have no access to advance information on the adaptation options available to them. Mchombu (2002) confirmed these findings and

observed that access to information sources by farmers were a critical factor influencing their decisions to adopt innovation. He explains that individuals who have access to a variety of information sources, such as radio, newspapers, training and books, are in a better position to adopt innovative information than their colleagues who lack access to such information resources. Findings on farmers' adoption of innovations in the study villages indicate that adoption of innovations was contributed by well-timed access to information from experts. Use of effective communication channels are well explained by the DOI model, which emphasises the fundamental role of communication channels in enhancing farmers' access to farm inputs (Rogers 2003).

In spite of appropriately timed information being critical to the adoption of information and adaptation to climate change and variability, trustfulness, credibility and reliability of information has been observed to influence farmers' use of innovations and adaptation (Cherotich, Saidu and Bebe 2012). The findings of this study revealed that farmers complained about receiving unreliable information from agricultural inputs suppliers and this resulted in the loss of their crops. Close contact and collaboration between farmers, researchers and agricultural experts will enhance adaptation, as farmers will be able to acquire feedback from experts. Farmers' adoption risks could be reduced through access to reliable sources of information and having time to compare and critically analyse an innovation based on trialability, observability, compatibility and complexity of that innovation. These findings confirm those of Rogers (2003), Orindi and Murray (2005), Rousan (2007) and Agrawal (2008), who observed that access to reliable, credible and competency of information sources and personal trial of a new innovation enables an individual to minimize uncertainty and risks about an innovation and encourage its adoption.

The current study indicated that farmers relied mostly on informal networks in their access to information and communications (refer to section 5.12.1 of Chapter Five). Supporting these findings, Boahene, Snijders and Folmer (1999) found that social networks were the major determinants of farmers' adoption of innovations in Ghana. These authors found that social networks played a crucial role in facilitating farmers' access and use of farm inputs to enhance their adoption of new cocoa varieties, which were relatively advantageous compared to the local variety. The role of social networks in helping farmers to change their attitude towards an innovation has been acknowledged by Rogers in the Diffusion of Innovations model. Rogers (2003) stresses the role of social networks in promoting diffusion and

adoption of innovations by farmers. Rogers reasons that information dissemination is a major attribute which influences the innovation-decision making process by creating awareness, imparting new knowledge, changing individuals' attitudes and influencing farmers' decision-making in adopting an innovation (2003:171-189). Dutta (2009) found that people in developing countries mainly relied upon informal social networks to meet their information needs. The observed trend might be influenced by most farmers in developing countries having poor telecommunication infrastructure and low education levels, compared to farmers in the developed world.

Access to relevant knowledge is another factor which enhanced farmers' ability to adopt innovations which were introduced by CCAA experts. Farmers cannot be aware of the availability of new farming practices which are necessary in adaptation to climate change and variability if they are not informed and educated by experts. Drechsel *et al.* (2006) found that information and knowledge sharing was necessary to shape farmers' attitude towards an innovation. Erbaugh, Donnermeyer and Amujal (2007) confirmed the above results and learned that farmers' in Uganda indicated that knowledge was a major factor promoting the adoption of innovations. A study by Mukhopadhyay (1994) in India observed that adoption of innovation and technology was promoted by farmers' knowledge of local conditions and the experience and availability of extension services. Mutekwa (2009) found that in Zimbabwe farmers had adopted drought-resistant and short-season crop varieties as a result of knowledge they had received from experts on climate change and variability.

Research findings by Dimelu and Saingbe (2006) confirmed that the adoption and utilisation of appropriate agricultural technology by rural farmers is not only dependent on the relevance and effectiveness of information disseminated, but also on the ability of the agents to convince the farmers. Access to relevant knowledge does not guarantee an innovation will be adopted by farmers. In Nigeria, Agwu, Ekwueme and Anyanwu (2008) found that farmers' educational levels contributed significantly to the adoption of new technologies. The authors observed that farmers who were illiterate could not follow, even when simplified technical language was broadcast. In this regard, farmers' adoption depends heavily on their ability to understand the innovations disseminated to them on their having a positive attitude towards that innovation.

This study has established that close collaboration between farmers and other stakeholders in the agricultural sector was a necessary step towards enhancing farmers' adoption of innovations and adaptation to climate change and variability. These findings are confirmed by those of Kandji, Verchot and Mackensen (2006), who explained that for effective diffusion and adoption of innovations, a close partnership is needed between meteorological, farmers, farmer groups, research and agricultural extension services and NGOs and community-based organisations (CBOs) to foster the use of information on climate change and variability. Supporting the notion of collaboration, Rohrbach, Lechner, Ipinge and Monyo (1999) found that the adoption of new varieties by farmers was effective when farmers were involved early in the selection of varieties, advanced government distribution of high-quality seeds and responding to the farmers' choice.

A need for close collaboration between agricultural stakeholders was advocated by Sturdy, Jewitt and Lorentz (2008) in South Africa. These authors elaborated on the role of collaboration between researchers, extension officers and farmers in enhancing effective information and knowledge transfer and sharing through farmers' trialability and observability. The authors emphasised the willingness of the farmers to learn as key towards facilitating effective adoption. Their study showed that farmers who were willing to learn and practise new farming methods, develop new farming skills and acquire new farming knowledge would improve their agricultural production. Sturdy, Jewitt and Lorentz (2008) found farmer-driven experimentation as an effective method for spreading scientific farming knowledge to farmers. The close collaboration between farmers and other agricultural stakeholders promoted active participation, which enhanced effective communication and feedback. As a result, farmers were able to evaluate an innovation from researchers and researchers were allowed to assess their innovations introduced to farmers and scientifically identify reasons for their acceptance or rejection.

A socio-economic analysis of adoption of hybrid cocoa varieties in Ghana by Boahene, Snijders and Folmer (1999) found that the determinants of the adoption of innovations were social, economic and culturally related. Scholars explained that disciplines describe factors influencing adoption by leaning towards the nature of that particular discipline. For example, sociologists lean more to the compatibility, values and norms of a society and communication channels. Economists lean more to profitability, cost and risk on innovation investments. In support of Boahene, Snijders and Folmer argument on social-economic determinants of

adoption of innovations, Rousan (2007) found adopter characters such as attitude towards change, land occupancy schemes, risk taking, income level, technical skill, educational level and labour availability were strong adopter characteristics supporting adoption. Effective adoption of innovations which strengthen farmers' capability to adapt to climate change and variability can be improved by integrating social-cultural and economic variables influencing adoption. However, the availability of social and economic attributes of innovation can hardly benefit farmers if farmers have no access to relevant and timely information. This notion is supported by Rousan (2007), who established a positive correlation between ability to access and share information, communication capability and adoption rate as major factors determining farmers' adoption levels and farm decision making enhancing adaptation.

6.9 Access to, and Use of, Information on Climate Change and Variability by Farmers

Mchombu (2002) states that access to information and knowledge, among other benefits, saves the time and resources of members in a community as they learn and adapt to new ideas. Yanda and Mubaya (2011) feel that a key component to farmers' planning, coping and adaptation to climate change and variability is their ability to access credible information which will enable them to change their agricultural production systems. Mukhala (2000) and Sivakumar and Hansen (2007:9) explain that the effective use of information on climate change and variability to a large extent, depends on information disseminators understanding potential users, their behaviour and how information flows between actors. Deressa *et al.* (2008) stressed that access by farmers to extension, weather information and access to formal agricultural extension information enhances farmers' ability to utilise adaptation programmes.

6.9.1 Level of Access to Information on Climate Change and Variability

Kadi, Njau, Mwikya and Kamga (2011) and Mowo *et al.* (2011) observed that the majority of potential users, including farmers in East African countries, have not adequately benefitted from natural resource management research, as they have not accessed the research findings or extension services. Research findings indicate that, despite farmers accessing information on climate change and variability, the information was not delivered on time and was not accurate. Tarhule's (2007) and Kandji and Verchot's (2007) studies in West Africa and East Africa, respectively, found that people fail to apply and utilise climate research findings due to poor access to information on climate change and variability. Tarhule detected an

information gap between policy-makers, the research community, the media and information users in applying the information on the mitigating effects of climate change and variability.

Gunasekera (2011) argues that in most developing countries there are still obstacles which farmers face in accessing, communicating and disseminating reliable and detailed information on the impacts of climate change and variability. He suggests enhancing the collecting of quality and quantity of information through research. Majule and Yanda (2009) are of the view that the majority of farmers fail to adapt to climate change and variability because of poor access to information on new farming innovations. The authors suggest improving access to information on climate change and variability so as to enhance farmers' capacity to adopt innovations.

Ziervogel and Opere (2010) investigated the integration of meteorological and Indigenous Knowledge on seasonal climate forecasts by farmers in sub-Saharan Africa. They found that in the past decade an increase in the awareness of information on climate change and variability, as a result of great advancement in seasonal climate forecasting science, had been observed. These authors found an increased level of access to information on climate change and variability while, usage of this information was substantially low. The findings of Ziervogel and Opere (2010) were different from those of Tarhule and Lamb (2003) who found the majority (two-thirds) of farmers in West Africa were still using traditional farming techniques as a result of failure to access climate information. One of the reasons which might explain the results inconsistency between those of Tarhule and Lamb (2003) and those by Ziervogel and Opere (2010) is the difference in time when the two studies were conducted. Factors which affect farmers' access to and use of information on climate change and variability are discussed in section 6.9.2, sub-section 6.9.2.1 and section 6.11.

6.9.2 Dissemination and Use of Information on Climate Change and Variability

The present study sought to discover out how useful the information disseminated to them on climate change and variability (cf. question h58, h59 and h60, h61) was (Appendices 1 and 2, respectively). The findings recorded in section 5.12.2, state that the information disseminated to farmers on innovations was useful, because it was used effectively to adapt to new farming methods under the observed changing climatic conditions. Garforth (1998) points out that dissemination does not simply mean passing on information to the user, but rather communicating with the user. Mukhala and Chavula (2007) emphasised that the availability

of weather information was not important if it was not being used by farmers to improve yields. However, disseminating and communicating information does not ensure its usage. This is because there are various factors which need to be considered, as the communication process involves more than one person. These include the need for information, awareness, credibility of communication channels, timeliness, cost, language, reliability and ability of the communication source to effectively respond to the needs of users. Meyer (2005) found that the successful use of information to enhance development relies on knowledge of the nature of information and the disseminators' ability to communicate the information in a format recognised by local people. Section 6.9.2.1 discusses factors which influenced farmers' uptake of information on climate change and variability for effective adaptation.

6.9.2.1 Factors Enhancing Farmers' Uptake of Information on Climate Change and Variability

A study by Cherotich, Saidu and Bebe (2012) in semi-arid Kenya found credibility, reliability, timeliness, cost, information content and language to be factors which influenced farmers' access to, and use of, information on climate change and variability. Ingram, Roncoli and Kirshen (2002) found incorporating a local language in the content was crucial in disseminating this information to farmers. Rousan's study (2007) in Jordan found that the characteristics of the information source, such as credibility, cost and ability promoted the adoption of information on climate change and variability.

Ayers and Huq (2009) explained that to promote the use of innovations and technologies by farmers, communication channels must be identified and developed to ensure that the information and knowledge generated are communicated, delivered and transferred to other potential users. Garforth (1998) emphasised the use of proper channels, referred to as dissemination pathways, to enhance effective dissemination and usage of information. Mchombu (2002) explained that the agricultural information disseminated to farmers involves two stages. The first stage is when information flows from the media and extension workers to opinion leaders or influential individuals. The second stage involves information flowing from the information disseminators to farmers. In this regard, to enhance effective usage, the proper use of communication channels is highly needed.

The findings of the present study implicitly showed feedback to be an important aspect which influenced farmers' effective absorption of innovations (see, section 5.7). Feedback is crucial

in the process of information dissemination and communication of information on climate change and variability. Feedback improves the communication process as well as the quality of the information (Tarhule 2007). Garforth (1998) emphasises the need to consider feedback from users when managing the dissemination process, so as to provide relevant information to users. Majule and Yanda (2009) in Tanzania felt that to adapt to climate change and variability effectively and maintain agricultural production, two-way communication between farmers, researchers, extension officers and decision-makers was essential. Tarhule (2007) found that with information on climate change and variability, dissemination in many cases is unidirectional and linear, as it aims to send information to users but does not seeking feedback from users.

The climate change and variability information disseminated should be timely, reliable, accurate and credible, as these attributes are of major concern in promoting the use of the information by farmers. The current study found that the credible information which farmers had received due to direct contact with experts enhanced their belief in the content of information and thus its usage (see section 5.8.2). Ayers and Huq (2009) reason that information providers should strengthen the tools used to analyse climate change and variability data, to ensure that information provided is both credible and relevant to end-users. In East African countries, Orindi and Murray (2005) confirmed the need to reinforce the collection and timely dissemination of information on climate change and variability and suggested the use of both print and electronic media to maximise information dissemination.

Stefano (2004) recommends that information being disseminated to farmers is accurate and up-to-date, while Kandji, Verchot, Mackensen (2006) stressed that reliable seasonal climate prediction will enable farmers to make the right decisions based on the information disseminated. They suggested strengthening the collaboration between international, regional and national climate research centres, as a means to acquire timely weather information which could foster trust between the users and producers of weather forecast information. This study established that despite there being a number of information sources which farmers could use, sources which are easily accessed, and are reliable and credible, were used to a greater extent. Nevertheless, farmers do make use of multiple sources of information, such as the mass media and interpersonal means to access updates on climate change and variability.

User resource empowerment at the local level enhances information uptake and usage by farmers (Garforth 1998). Garforth learned that farmers' access to technical expertise and the provision of agricultural implements motivated the diffusion of information disseminated by agricultural experts. Mutekwa (2009) found that soil and water conservation strategies were least adopted by farmers in Zimbabwe as a result of the inadequate resources which farmers had to enhance the adoption of the innovation. Mutekwa indicated that, in most cases, an innovation introduced requires more training, labour, additional resources and assets such as agricultural implements to be effectively adopted by farmers. Farmers' effective use of the information disseminated to them will mostly depend on the resources they have and the ability of farmers to absorb the innovations. Therefore, despite farmers seeing an innovation as being a relative advantage, as was suggested by Rogers (2003), effective application and adoption of innovations for adaptation to climate change and variability will depend on farmers being provided with resources and assets (Yanda and Mubaya 2011) and the Sustainable Livelihood Framework (Carney *et al.*, (1999).

The climatic conditions of the surrounding environment are location specific and the introduction of user needs assessment is vital if information disseminated on climate change and variability is to be utilised. User needs assessment is important when introducing an innovation, as it provides a chance for farmers to select an innovation of their choice, which will enhance their ability to cope and adapt to climate change and variability. The study findings indicated in section 5.4 of chapter five, that a user needs assessment, had been done prior to the launch of the CCAA project and this might have contributed to the increase in farmers' uptake of information on climate change and variability. These findings are supported by Shetto (2008) and Mowo *et al.* (2011), who observed that user needs assessment was important in enhancing uptake of results from natural resource management research targeted users. These findings support those by Cartmell II, Orr and Kelemen (2004), who stressed that knowing user needs was crucial to enhance delivery and use of information on climate change and variability.

Further supporting the role of information needs assessment, Orindi and Murray (2005) state that despite drought-resistant and fast-maturing crop varieties being direly needed in areas where rainfall has been minimal, research should be done which involves both the experts and local communities, to ensure that farmers use the varieties of their choice and those which are less complex, more advantageous and more compatible with their surroundings.

Rees *et al.* (2000) in Kenya established that despite being exposed to a number of innovations, farmers mostly needed technical farming information on the application rates of chemicals, access to quality and reliable seed, seed varieties specific for a particular location and information on crop diseases. On the other hand, a study by Kandji, Verchot and Mackensen (2006) in southern Africa explained that information on climate change and variability, such as onset and end of the rainfall season, was disseminated to farmers and they perceived it to be useful and thought it addressed their needs.

Respondents were asked about the types of innovations which they have adapted based on information they had received from their CCAA trainers (cf. question f41 and f42 in Appendices 1 and 2, respectively). The findings indicated that the majority (81%) of farmers adopted high-value crops. The study established that farmers perceived that the relative advantage of an innovation was crucial in encouraging acceptance and use of the innovation by farmers. These findings appear to contradict those of Eriksen, Brown and Kelly (2005) in Kenya and Tanzania. These researchers found that farmers in semi-arid areas were hesitant to use some drought-resistant seed varieties as a result of high labour investment, low consumption values and low market value. The relative advantage to this group did not lie in the seeds being brought, as the advantages of the drought-resistant seeds were outweighed by the disadvantages perceived. Their study used semi-structured interviews, focus group discussions, household questionnaires, open-ended discussions, key informants interviews and workshops, to collect data.

These two studies differed with regard to the context which might have contributed to the difference in findings. In the current study, farmers had access to reliable and credible information from experts, unlike those in study of Eriksen, Brown and Kelly (2005). Thus the associated benefits of information disseminated to farmers influenced how individuals used the information to adapt to climate change and variability. Garforth (1998) makes the point that when the benefits of certain innovated information on climate change and variability outweigh the predicted risks, users will invest their scarce resources. Kandji, Verchot and Mackensen (2006) observed that the use of adapted seed varieties by farmers in southern Africa was a result of reduced uncertainty in crop production which, in turn, improved farmers income levels, reduced land degradation and improved soil quality. The perceived relevant advantage of innovation was highlighted by Adejuwon, Odekunle and Omotayo (2008:176), who explained that farmers tended to evaluate and compare the information they

receive to that which they already had from their previous experience. Researchers thus recommend that information on climate change and variability be more detailed and inform farmers on the outcome of the forecast weather.

The availability of scientific information does not guarantee its use if the local institutions such as the village government, good leadership, agricultural equipment, road infrastructure and formal and informal networks, are not well-established. Local institutions were not well structured and were poorly managed and weak. It would therefore be prudent to invest in knowledge and finance to ensure people receive and use disseminated knowledge (refer to section 5.13). Mutekwa (2009) revealed that, despite the fact that the meteorological agency disseminated information to farmers in Zimbabwe, farmers were not aware of the seasonal climate forecast information and they did not use this information to make farm decisions to mitigate the adverse effects of climate change and variability. Mutekwa's study sought views from extension officers and farmers on climate change impacts and adaptation in the agricultural sector in Zimbabwe. The study adopted interviews, questionnaires and documentary analysis to collect data.

Agrawal (2008) and Ayers and Huq (2009) stress that institutional receptivity is of major concern in ensuring that information disseminated to farmers is effectively utilised, as anticipated. If the local institutions are not well-structured to accommodate innovations, they can hardly assist farmers to make adequate use of information to adapt to climate change and variability. In this regard there is a need to invest in assets and human capital at local levels, such as in good policies, good leadership, well-established local governments, strong networks, road infrastructure, farm implements and farm inputs in the district where the majority of people are vulnerable and affected by climate change and variability (Rogers 2003; Ayers and Huq 2009).

Incentives were observed to be crucial in the use of information on climate change and variability. Incentives encourage the scaling-up of innovation and facilitate farmers' adoption of innovations and sustainable use of resources, which promote adaptation (Maddison 2007; Ngigi 2009; Linn 2012). The present study sought to find out what the project had achieved since its inception (see question b12 in Appendix 4). The findings indicate that farmers were able to produce seeds from the information they had received by the CCAA experts (refer to section 5.4 also cf. questions c17 and c19 in Appendix 3, and f41 and f42 in Appendices 1

and 2, respectively). Through selling seeds to their fellows, farmers generated money, which was an incentive to producing more seeds to cater for needs at village level. Kandji, Verchot and Mackensen (2006) observed that creating incentives provided an additional source for farmers, which was crucial in ensuring the availability and accessibility of seeds. Another incentive observed in each study area were farmers' concerns about recording daily weather from weather equipment installed from the CCAA project. Incentives can only be effective when the innovation is perceived to be compatible, less complex, triable, advantageous and observable, within a specific time (Rogers 2003). The present study found lack of incentives and poor co-ordination of ways to access and store weather information at village and district levels, respectively, discouraged farmers on the need to maintain and record weather information.

Targeting a user group helps to provide a focus on their information needs concerning climate change and variability. Identifying user group needs enhances uptake and use of that information by users (Mowo *et al.*, 2011). This could have been one of the factors which enhanced farmers' uptake and use of the information they received from experts in the present study. Orindi and Murray (2005) caution that use of information on climate change and variability by farmers depended on the information provider's capacity to effectively disseminate relevant information on climate change and variability to a particular user group. Targeting a particular user group will enhance the design of strategies to disseminate information and promote its usage. Adejuwon, Odekunle and Omotayo (2008:176) observed that, in addition to targeting a user group, the meteorological forecast information disseminated to farmers, to be applied by farmers, should be released well before the season commences, to give time for farmers to plan their activities well in advance. These findings argue well for relative advantage, compatibility and observability, which are attributes of adoption of an innovation and which are explained in the Diffusion of Innovations model by Rogers (2003).

6.9.3 Role of Packaging in Access to, and Use of, Information on Climate Change and Variability

The programme manager was asked how information on climate change and variability was packaged and disseminated to farmers (cf. question c17 in Appendix 4 and g51 in Appendix 1). The study learned that farmers were involved from the initial stages of packaging information when the project first started. The CCAA experts conducted an information

needs assessment (refer section 5.4 of Chapter Five). Research results revealed that innovative information was being packaged and disseminated to farmers through Farmer Field Schools, public meetings, farmer groups, face-to-face communication, demonstrations on learning plots, publications (compendium), fliers and pictures.

Shetto's (2008) study concerned the scaling-up of natural resource management research output in Tanzania. The study used household interviews, semi-structured questionnaires, focus group discussions, key informant discussions and workshops to collect data. The study focused on trained and untrained farmers who underwent short training courses on rainwater harvesting technology in the Maswa, Mwanga and Same districts in Tanzania. The findings of Shetto's study confirmed the role of packaging in increasing the uptake of research outputs. Shetto's study suggested using appropriate contents, packaging and communication of information to enhance usage. Agwaru, Matsiko and Delve's (2004) study in Tororo district, Uganda, revealed that information-sharing by farmers was based on group discussions and field demonstrations. Sturges and Chimseu's (1996b) exploratory Malawian study on information repackaging revealed that the information repackaging process started with investigating the potential users, then choosing primary sources of information and assessing their information content. These authors explained that, subsequent to these steps, examining and testing the content follows before validating the new packages of information.

This study sought to identify the other preferred channels which farmers would understand (refer questions g52 and g55 in Appendices 1 and 2, and research 12 in Appendix 5). The findings of the study indicated that audio-visual methods such as video, pictures and drawings were less utilised in demonstrating issues related to climate change and variability adoption of innovations by CCAA experts. The majority of farmers perceived audio-visual tools to be the best in disseminating information to farmers, as most could not read or write. These findings are inconsistent with those in the USA, by Cartmell II, Orr and Kelemen (2004), who recorded that although extension officers still disseminated information through meetings, on-farm visits and field days, there was a shift by farmers to use other means to access information, such as the Internet and video. A major factor could be the difference in literacy levels between the two countries.

These authors chose respondents through random sampling and collected data through telephone interviews. The study targeted farmers with land sizes of more than 50 acres. The

study in the USA differs in the methodology used to collect data from respondents and the characteristics of the respondents. Unlike the study of Cartmell II, Orr and Kelemen, the present study used semi-structure interviews and focus group discussions methods, as most farmers were illiterate. Contrary to the findings in the USA, a study in Nigeria by Ofuoku and Agumagu (2008) on farmers' perceptions of audiovisual aids in technology dissemination used structured interviews to collect data from farmers. The study revealed that radio, television and posters were mentioned as the most common audio-visual formats used to disseminate information to farmer on agriculture. The study established that farmers preferred a combination of audiovisual sources in learning innovations. Dutta (2009) is of the view that people in developing countries rely mainly on informal social networks to meet their information needs. The differences between developed and developing countries might be elucidated by a wide gap in terms of the reliability of power sources, telecommunications infrastructure and farmers' low levels of literacy and education.

Despite the findings of the study, in section 5.7, showing that the CCAA project repackaged information for farmers, it was found that there is a problem in the repackaging and disseminating of information by experts and researchers to farmers (see question g34 and g35 in Appendix 4). These findings are inconsistent with those by Shetto (2008), who found that researchers' poor targeting, packaging and communication skills were the factors mostly affecting the dissemination of scientific information to farmers. Mukhala and Chavula (2007) stressed that repackaging is of immense importance and that users currently have difficulties in fitting the acquisition and adoption of credible information on climate change and variability into their activities. Mukhala and Chavula elaborated that the applicability of information on climate change and variability depends so much on the extent to which the producers of the information considered users while generating the information. The researcher further reason that tailoring information on climate change and variability for particular users would simplify information usage.

This study's research results established that at the local district level, information for farmers is being packaged by extension officers before being disseminated to farmers (see, section 5.7) (see questions b10 and b11 in appendix 3). It was observed from the study that there is a gap in knowledge existing between researcher, extension officers and farmers. These findings show a need to repackage and disseminate information to farmers at this time, where climate change and variability is observed. These findings agree with those of Kandji, Verchot and

Mackensen (2006), who found a substantial existing gap between generated agricultural scientific knowledge and its application at local level, as people had not experienced the expected benefits of improved livelihoods.

The studies of Mukhala (2000) and Mowo, Tanui, Masuki, Lyamchai and Adimassu (2011) explained the need for packaging information on climate change and variability and natural resource management research to facilitate usage. Mukhala (2000) observed that, despite the availability of media and communication channels, information was not understood by the targeted users. The study found that the institutions commissioned to package and disseminate information on climate change and variability had inadequate communication skills and failed to identify their users' characteristics. Mowo *et al.* (2011) indicated that inappropriate packaging was among factors which had resulted in the failure of extensive information and experience from natural resource management research to reach potential users. Mowo *et al.* (2011) further observed that the desired impact of integrated natural resource management research would hardly be achieved without purposeful packaging, targeting of information, dissemination strategies and documentation.

Studies in West Africa by Tarhule (2007) and Ngigi (2009) in sub-Saharan Africa found that the majority of African countries in these areas had not benefitted from climate research and climate forecasting as a result of the poor repackaging of information on climate change and variability. Their studies emphasise the need to repackage climate research findings and the use technologies to meet user needs, so as to enhance their capacity to respond to impacts of climate change and variability. Tarhule's study suggests establishing a database which stored grey literature in technical reports and academic journals of relevance to African situations which could be used by researchers to repackage information on climate change and variability. Inadequate benefits by farmers were indicated by Blench (1999), who noted a substantial gap between the information needed by small-scale farmers and that provided by the meteorological services in southern Africa. These results are confirmed by Adejuwon, Odekunle and Omotayo (2008:163-165), who learned that the most needed information on climate change and variability by farmers in Nigeria was about the onset of the rainfall season and the ending and length and amount of rain that falls during the peak rainfall period.

Orindi and Murray (2005) and Adejuwon, Odekunle and Omotayo (2008) argued a need to repackage information on climate change and variability to farmers. The authors felt that

information should be tailored in a simple and easily understood format and, whenever possible, interpreted and translated into local languages to enhance its use. A similar observation was noted by Shetto (2008), who emphasised the need to package research outputs in a relevant, simple and understandable format to enhance usage. Well repackaged information is of great value to farmers, as it improves their capacity to effectively identify appropriate drought resistant and fast maturing crop varieties of their choice (Orindi and Murray 2005). Findings by Gunasekera (2011) noted that disseminated information to farmers will only be effectively used if it reaches the end-users in an appropriate, reliable, user-friendly and comprehensible manner.

Despite this study showing that there was effective communication during the project, poor communication between researchers, extension officers and farmers is generally recognised as a major contributing factor hindering agricultural information delivery to farmers in many developing countries. Rees *et al.* (2000) indicated that information did not flow effectively from researchers to farmers, as a result of inadequate communication between the stakeholders involved. Kandji, Verchot and Mackensen (2006) also observed that farmers were not fully utilising information on climate change and variability, because of poor communication and complexity in interpreting forecast outputs. Mukhala (2000) supported observations of the communication barriers users face and indicated that failure to understand the information disseminated contributed to users shunning disseminated weather information from experts. A study carried out by the Regional Remote Sensing Unit (RRSU) of the Southern African Development Community (SADC) observed that in most countries there is a weak link between meteorological experts and the extension services or other agricultural expert intermediaries (SADC-RRSU 2002).

Poor choice of communication channels may result in poor interpretation of information on climate change and variability. Mukhala (2000) stated that poor communication between agricultural stakeholders poses a challenge to farmers in accessing and using information. Mukhala added that inadequate capability to interpret and communicate information on climate change and variability among experts was a major barrier to farmers' access to, and use of, information on climate change and variability. A study by Sivakumar and Hansen (2007:9) emphasises the problem of interpretation of information by extension officers. The study observed that extension officers did experience problems in interpreting and translating the probabilistic forecasts into language that was easily understood by farmers. Mutekwa

(2009) further suggests the need to repackage information and to disseminate agricultural research results which are relevant to farmers. In this regard, there is an urgent need to strengthen the capacity of both extension officers and farmers to interpret the information on climate change and variability from researchers.

The format of the climate change and variability information being prepared and disseminated has been observed to be a challenge to farmers' ability to use information on climate change and variability for adaptation. Tumbo, Mbilinyi, Rwehumbiza and Mutabazi (2010) observed that climate and weather forecasts are prepared in formats which are not easily comprehended by farmers. These findings are confirmed by Ayers and Huq (2009), who observed that the information on climate change and variability disseminated was not utilised effectively as a result of poor formats. This meant that the information could not be practically applied by users such as civil engineers, policy-makers, researchers and planners. Ayers and Huq (2009) suggest that, as users vary according to their information needs, information on climate change and variability for a specific user group should be targeted for them and well prepared from the generation and collection to the dissemination stages, to ensure effective usage. Shetto (2008) supported this concern about the formats used to convey the information and claimed that packaging of research results would receive more attention if its repackagers took into account user needs and documented it in an understandable language.

Even using an appropriate format for the information on climate change and variability will not reap the expected benefits if the information is not tailored for application at local level. The tailoring of information on climate change and variability from the higher global and national scales to village local level is critical in ensuring farmers make use of information on climate change and variability in improving their agriculture. Ayers and Huq (2009) recommended that to ensure farmers effectively use information at local level, climate modelling data should be down-scaled, to be meaningful in meeting local peoples' needs. Ayers and Huq (2009) and Kandji, Verchot and Mackensen (2006) confirmed that the major problem which faces farmers in utilising climate forecasts information was not downscaled and tailored to the needs of local farmers.

The current research sought to discover which specific channels farmers used to access information on climate change and variability (cf. question g54 and g52 in Appendices 1 and

2). Findings in section 5.7 of Chapter Five indicated that the extension officers and village government leaders are mostly used to inform farmers on issues related to climate change and variability. The study by Shetto (2008), on the scaling-up of natural resources management, showed that village government leaders were widely used to transfer information to farmers on new ways of using rainwater harvesting technologies. Village government leaders took directives from the extension officers and informed farmers on climate change and variability. The need to build capacity in the stakeholders involved in disseminating information on climate change and variability and the complexities arising in agricultural production, are of paramount importance in the present observed, variable climatic conditions.

The repackaging of climate change and variability, which is an innovation on its own, cannot be ignored. Mowo *et al.* (2011) did participatory research on farmers in the highlands of East Africa to investigate how knowledge on natural resources management can be transformed and used by farmers. Their study learned that an increased up-take of integrated natural resource research can be facilitated by building capacity in, and designing information dissemination strategies for, the intended users of the information. As a result, the repackaging information has the potential to contribute to reducing farmers' vulnerability and enhance their coping and adaptation capacities. Agricultural stakeholders such as farmers, researchers, extension officers, community based organizations, decision-makers and NGOs need to be provided with adequate knowledge on climate change and variability through proper training to cope with challenges associated challenges.

The inadequate knowledge of village government leaders, opinion leaders and decision makers can be detrimental, as messages might have become distorted in the process of travelling from the main source to the local message recipients. Supporting the importance of knowledge repackaging in the adaptation process, Majule and Yanda (2009) stated that effective climate change and variability adaptation hinges on understanding of the adaptation strategies and the context by decision-makers, farmers and other stakeholders. The need to build capacity in the stakeholders is of major importance. Mutekwa (2009) stressed the need to build capacity in farmers on how to use the relevant disseminated research findings to make on-farm decisions. Similar findings were observed by Ayers and Huq (2009) who emphasise the need to build capacity related to climate change and variability scientific and

technical issues which is accurate and reliable, so that it can be applied in development plans and policies.

Participatory learning is seen as an important element in ensuring that repackaged information is disseminated and effectively delivered and used by targeted end-users (Shetto 2008; Mowo *et al.*, 2011). Channels used in participatory learning involve Farmer Field Schools, village meetings and farmer learning groups. The participatory approach is important as the traditional means of disseminating information have been critiqued as they involve a top-down approach (Mchombu 2002). Mowo *et al.* (2011) found that traditional knowledge was blended with scientific knowledge to enhance the uptake of knowledge by farmers. Rees *et al.* (2000) suggest the use of diverse teaching and learning materials for farmers and extension officers as they are effective in enhancing participatory learning. Participatory learning is effective as farmers have time to assess the innovation and measure its importance before adopting or rejecting it. Rogers (2003) supports the notion of participatory learning through the DOI model, by explaining that a farmer's decision to use an innovation depends on its relative advantage, compatibility, observability, trialability and complexity. These attributes can be measured by farmers very well when they undergo practical training.

6.10 Attitudes to, and Perceptions of, Farmers on Climate Change and Variability

The attitudes and perceptions of farmers constitute a critical component in understanding and designing adaptation strategies on climate change and variability. The study sought to reveal how farmers compare the rainfall pattern and temperature pattern now and in the last decade (cf. question i64, i66 in Appendices 1 and 2, respectively and 14 in Appendix 5). Findings presented in section 5.10.1, demonstrate that most farmers (97.6%) had recently observed frequent drought and erratic rainfall patterns while 82.1% perceived a temperature increase. In Tanzania, Slegers (2008) observed that farmers in semi-arid central Tanzania perceived an increased prevalence of drought and rainfall variability in the past two decades. Her study used in-depth interviews, open-ended questions, pictures, field visits, group discussions and workshops to collect data from 120 farmers. Her study indicated that farmers perceived that drought had increased and they were able to differentiate between drought vulnerability indicators, such as types of soil and land changes, using their existing knowledge. Similar observations were made in Zimbabwe by Mutekwa (2009), who found that farmers perceived

a high frequency and severity of drought, changes in the timing and pattern of seasons, excessive precipitation and the drying up of dams, rivers and wells.

Studies by Gwimbi (2009) and Mengistu (2011) found that farmers in Zimbabwe and Ethiopia perceived an increase in drought, reduced and erratic rainfall and an increase in temperature in recent years. The studies which investigated farmers' perceptions and understanding of climate change and variability adopted qualitative and quantitative methods, which this current study applied, as well as the time series analysis method. The authors' results demonstrated that farmers' attitudes to climate change and variability were shaped by how they adopted innovations to adapt to climate change and variability. There are several factors which are thought to have contributed to farmers' change in attitudes and perceptions towards climate change and variability. These factors are discussed critically in subsequent sub-section 6.10.1.

Findings as presented in section 5.10.2, indicate that the attitudes and perceptions farmers have regarding an innovation determines how they respond. Farmers' attitudes are of paramount importance in the mitigation and adaptation to climate change and variability. Newly introduced programmes on adaption to climate change and variability can be adapted effectively if people have positive attitudes to that innovation. This argument is supported by Moser and Ekstrom (2010), who explained that attitudinal and behavioural change are crucial in collaboration, changing peoples' ways of thinking and determining a paradigm shift in resource allocation. The authors add that attitudinal change is important in institutional settings and facilitates effective use of natural resources. Attitude change can be extremely hard to achieve, however. Rogers (2003) also indicated that the attitude to and decisions made, regarding an innovation, to a great, extent lie in the perceived characteristics of the innovation by potential users. Nevertheless there are a number of factors which influence farmers' attitudes to, and perceptions of, adaptation to climate change and variability. These will be discussed.

It has been learned that farmers' levels of understanding of the concepts of climate change and variability are a critical factor in ensuring that farmers adapt to climate change and variability. Orindi and Murray (2005) explain that most local people in East Africa do not understand the impacts of climate change and variability and that they see it as a distant problem. The level of understanding aspect has been noted by Adger *et al.* (2008), who

explain that adaptation hinges on peoples' attitude to the presence and magnitude of the problem, which may or may not foster action. In Australia, Jonge (2010) supports the role of understanding climate change and variability. This researcher observed that farmers in Australia lacked knowledge on adaptation options and future water availability, which contributed to their negative attitudes to adaptation to climate change and variability.

This study sought to identify the challenges which farmers face in applying new farming methods (cf. questions i68 and i70 in Appendices 1 and 2). The findings showed that previous bad experiences and risk and reward were major attributes towards forming attitudes to farmers which shape their adaptation to climate change and variability. The results established that farmers had a negative perception of the use of inorganic fertilizer and new improved seed varieties, as a result of previous farming experience. They perceived that inorganic fertilizers destroy crops and that improved maize seed varieties were susceptible to diseases. Farmers also viewed the new sorghum variety to be lacking in flavour when compared to the local variety (refer section 5.10.2). Farmers' previous observed experience on climate related conditions has enabled them to form certain perceptions regarding an innovation introduced.

Explaining the role of farmers' previous experience in influencing attitudes and adaptation to climate change and variability, the study sought to discover how often farmers experience drought and/or erratic rainfall patterns (cf. question i65 and i67 in Appendices 1 and 2, and 15 in Appendix 5). The study results showed that the majority of farmers (72%) have often experienced an incidence of drought and or erratic rainfall pattern, compared to only 17% who rarely observed the trend. Results have shown that few (11%) respondents were neutral in the sense that they neither observed, nor did not observe, the frequency of changes in drought and erratic patterns of the climate. These findings explain how farmers' previous experiences and observations shape farmers' attitudes and the adaptation process.

These results emphasised the role of previous experience in forming farmers' attitudes, confirm those by Apata, Samuel and Adeola (2009) and Dhaka, Chayal and Poonia (2010) in South Western Nigeria and India, respectively. These authors indicated that farmers' decision to adapt to climate change and variability were greatly influenced by their previous farming experience. Apata, Samuel and Adeola's study used both qualitative and quantitative methods namely structured questionnaires, interviews and focus group discussions, to collect data. The

study of Dhaka, Chayal and Poonia (2010) applied structured interviews. Adejuwon, Odekunle and Omotayo (2008:175) recorded that the bad previous experiences which farmers had regarding forecast information would make them ignore subsequent forecasts. Adger *et al.* (2008) and Mutekwa (2009) observed that lessons acquired from previous and recent experience on climatic stresses provided a critical role in social learning, shaped farmers attitudes and decision-making and enhanced farmers' capacity to adapt. In a related area regarding the influence of experience, Slegers (2008) observed that farmers had stopped using manure despite believing that manure enhanced soil water retention capacity, productivity and soil fertility, because they had previously noted that manure contributed to the burning of their crops.

Risk and reward regarding an innovation affect farmers' attitudes to an innovation. It has been learned that perceived risks and rewards of an innovation determine farmers' attitudes to the innovation. Nhemachena and Hassan's (2007) study confirms this notion and states that farmers' perceptions of the benefits and associated risks shape farmers' adaptation. Their study, which was explorative in nature, was done in South Africa, Zimbabwe and Zambia and used database information from the Climate Change and African Agriculture project. Yanda and Mubaya (2011:116) found that in Africa the substantially higher labour required and low market and consumption values contributed to the farmers' reluctance to adopt a particular drought-resistant species. Coles and Scott (2009) and Jonge (2010) noted that a lack of financial incentives and poor commodity prices were the major obstacles in adaptation to new innovations which aimed at enhancing farmers' adaptation to climate change and variability in the USA and Australia. Rogers' Diffusion of Innovations model highlights the role of risk and reward by explaining that users choose an innovation based on its relative advantage, compatibility and complexity (2003:229-258). Supporting this view, a study by Mukhopadhyay (1994:99) in India also found that farmers' decisions to adopt the new agricultural technology high yield varieties (HYV) depended on discounted returns per unit cost and the added risk or uncertainty that HYVs entailed, compared with traditional varieties.

Education and awareness were factors which influenced farmers' attitudes to, and perceptions of, an innovation. The current findings indicated that the education which farmers had received contributed to their awareness of new farming methods which, in turn, enhanced their adaptive capacity and resilience to climate change and variability (refer to section 5.6.1).

A study by Apata, Samuel and Adeola (2009) noted the critical role of education and awareness in changing farmers' attitudes to adaptation to climate change and variability. Deressa *et al.* (2008) confirmed the findings by Apata, Samuel and Adeola (2009) and observed that the level of education and awareness were important factors in changing farmers' attitudes to adaptation in Ethiopia. The study by Apata, Samuel and Adeola (2009) used focus group discussion, structured questionnaires and interviews for 350 respondents. Simple random sampling was used to select study areas. The study by Deressa *et al.* (2008) used survey and interviews for 1000 respondents in districts that were purposively selected.

Despite the present findings from cross-tabulation and those by Deressa *et al.* (2008) and Apata, Samuel and Adeola (2009), showing that formal education and awareness were crucial in changing farmers' attitudes, these findings are called into question by part of the current findings from the FGDs. The focus group results of the this study indicated that farmers perceived the farming educational level, which refers to prior existing knowledge in farming, to be adequate in changing their attitudes and creating awareness towards adoption of new farming methods for adaptation to climate change and variability (refer section 5.13). These findings implied that farmers were of the view that, despite formal education being important, transfer and adoption of new farming methods to mitigate climate change and variability can be effective, even when a farmer does not have access to formal education. The results from FGDs are well supported by those of Sivakumar, Mannava and Motha (2007), Maddison (2007) and Gundu (2009), who found farmers' awareness and literacy levels to be strong influential factors in forming farmers' attitudes towards adoption of innovations, adaptation to climate change and variability and improving food security, respectively. However, despite the FGDs results showing formal education was not necessarily perceived important by farmers in adoption of new farming methods, the present study confirms the cross-tabulation findings showing that farmers' formal education is crucial in influencing adoption of innovations as endorsed by Rogers (2003). Rogers revealed that formal education contributes positively to farmers' better and quicker adoption of innovations. Thus, formal education is crucial for farmers as it enhances their adaptation capacity to effectively mitigate climate change and variability. Todd (2005) revealed that formal education provides an opportunity to introduce people to various ways to do things and creates awareness to individuals on the availability of options.

The findings of this study indicated that the particular culture embedded in farmers is believed to contribute to their attitudes to, and perceptions of, adaptation to climate change and variability (refer sections 5.10 and section 5.13). The culture includes unwillingness to learn, ineffective participation in awareness programmes and strong cultural backgrounds which resist changes. Roncoli (2006) reasons that farmers' culture embracing religion, beliefs, norms and language used in communicating contributed to farmers' misinterpretation of, and the developing of negative attitudes to, adaptation to climate change and variability. Roncoli's study observed that inappropriate language used in communicating information on climate change and variability, lack of credibility and inaccuracy of information disseminated might be caused by the misinterpretation of concepts, religious beliefs and past experiences. These findings are supported by the DOI model by Rogers, which explains that, for an innovation to be accepted in a community, it should be compatible with the values, norms, beliefs, culture and meet individuals' needs (Rogers 2003:240-246).

6.11 Limiting Factors Affecting Access to, and Use of, Information on Adaptation to Climate Change and Variability by Farmers

There are various factors which affect farmers' access to, and use of information for adapting to climate change and variability (see section 5.13). The present research sought to find barriers to access to, and use of, information on climate change and variability (cf. question j74 and j76 in Appendices 1 and 2). The study found lack of timely access to, and inappropriately prepared, information on adaptation to climate change and variability to comprise the majority factor which prevented farmers using information for adapting to climate change and variability. Advanced access to information enables farmers to make timely decisions with regard to use of their limited resources and thus minimises their vulnerability. Mukhala and Chavula (2007:45) learned that farmers in Swaziland and Mozambique received information on planting too late to make their farm decisions. Bad timing and the late release of this information to farmers highly affected the effective use of the information.

A similar observation was noted by studies in Africa by Tarhule (2007); Kandji and Verchot (2007); Mutekwa (2009); Gwimbi (2009), Mengistu (2011) and Yanda and Mubaya (2011), which indicated that untimely access to information on adaptation to climate change and variability undermined most farmers' ability to make on-farm decisions and contributed to poor usage of information on climate change and variability by farmers in Africa. Studies by

Kandji and Verchot (2007); Mutekwa (2009); Gwimbi (2009), Mengistu (2011) and Yanda and Mubaya (2011) were conducted on farmers in southern Africa, including Zimbabwe, Ethiopia and East Africa. These studies used interviews, survey methods, documentary analysis and time series analysis to investigate farmers' perception towards climate change and variability. Similar methods were used by this current study. Gunasekera's (2011) exploratory study confirmed the need for timely access to information and explained that untimely access to information on climate change and variability deters efficient and effective adaptation and causes poor decision-making.

Despite the results of this study not indicating heterophily to be a major factor affecting farmers' access to, and use of, information on climate change and variability, the findings indicated that the most illuminating challenge affecting farmers' access and use is the communication barrier between farmers and researchers. Even though farmers' knowledge and attitudes were influenced by the communication channels which played a vital role in the innovation-decision process in the adoption of innovation, Rogers (2003:205) elaborates on this aspect and indicate that collaboration between information disseminators and users cannot be over emphasized.

Poor communication predicaments were observed by Tarhule (2007) in West Africa, where he found a wide gap between experts, extension officers and farmers. His study was based on a survey conducted on 600 end-users and 27 organisations. The communication barrier between these user groups contributed to farmers' low usage of information on climate change and variability. Despite the current study's findings, indicating that some farmers have access to information on climate change and variability such as rainfall, farmers seem to mostly wish to access information which covers the distribution of rainfall across the entire rainfall season. These findings agree with those of Ziervogel and Opere (2010), who collected data from participatory action research experiences conducted in sub-Saharan Africa. The current study found that farmers may only need certain information, such as the total rainfall expected in the season, to complement what they already have. The study further found that users were mostly interested in information on the onset, ending, intra-seasonal variations in climate, which support decisions about what crops to plant, when to plant, which technologies to use and when to harvest.

Another obstacle which hinders farmers' access to, and use of, information on adaptation to climate change and variability is an untimely response to climate issues from experts with knowledge of climate change and variability. One of the major reasons which might explain this situation, as elaborated on by Yanda and Mubaya (2011), is failure to access, and the lack of, dependability of climate forecasts. Mutekwa (2009) observed that farmers' major barrier to access and use of information on climate change and variability was limited awareness by researchers and academics of the nature and magnitude of climate change. This lack of awareness affects the nature of the information that was relayed to the farmers and the specific strategies to be devised, promoted and adopted. Having expertise is not enough to overcome communication barriers. Mukhala and Chavula (2007) explain that language and terminology barriers affected the communication flow of information to farmers. They found that insufficient translation in terms of language and terminology by those mandated to communicate information to the users constituted a barrier. Cultural barriers have also been documented in the Diffusion of Innovations model (Rogers 2003).

Access to credit has been pointed out by this study and a number of authors in the field of agriculture as affecting farmers' ability to access and use information on climate change and variability. Farmers perceived access to credit as a resource which influenced their attitude to the adoption of an innovation. Carney *et al.* (1999), Kandji, Verchot and Mackensen (2006) and Mensah-Fosu, Vleck and Manschadi (2010) explained that access to credit schemes is among the major constraints affecting farmers in access to, and use of, information on climate change and variability, as they cannot purchase new farm inputs and farm implements which are needed as a result of the farming challenges emanating from the changes in the environment. These findings were supported by Ziervogel and Opere (2010) and Yanda and Mubaya (2011), who noted that access to micro-credit was an influential factor affecting farmers' ability to respond to adaptation challenges of climate change and variability.

Socio-economic differences between individual farmers were believed to be factors which influenced farmers' access to, and use of, information on climate change and variability. Stigter *et al.* (2007:178-180) stated that wealth determined the type of source that farmers in China had access to and used. These authors learned that very poor farmers obtained information from leaders, neighbours, and relatives, while low-income farmers mostly used the mass media, leaders, capable friends and relatives. This study learned that middle-income farmers used television, radio, interpersonal communication, newspapers, brochures and

books, while richer farmers used TV, the press, radio broadcasts and the Internet. The study further discovered that very poor farmers failed to use the existing technological information services and had limited demand for such services. The awareness of low-income farmers of technological information services was low. Stigter *et al.* (2007:180-182) learned that middle-income farmers cannot utilize information services effectively, compared to rich farmers, who have the greater ability to utilise information services.

The findings of the study showed that the content of information was a factor affecting access to, and use of, information on climate change and variability. Mutekwa (2009) found that complexity limited understanding of the nature and the projected outcomes of climate change and variability by farmers, academics and researchers and constituted an obstacle to farmers' access to, and use of, information of climate change and variability. The author found that information on rainfall onset and dry spell duration was uncertain and experts' intervention strategies enabled adaptation to current, but not future, climatic change and variability. Yanda and Mubaya (2011) raised the problem of the inadequacies of knowledge by mentioning that lack of understanding of the projected impacts of climate change and variability on cropping systems affected access to information on climate change and variability for planning. These findings are supported by those by Rogers (2003) who found that complex innovations had a higher risk of being diffused and adopted in a community, compared to a simple innovation.

Information distortion from the agricultural sources and information and communication channels has been observed to affect access to, and use of, information for adaptation to climate change and variability. Garforth (1998) pointed out that, as information is passed on, users tend to interpret, evaluate, select and reformulate disseminated information. Garforth explains that this leads to distortion, simplification, loss of detail and misunderstanding. A number of scholars have observed that information distortion was a critical factor in preventing farmers' access to, and use of, information for adapting to climate change and variability. Rees *et al.* (2000) and Adejuwon, Odekunle and Omotayo (2008) observed that information distortion was a barrier to farmers accessing information for adaptation to climate change and variability. These authors explain that as information flowed from the agricultural extension agent, information was distorted as a result of extension officers exaggerating information from forecasters to enhance acceptance by farmers. Mchombu (2002) and Rogers (2003) warned that as information flows from the media and extension officers to opinion leaders and farmers, information may not reach end-users (farmers) in its

original form. The distortion occurs as the information flows through a number of communication channels as it can be misunderstood and misinterpreted by the recipient. This might then result in changes to the original meaning of the information disseminated and distort the message intended to users. These sentiments were observed by Garforth (2008), who researched dissemination pathways for renewable natural resources and found users tended to unavoidably distort, misunderstand and change details as a result of different interpretations of the disseminated information. It is thus imperative to ensure that accurate information is disseminated to users for effective usage.

Information flowing from the source to the user is another factor which affected farmers' access to, and use of, information on climate change and variability. The present findings were that farmers sometimes fail to access information channelled from extension officers, as information failed to flow adequately to them. There are two obstacles explaining the problems encountered when information flows from the source to the recipient. One is difficulties in relation to poor packaging of the information to meet end-user needs. Mutekwa (2009) pointed out that, despite a lot of information existing at global, continental, regional level, the information did not flow effectively to the farmers at local level. Stefano (2004) observed that the availability of information on best agricultural farming practices which enhance adaptation to climate change and variability did not ensure its usage unless it was appropriately repackaged. This process required consideration of the format and local language and needed to be correctly written to reflect farmers' literacy levels. The present study findings corroborate those by Mchombu (2002), who stated that information did not flow adequately and was not applied by farmers as the packaging was poorly designed and did not reflect the literacy levels of ordinary farmers.

The flow of information could be affected by inadequate knowledge on the part of information disseminators. Rogers (2003:24) found change agents such as extension officers, agricultural inputs suppliers and NGOs as largely influencing the diffusion of innovations. The change agents may enhance or slow the adoption and diffusion by failing to assist farmers effectively, thus leading to uncertainty in access and use of innovations (Rogers 2003:27). Mutekwa (2009) found extension officers were not capable of disseminating information on rainfall for a specific location, as the available models failed to predict the nature and magnitude on a very small scale. Hisali, Birungi and Buyinza (2011) and Cherotich, Saidu and Bebe (2012), in Uganda and Kenya, similarly noted that extension

officers' inadequate knowledge contributed to farmers' limited access to, and use of, information on climate change and variability.

The second obstacle describing challenges as the information flows from the source to the recipient is farmers' poor information-seeking abilities. In Zimbabwe, Mutekwa (2009) found that all farmers in Maruwa village were aware of seasonal climate forecast information and did not use it to make on-farm decisions to mitigate changes in Climate and Variability. These findings are supported by those of Tarhule (2007) in West Africa who found that low literacy levels and absence of institutions to effectively translate the research findings into practice contributed to farmers' low access to information on climate change and variability. Low literacy levels were not the only factor which hindered farmers' ability to access and use information on climate change and variability.

Social-cultural barriers, which include norms, values, beliefs, experience and behaviour have been noted in the study to be barriers to access to the use of information for adaptation to climate change and variability. These barriers are substantially contributed by farmers' limited exposure and failure to observe from others on how to adapt to new, more productive farming practices. These findings confirm those by Rogers (2003) and Adger, Dessai, Goulden, Hulme, Lorenzoni, Nelson, Naess, Wolf and Wreford (2008), who found that cultural issues affect farmers' access to, and use of, information on climate change and variability. In line with this observation, Rees *et al.* (2000) found that poor attendance at meetings and ignoring information from experts were reasons for farmers' low access and use of information to adapt to climate change and variability. These results corroborate those by Rogers (2003:26), who observed that the diffusion of innovations is influenced by the individuals' characteristics and the nature of the social system representing the individual. However, some of the social-cultural barriers could have been minimised by farmers' ability to witness innovations adopted by others farmers outside the study villages. This would have promoted their ability to switch to other crops which might substantially increase their income.

Poor institutional infrastructure and receptivity was another set of factors hindering farmers' access to, and use of, information on climate change and variability. These findings back-up those by Agwu, Ekwueme and Anyanwu (2008), Agrawal (2008) and Mutekwa (2009), who observed that local institutions, limited access to information on climate change and

inappropriate broadcasting times affected farmers' access to, and use of, information in performing their agricultural activities. The study findings indicated that extension officers were regarded by farmers as less reliable and farmers tended to depend more on mass media sources to access information on climate change and variability. Nevertheless, farmers in most rural areas had no access to electricity, which limited their ability to access media such as radio and television (Tumbo, Mbilinyi, Rwehumbiza and Mutabazi 2010). Not only electricity was seen as the problem in accessing and using information on climate change and variability. Sturges and Chimseu (1996a) and Shetto (2008) point out that farmers' ability to enjoy the radio programmes depended on their possessing a radio receiver and on programmes being aired at times convenient to listeners. The study also learned that most frequently the radio disseminated information with inadequate content, which did not cater for farmers' needs and users preferred entertainment programmes. These findings agree with those of Shetto (2008), who found limited use of radio in the rural areas of Tanzania was a result of unattractive poorly designed radio programmes and public and private programme competition.

This study established that insufficient institutional resources contributed to the difficulties in accessing and using information to adapt to climate change and variability. Inadequate institutional resources have been described in the Sustainable Livelihoods Framework (SLF), which explains the role of policies, government institutions, financial capital, human capital, social capital, natural capital and physical capital in adaptation of farmers (Carney *et al.* 1999). Rees *et al.* (2000) found that there were both a low number of public and NGOs extension officers and inadequate resources to mobilise communities as serious institutional factors. These factors limit farmers' ability to access and use information on climate change and variability.

Ziervogel and Downing's (2004) study in Lesotho showed that limited information dissemination, poor institutional co-ordination and stakeholders' involvement were among the major barriers to achieving an effective climate change and adaptation plan. The current study found that, despite stakeholders' expressing their willingness to use forecast information, there were no mechanisms arranged for them to efficiently and effectively receive and use the information disseminated. Tumbo, Mbilinyi, Rwehumbiza and Mutabazi (2010) found that, despite the Tanzania Meteorological Agency (TMA) having scientific skills and being mandated to forecast, generate and disseminate information on the weather,

the institution's limited resources had forced them to use the District Agricultural and Livestock Development officers to disseminate information. However, this challenge might be attributed to inadequate communication skills which were observed by Mukhala (2000) to be affecting effective communication of weather information to potential users.

Inadequate institutional resources were seen as a factor contributing to farmers' inability to access and manage seed banks in the respective villages. The study findings from the focus group discussions with farmers indicated a decrease in the number of farmers producing seed to sell to villagers (see section 5.13). Farmers' access to, and use of, the seed was hindered by improper management of seed banks. Yanda and Mubaya (2011) observed that despite seed availability, farmers faced the problem of access to seed. The present study findings indicated that few farmers were trained in establishing seed banks to be used as sources for easy availability of seed in the villages. Kandji, Verchot and Mackensen (2006) found that adoption of information on climate change and variability was being hindered by most African governments' failure to create and maintain an efficient seed production and delivery system. The authors further point out that failure to maintain the seed production and delivery scheme had caused farmers to experience difficulties in accessing seed and failing to recognise the availability of new varieties, or even if they are aware they did not have access to them.

Poor leadership was observed in the study to be a factor preventing farmers' access to, and use of, information on climate change and variability. Despite the effective role played by farmers' groups in reducing vulnerability and facilitating the diffusion of innovations due to farmers' shared common interests, study findings indicated that a number of farmers dropped-out from the groups as a result of dissatisfaction regarding the way the group leaders ran their groups. Access to agricultural inputs by members in a group was seen as a key challenge to the management of resources. Thus, despite Munyua and Stilwell (2009) observing the generally positive roles of farmer groups in information transfer, exchange, adoption of an innovation and knowledge acquisition, the current study, like that of Rees *et al.* (2000), found that poor local leadership in farmer groups was seriously affecting farmers' inadequate access to, and use of, information on climate change and variability.

6.12 Summary

This chapter discussed and interpreted the findings of the study, presented in Chapter Five of the thesis. The chapter was arranged in themes and sections organised from around the data collection questions. Discussion and interpretation of the research findings showed how previous similar studies are consistent or different from the current research findings.

Chapter Six has shown that effective packaging and dissemination of information on climate change and variability enhance the adoption of innovations by farmers. It showed how access to relevant, timely, reliable, user friendly information format and proper use of communication channels enhanced knowledge transfer and information usage. It was found that farmers made use of multiple sources of information to access information on climate change and variability. Application of multiple sources helped farmers increase understanding and reduced risks in using innovations.

The chapter also indicated that most farmers were aware that the climate is changing. However, the knowledge gap that existed was farmers' inadequate knowledge about understanding climate change and variability. Farmers' knowledge was minimal with regard to contextualizing main causes of climate change and variability and linking the causes to changes they observe in their environment. Extension officers indicated a need for more training on the vagaries of climate change and variability as they had inadequate knowledge on dealing with the problem.

Chapter Six also indicated that farmers rely on Indigenous Knowledge (IK) for weather prediction. It was learned that IK is fading away and is neither documented nor preserved (Munyua and Stilwell 2013). It was observed that farmers coping and adapting to climate change and variability was not a new phenomenon, as they have been coping and adapting to climate change and variability indigenously for quite some time. However, the most critical observation is that climate change and variability impacts have been recurring more frequently. The high frequency of droughts, dry spells and floods seem to outweigh farmers' capabilities of indigenously responding to hazards. This makes new scientific knowledge on adaptation to climate change and variability urgent and a necessity.

Results showed farmers' adoption of innovations and adaptation to climate change and variability is complex and depends on multiple factors. The study findings showed in most developing countries diffusion and adoption of innovation is influenced to a greater extent by

the five attributes of innovations, namely relative advantage, complexity, observability, trialability and compatibility (Rogers 2003).

Chapter Six further showed that the farmers' access to information is crucial in mitigating and adapting to climate change and variability. However, to promote usage of information, qualities of information such as timeliness, relevance, accuracy, credibility and understandable format should be incorporated with other socio-economic factors to motivate usage. The chapter implies that farmers' access to quality information on climate change and variability has the potential to reduce farmers' vulnerability and increase food production.

From the discussion and interpretation of the study findings, the originality hinges on two aspects. First, despite several studies on climate change and variability being conducted in Tanzania and notably the semi-arid areas of Tanzania, no study could be traced which explored how information is being packaged and disseminated to farmers and how the information is accessed and used by farmers to influence adoption of new agricultural knowledge for adaptation to climate change and variability. A similar study was done by Shetto (2008) on ways of scaling-up research output on natural resource management, particularly on rainwater harvesting research. This study fills existing knowledge gaps in existing empirical and theoretical evidence on how information generated through research on climate change and variability can be packaged and disseminated effectively to farmers to improve agriculture production in Tanzania.

In spite of a few studies being conducted on the IK farmers use for adaptation to climate change and variability in Tanzania, the study could not find a study which has been conducted in Maluga and Chibelela villages which explored, in detail, the use of knowledge on local indicators to predict weather in the next season. This study therefore addressed the need for documenting and preserving IK, so that it can effectively be used by farmers in the adaptation to climate change and variability. The study investigated on farmers possessing IK, reliability of IK and use of IK local indicators for predicting weather at village level.

The next chapter provides a summary of the findings, conclusions and recommendations relevant to the study. The chapter also makes a contribution to the theory, study benefits to society and originality of the study and suggests areas for further research.

CHAPTER SEVEN

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

7.1 Introduction

This chapter provides a summary of the findings, conclusions and recommendations of the study. It describes data presented and interpreted in Chapters Five and Six of the study. Section 7.2 restates the research purpose and research questions. Section 7.3 explains the summary of the findings based on the research questions. Section 7.4 of the chapter presents the conclusions of the study based on the research objectives and findings. The recommendations of the study are made in section 7.5.

The chapter provides details of the originality of the study in section 7.6. Section 7.7 describes the implications of the research for theory. Section 7.8 elaborates the implications of the study for policy. The implications of the study for practice are provided in section 7.9. Section 7.10 of the chapter discusses the benefits of the study to the community. The limitations of the study are provided in section 7.11. Section 7.12 makes suggestions for further research.

7.2 Research Purpose and Research Questions

This study investigated how information on adaptation to climate change and variability was packaged and disseminated to farmers in Maluga and Chibelela villages in Central Tanzania. The study was guided by the following specific research questions:

1. What are the goals of information disseminated to farmers on climate change and variability?
2. What type of information on climate change and variability is disseminated to farmers?
3. What specific channels are employed when disseminating information on climate change and variability?
4. What methods are applied by farmers to mitigate the effects of climate change and variability?
5. What is the farmers' current level of adoption of information on adaptation to climate change and variability?
6. How is information on climate change and variability accessed and used?

7. What are the attitudes to, and perceptions of, farmers of climate change and variability?
8. What are the limiting factors affecting access to, and use of, information on adaptation to climate change and variability by farmers?

The study was underpinned by Rogers' (2003) Diffusion of Innovations theoretical model. The post-positivist paradigm was used. Both qualitative and quantitative methods were applied, with the former approach being dominant and the latter less dominant. Interviews and focus group discussions were used to collect data. The study population comprised three categories of respondents, namely farmers, agricultural extension officers and the CCAA project manager. Purposive sampling technique was used to select the sample of farmers to be studied.

Semi-structured interviews were carried out with 84 farmers from Maluga and Chibelela villages. Two in-depth interviews were conducted with the district agricultural extension officers and one in-depth interview with the Climate Change Adaptation in Africa project manager. Two focus group discussions were conducted, one with farmers in each village. Quantitative data was analysed using descriptive statistics facilitated by SPSS, while qualitative data was analysed thematically.

7.3 Summary of Research Findings

This section presents a summary of the research findings based on the research questions of the study.

7.3.1 Characteristics of the Respondents

The findings of the study revealed were that:

The majority (31%) of farmers were between 36 and 45 years of age. The study showed that a large number of respondents (23.8%) were above the age of 60 and were still actively involved in agricultural production in the Maluga and Chibelela villages.

More (69%) females were involved in farming activities than men (31%) were involved. The majority of farmers in Maluga (55.6%) and Chibelela (79.1%) were females. The high percentage of women involved in farming activities is explained by the observation that in Africa men are less involved in agriculture than women (Ngigi 2009).

There was no association found between age, income, level of education and climate change and variability awareness. Depending on the socio-economic characteristics of a community these factors can influence farmers' awareness on climate change and variability (refer Chapter Three, sections 3.10, 3.12 and 3.13).

There was no correlation between gender and awareness, on one hand, and adoption of innovations on the other, while there was a positive correlation between adoption of innovations and demographic factors such as age, income level and level of education. The studies by Masangano and Miles (2004), Erbaugh, Donnermeyer and Amujal (2007) and Akudugu, Guo and Dadzie (2012) produced similar findings on these factors influencing the adoption of innovations (refer Chapter Six, section 6.8.2).

The majority (75%) of farmers had basic primary education, 9.5% had secondary and 1.2% had tertiary education. The study established that education enhances the adoption of innovations, as farmers can follow instructions in formal training by agricultural experts. Ngigi (2009) found education to be important in helping farmers to make careful decisions on effective and efficient use of resources for adapting to climate change and variability.

Most (59.6%) farmers had more than five acres of land. This was particularly true of Chibelela village. Access to land and proper farming knowledge is crucial in increasing agricultural production. However, unless farmers have been trained in how to make adequate use of new farming knowledge they will struggle to make use of the land to alleviate poverty and reduce their vulnerability to the impacts of climate change and variability.

Poverty levels were higher in Chibelela village than in Maluga village. Poverty levels need proper consideration when designing adaptation strategies. The major reason is because poverty levels affect the diffusion of knowledge to farmers and their adoption of innovations. Resource-constrained farmers appeared to have lower adaptive capacities, which could reduce their ability to make judicious decisions about farming concerning adaptation to climate change and variability.

Crop farming and livestock rearing were the economic activities most practised by farmers. Despite the activities being heavily relied upon by farmers in order to cope with adverse effects of climate change and variability, the study found that in the two villages crop farming and livestock were being seriously affected by climate change and variability.

7.3.2 Goals of Information Disseminated to Farmers on Climate Change and Variability

The findings on the goals of the information disseminated to farmers on climate change and variability showed that the CCAA project aspired to:

Build capacity in farmers, organisations and the private sector, to enable them to improve agricultural innovation systems in both the favoured and unfavoured agro-ecological areas of Tanzania and Malawi. The ultimate goal of capacity building was to create awareness and to impart knowledge on new farming methods to enhance their adaptation capacities under the conditions of climate change and variability.

Reinforce farmers' ability to access and use quality information through training them to improve their agricultural produce. Access to, and use of, information is a key to adaptation to climate change and variability. Farmers need new varieties and farming methods which are compatible with their soil characteristics and environment.

Involve public and private sector stakeholders in developing efficient agricultural innovation systems. The government is resource-constrained and needs the private sector to assist in developing the initiatives to mitigate the adverse impacts of climate change and variability. Adaptation to climate change and variability is a long-term process which requires substantial investment in resources, namely financial, human, physical and social capital. Collaboration between the government and private sectors will enhance effective implementation of adaptation plans.

Enable farmers' learning and sharing of experiences for enhancing successful strategies to enhance the capacity of individuals, organisations and systems within the agricultural innovation systems. Researchers hold an important position in ensuring that the innovations from agricultural institutes and other scientific organs reach farmers to enhance their understanding of climate change and variability. If farmers are aware of the potential benefits and challenges brought about by climate change and variability, they can enhance their adaptive capacity.

7.3.3 Types of Information on Climate Change and Variability Disseminated to Farmers

The findings on the types of information on climate change and variability disseminated to farmers revealed that:

Information on improved seed varieties and drought-tolerant and resistant seeds, rainwater harvesting technologies (RWHT), food storage, maintaining soil fertility and use of affordable new farm implements was disseminated. This information is very important to Maluga and Chibeleda villages, which are semi-arid. Farmers in semi-arid regions are geographically disadvantaged when compared to those from other areas, due to the inadequate annual rainfall. They are thus prone to adverse climatic conditions, which reduce their crop production.

Information and knowledge on new farming methods was disseminated to farmers to enhance adaptation to climate change and variability. Such information and knowledge included proper use of fertilizer, soil nutrient retention, weather forecasting, early farm preparation and the types of plants to grow in a given season. Other farm innovations which were disseminated to farmers were information on spaced planting, inter-cropping, seed production, grain preservation, rainfall patterns and the use of pesticides. The study found that new adaptation information enhances farmers' adaptive capacities and reduces their vulnerability to climate change and variability.

Farmers had information disseminated to them that helped them to understand the effects of drought on agriculture, access to, and use of, improved seeds, access to markets, seed availability and early warning signs of impending floods. The availability of such information enables farmers to respond appropriately to climatic shocks.

Farmers mostly needed timely information on the onset of the seasonal rainfall, access to information on new seed varieties, the proper use of organic and inorganic fertilizers, crop diseases, proper use of pesticides and types of crops to grow in a particular season. The information needs of farmers on climate change and variability should be addressed to complement the existing adaptation initiatives on climate change and variability.

Despite farmers' having new information, to enhance their adaptive capacity, disseminated to them, they were experiencing difficulties in accessing and purchasing the necessary

agricultural inputs from the service providers. Long distances from the agricultural shops and the high prices of agricultural inputs prevented farmers from fully making use of the information provided to them to cope and adapt to climate change and variability.

The inadequate and inaccurate information supplied to farmers was a major contributing factor to the low rate of adoption of new farm inputs. Farmers complained about receiving inaccurate and inadequate information from agricultural inputs providers and advisers who provided them with technical information on ways of using agricultural inputs. Farmers also criticised the inaccurate information they received from the Tanzania Meteorological Agency, as not also being explicit on the rainfall distribution in a given season. Farmers expressed concern about delays in receiving information from the district authorities on the types of crops to grow in a season. These delays were attributed to communication and institutional barriers in the agricultural sector.

7.3.4 Channels Employed in Dissemination of Information on Climate Change and Variability

The findings on the packaging and dissemination of information on climate change and variability showed that:

Information on climate change and variability was not packaged well for the farmers. Effective packaging and dissemination of information on climate change and variability is critical for rural farmers. Well-packaged information is easily understood and applied by farmers. Proper packaging of information is also important in the scaling-up use of research findings by the farmers.

The means and channels that were being used to disseminate information on climate change and variability to the farmers do not give farmers an opportunity to seek feedback and clarification from extension officers. The results indicated that information from the extension officers disseminated to farmers followed a top-down approach. Farmers were therefore not satisfied with the frequency of feedback from extension officers and other researchers and thought the means of communication needed improvement.

Extension officers lacked adequate expertise to communicate their information on climate change and variability effectively to farmers. The communication challenge was attributed to lack of knowledge about climate change and variability by extension workers. Possessing

adequate knowledge on these issues would enhance extension officers' capacity to respond to farmers on issues related to climate change and variability. Sufficient knowledge of how to communicate such knowledge to farmers on the part of the extension officers would breach the communication barriers between extension officers and farmers.

Agricultural extension officers expressed technical difficulties in packaging and interpreting weather forecasts at local level. Weather forecasts are provided by the Tanzania Meteorological Agency, but at national and regional levels. Tailoring weather forecasts to local village level was needed. However, such tailoring of weather forecasts requires competencies which most extensions officers do not have.

Farmers' field experiments were used to unpack the knowledge from experts to assist its dissemination to farmers. The farmer field schools were an effective communication and knowledge transferring channel. They provide a chance for farmers to observe, try out and make critical evaluations of an innovation to identify its benefits, complexities and compatibilities.

Researchers and extension officers were used to teach farmers about new farming methods. As a means of enhancing knowledge exchange and transfer from researchers and extension officers, farmers participated in farmers' field training. Extension officers were deployed as they worked more closely with farmers and were more aware of farmers' challenges than researchers. Sharing knowledge on innovations provided an opportunity for farmers to learn new farming practices. It gives researchers and extension officers time to observe practices and learn the effectiveness of the innovations.

Despite the role of extension officers as the proper official channels in packaging and disseminating information on climate change and variability to farmers, village leaders were the ones widely used to transfer information to farmers. However, farmers complained about sometimes receiving inaccurate information on climate change and variability from village leaders.

Although audio-visual channels were mostly preferred by farmers, village meetings were the most widely and effectively used communication channels in disseminating information to farmers. Audio-visual equipment is effective in teaching and learning, as they provide both visual and hearing capabilities, thus improving farmers' social learning processes.

7.3.5 Methods which Farmers Apply to Mitigate the Effects of Climate Change and Variability

The findings on the methods which farmers applied to mitigate effects of climate change and variability indicated that:

Farmers had experienced significant changes in the environment, such as:

- Deforestation
- decreases in rainfall and access to water
- increased temperature
- increases in pests and crop diseases.

They had also changed their farming norms and adopted new farming practices to enhance their coping and adaptation capacities. Farmers' observations of changes in the environment are critical in designing and implementing coping and adaptation plans, as through observation farmers gain experience and witness changes in their surroundings.

Farmers in Maluga and Chibelela villages had adapted to climate change and variability by applying new farming methods such as early farm preparation, planting in rows, increased use of manure, improved seed growth, irrigation, early or late planting, use of drought-resistant seeds and early-maturing varieties. Other adaptation strategies employed by farmers included farm cultivation carried out in a participatory manner, soil fertility improvement by leaving farm residues to decompose, deep soil cultivation, the use of ridges, the use of more efficient farm implements, such as ploughs and tractors, and the use of pesticides. The application of these coping and adaptation measures reduces the vulnerability of farmers.

Farmers' awareness and knowledge of adaptation to climate change and variability was acquired through training. Access to knowledge through training was an important entry point in enhancing farmers' ability to cope with the effects of climate change and variability. As a result of the adoption of innovations, farmers' annual yields were indicated as having increased significantly.

Farmers still applied their indigenous knowledge in food and grain preservation. The use of indigenous storage tools by farmers was observed to be minimal. The few farmers who still used indigenous storage tools might be explained by these farmers' lack of access to

chemicals for food preservation. These farmers stored their grain in traditional storage pots such as *nhungu*, *kyungu* and in baskets such as *shakasaka*, *chidongha*, *nfoto* (see section 5.9.2 and Appendix 6 of the thesis).

Farmers used local indicators such as plant phenology, and the observation of animals, insects, birds, stones, wind direction and astronomical indicators such the sun, moon and stars, to forecast weather patterns. The use of these indicators in weather forecasting was, however, declining due to the demise of elders, a lack of documentation and preservation of the IK methods, climate change and variability and the youth's unwillingness to learn about the indigenous knowledge on weather and climate prediction.

Most (92.9%) farmers possessed Indigenous Knowledge (IK) on seasonal weather forecasting in Maluga and Chibelela villages. The study established that elderly farmers possessed IK to a greater extent than young farmers, despite statistics showing no correlation between age and the possession of IK. Thus age was observed to be a major determining factor in farmers' ability to predict rainfall onset and intensity in Maluga and Chibelela villages.

Few elderly farmers had knowledge on predicting the quantity of rainfall in the next farming season. This knowledge is important in mitigating the effects of climate change and variability, as it enables farmers to make decisions about the types of crops to grow in a season or adopting other coping strategies. It appeared that farmers' decisions to adopt an innovation are increased by advancing their confidence in the existing local knowledge which they possess.

The majority of farmers (76.2%) in Maluga and Chibelela villages relied on IK for weather prediction. Farmers were concerned that the local indicators which they had been using to forecast weather were becoming increasingly less reliable than was the case in the past. Farmers perceived changes in the environment to be the major cause of the unreliability of local indicators in predicting weather patterns.

IK was disappearing at an alarming speed, yet no initiatives had been introduced that sought to document or preserve this knowledge. Preserving and documenting this knowledge is important for designing coping and adaptation strategies which are affordable, sustainable and which respond effectively to the local environment. Most IK local indicators such as observed patterns concerning plants, birds, animals and insects depend on the environment

being hospitable for their existence. Preservation and documentation will be meaningless if the environment is not conserved.

Most young farmers did not possess IK and were less interested in using it to mitigate the effects of climate change and variability. Some young farmers viewed this knowledge as witchcraft, while other thought it was outdated. Findings showed that young farmers were diversifying their economic activities as a coping strategy to mitigate the effects of poor yields resulting from the inadequate rainfall.

Farmers utilised scientific weather forecast information from the Tanzania Meteorological Agency and compared it with their indigenous knowledge on weather forecast information. The use of both IK and scientific weather information together is indicative of the efforts made by farmers to mitigate the risk and uncertainty farmers try to overcome in farming.

Farmers had recently been diversifying their farming activities from rain-fed agricultural activities to small-scale irrigation agriculture. The cultivation of short-duration maturing vegetables such as onions, tomato, cabbages, peas and grapes was preferred by the majority of farmers. Irrigation farming is more reliable compared to rain-fed farming due to access to water being reliable. As a result, farmers can produce more food and earn more income using irrigation than when they depend on rain-fed agriculture at this time when rainfall is highly erratic.

Farmers have adopted other off-farm economic activities such as selling groundnuts, livestock, and fish, making and selling charcoal and selling firewood to mitigate the effect of climate change and variability on their usual means of livelihood. Other economic activities being applied to mitigate the effects of climate change and variability include building, sewing, keeping small shops (viosk) for selling food, beverages and other products catering for daily human needs. Others are diversifying into salt-making and providing a taxi service, using motorcycles famously known as “bodaboda”. The farmers were also involved in selling solar power machines, beekeeping and wax production, carpentry, casual labour and supplying grinding mill services and sunflower machines. There was also a growth of entrepreneurial activities (VICOBA) in Maluga and Chibelela villages.

7.3.6 Farmers' Current level of Adoption of Information on Adaptation to Climate Change and Variability

The findings of the study were that:

The majority (93%) of farmers were aware of climate change and variability and had adopted new knowledge on adaptation to climate change and variability. The high percentage of awareness is explained by the training and type of effective training farmers had undergone. Awareness is a key entry point in farmers' adoption of innovations.

The innovations which were highly adopted by farmers were improved farming methods and the adoption of high-value crops. The least adopted innovations were improved seed growth and new farm implement technology. Adoption of the innovations was influenced by perceived benefits, compatibility, trialability, observability and attitude to that innovation, thus confirming these aspects of Rogers' (2003) Diffusion of Innovations model.

Despite many farmers adopting new innovations, there was a knowledge gap which farmers observed in their own understanding of climate change and variability. Extension officers indicated a need for more training for themselves to keep pace with climate change and variability knowledge and to cope with weather patterns that are continuously changing. Inadequate understanding of climate change and variability limits diffusion and adoption of knowledge among users.

There were no observed differences between CCAA directly trained and untrained farmers in terms of adoption of information and adaptation to climate change and variability. Similarly, there were no observable differences between the adoption of innovations in Maluga and Chibelela villages. There were more active farmer organisations in Chibelela village than in Maluga village. The presence of farmer groups in Chibelela village promoted more knowledge transfer, more sharing and the adoption of innovations, compared to Maluga village.

In both Maluga and Chibelela villages trained farmers tended to seek information and consultations more often from extension officers and researchers than their untrained counterparts. This observed trend is explained by the direct contact of trained farmers with the extension officers. Such contact builds trust and motivates farmers to seek more information to fill their knowledge gaps. Access to the extension officers is important for

farmers as they have access to credible and authoritative information on adaptation to climate change and variability. These findings are consistent with those by Maddison (2007), who did a survey study of 11 African farmers and found farmers who had access to extension services adapted more to climate change and variability.

A positive association between age, farmers' income and level of education and the adoption of innovations was found. This association is crucial in designing adaptation plans, as they positively influence farmers' adoption of innovations behaviour. As a result, the effective implementation of adaptation practices depends on how these factors will be taken into consideration by policy-makers. Policy-makers can make use of these findings by designing policies which facilitate access to credit, knowledge transfer and sharing between farmers of different age groups, income levels and levels of education. In addition, policy-makers can design policies which promote farmers' access to markets and education to increase farmers' income and knowledge. All of these are critical in mitigating the adverse effects of climate change and variability.

Although most women engaged in farming group activities, a negative association was observed between gender and the adoption of innovations in the two villages. Both men and women actively participated in farming activities and gender is an important variable when dealing with adaptation to climate change and variability. Failure to consider gender in the adoption of innovations could result in unequal transfer of knowledge between the two genders. This could offset efforts to educate and build capacity on adaptation to climate change and variability.

Relative advantage, complexity, observability, compatibility and trialability were major attributes which influenced individuals' adoption behaviour. These adopter characteristics, together with attitude, previous experience and time highly affected the adoption and use of innovations by farmers. These results are consistent with Rogers (2003) the innovation adoption behaviour of Rogers (2003).

Low risk tolerance and trialability were observed to be higher (77.4%) than other attributes among the majority of farmers in both villages. The majority of farmers had higher (85.7%) observability capabilities regarding innovations. The study found that the complexity of innovations for farmers was low (28.6%). The majority (60.7%) of farmers indicated the innovations to be compatible with their farming norms. The study results showed that farmers

perceived the innovations which had been introduced as having relative advantage, compared to the conventional ones (refer section 5.6.1 of Chapter Five which describes training usefulness). Farmers' higher levels of observability indicated that farmers tended to make judicious decisions before adopting an innovation. Higher observability signifies low risk tolerance levels which are impacted by the limited resources which rural farmers have.

Other major determinants of the adoption of information on climate change and variability by farmers were the availability of rainfall, timely access to rainfall information, ability to interpret and use the information, social networks, farmer groups, literacy level, previous experience, attitude, capital assets, human assets, age and local institutions.

7.3.7 Access to, and Use of, Information on Climate Change and Variability

The findings on access to, and use of, information on climate change and variability indicated that:

Access to information and knowledge was a major determinant of farmers' adaptation to climate change and variability. Information on climate change and variability was repackaged prior to being disseminated to farmers in the study villages. Information repackaging enhanced access to, and use of, information on climate change and variability. Access to relevant, credible, up-to-date information improved users' confidence and promoted its usage. These results confirm those of Meyer (2005).

Although the study did not conduct a baseline survey prior to the introduction of the CCAA project, the study established that farmers have changed their attitudes to access and use of information on climate change and variability, compared to when the CCAA project was first initiated. Farmers' access to researchers and extension officers enhanced the effective communication of, and timely access to, information on climate change and variability.

Mass communications media, especially radio and mobile phones, were widely used by farmers, compared to other media, to access information on climate change and variability. Print resources such as fliers, brochures and magazines were less used by farmers to access information on climate change and variability. User preference of a source is a factor of need, awareness, credibility, timeliness and format of a particular source (Poole 1985).

Word-of-mouth was the most preferred communication mode for village leaders with extension officers and farmers. Farmers mostly depended on village leaders, who were

influential, knowledgeable or trained to access information on climate change and variability. High use of this communication method could be explained by farmers' perceptions of the credibility of information from the extension officers. Similar findings were made by Meyer (2000) and Morris and Stilwell (2003), in South Africa.

Village meetings, farmer groups and public gatherings were major platforms used by farmers to access information on climate change and variability. High scoring criteria for preferring these sources by farmers were easy access and the trustworthiness of the information. Accessibility and credibility of information are of great importance in reducing farmers' perceptions of risk in the adoption of innovations.

Research institutes and NGOs were found to be effective sources of disseminated information on climate change and variability in Maluga and Chibelela, which are semi-arid villages in the central regions of Tanzania. These villages have been exposed to a number of research and awareness programmes on natural resource management aimed at mitigating the impacts of climate change and variability. Farmers viewed researchers as important sources and channels of information on climate change and variability.

Despite researchers being recognized by farmers as important sources for technical information, the most challenging issues for farmers in accessing information from them were the distance between the farm sites and the research institutes. Although researchers were crucial for providing information and training farmers, farmers noted they were not as easily accessed when contacted as compared to the extension officers who resided in the districts.

Chibelela village had 12 existing farmer groups, compared to only two in Maluga village. The presence of many farmer groups in Chibelela could be attributed to the good leadership and benefits which other farmers perceived to be enjoyed by the trained farmers. Nonetheless, the findings in the two villages indicated that the number of active group members registered in the farmer groups was decreasing.

Farmer groups played a significant role in disseminating information and knowledge-sharing and imparting technical skills to farmers on the ways to adapt to climate change and variability. Farmer groups contributed to motivating farmers to change their farming practices, provided social assistance and enabled members to access loan and find markets.

Farmer groups comprised members with similar attributes. Rogers (2003) reasons that effective communication takes place between individuals who are homophilous, as described in the Diffusion of Innovations model. Homophilous refers to the degree to which two or more individuals who interact are similar in certain attributes, such as beliefs, education and social status (Rogers 2003:19).

The findings indicated that farmers were provided with new weather measuring equipment to enable them to be aware of the local weather. This equipment was aimed at enabling farmers to adapt locally by being aware of the weather and climate. Despite weather forecasting equipment being installed in each study village, there were problems with recording weather data and communicating the forecasts at district levels.

The majority of farmers (91.7%) were able to make use of information on the climate change and variability which they accessed from researchers and extension officers. Effective usage was enhanced by farmers' perceptions of the usefulness of the information in responding to their farming needs. Farmers' benefits emanating from their having access to, and using, information on climate change and variability included improved annual harvests, increased household food security and new improved farming practices.

7.3.8 Farmers' Attitudes to, and Perceptions of, Climate Change and Variability

The research findings revealed that:

Farmers perceived a decrease in rainfall, erratic rainfall patterns, an increase in dry spells, temperature and wind, an increase in pests and diseases for both crops and humans and a shortened growing season as being brought about by climate change and variability. They had also recently perceived a loss in soil fertility, a need for increased fertilizer usage, a decreased water table and a decline in the water retention capacity of the soil.

Higher adoption of new improved seed varieties by farmers was the result of perceived relative advantage and return values. Farmers' attitudes were being shaped by previous farming experiences which they used to compare their existing farming practices with new ones, in order to make judicious decisions. The Diffusion of Innovations model recognises relative advantage to be among the attributes which highly influence the adoption of innovations (Rogers 2003).

Farmers have changed their farming attitudes and adopted new farming methods (refer to sections 7.3.5 and 7.3.6 of this chapter). This change has been attributed to the failure of the traditional farming methods to respond to the newly observed impacts of climate change and variability. Despite changing their farming attitudes, farmers still perceived some of their farming practices, such as the use of organic fertilizer and some local crop varieties, to be better than the new ones.

Farmers had a negative perception of the use of inorganic fertilizer and the new improved seed varieties as a result of their previous farming experience. They perceived that inorganic fertilizers destroy crops and that improved maize seed varieties were susceptible to disease. Farmers also viewed the new sorghum variety as lacking in flavour, compared to the local variety (see section 5.6.1 of Chapter Five). The introduction of innovations could be more effective if farmers' existing practices and experiences were taken into account.

Although there was no farmer who was found to rely on irrigation for agriculture, the study found a paradigm shift indicating that farmers were adopting irrigation agriculture. These results show that, although they are in the minority, some farmers have changed their attitudes to depending on rain fed agriculture. Due to resource constraints, the study could not explore the extent to which farmers were engaged in small-scale irrigation in the two villages. Despite irrigation requiring more investment in capital and human resources, it does bring greater economic returns. With the application of irrigation farming, farmers can make effective use of land and the available water supply to cultivate crops during the dry seasons of the year.

Farmers still perceived agricultural inputs such as fertilizers and pesticides as expensive and inaccessible. The study observed the existence of a dependency syndrome on the part of farmers in the Maluga and Chibelela villages. It appeared from the findings that farmers in most rural areas believe the government should provide free agricultural inputs to them. Most farmers were not ready to purchase farm inputs to improve the quality of their crops.

The majority of farmers (45.2%) perceived poor extension services, changes of climate resulting in unreliable rainfall, an increase in pests and disease and inadequate farm inputs as the major challenges hindering their agricultural activities. These challenges highly affected farmers' attitudes and behaviour regarding climate change and variability.

The results of the study showed that the majority of farmers indicated that they had low levels of preparedness to endure extreme weather conditions such as drought and floods. The study findings showed that food insecurity levels were high at household level. The results showed that farmers were better-off in terms of food security after the CCAA training than prior to the introduction of the project. Findings indicated nearly 30% of farmers were prepared for drought and floods, should they occur.

Farmers' previous experience of climate change and variability strongly influenced their attitudes to, and perceptions of, decision-making on issues related to climate change and variability. Thus, the previous experiences which farmers have are crucial in the adaptation to climate change and variability.

7.3.9 Limiting Factors Affecting Access to, and Use of, Information on Adaptation to Climate Change and Variability by Farmers

Findings regarding the factors which affected access and use of information on adaptation to climate change and variability showed that:

Major factors affecting access to, and use of, information for adaptation to climate change and variability include the inadequacies of experts regarding the repackaging and dissemination information, a lack of timely access to improved seeds, the high cost of seeds and unreliable seasonal forecast information. Other factors were income and lack of wealth, poor and unreliable extension services and age whereby young farmers do not like to listen to educative awareness-raising radio programmes. Bureaucracy in maintaining weather equipment, low levels of literacy and inadequate knowledge of climate change and variability were other factors limiting accessing and the use of information to adapt to climate change and variability.

Institutional factors, such as an inability to package information on climate change and variability appropriately, inadequate knowledge of agricultural inputs providers and advisers by farmers, low-risk tolerance levels, low government budgets, challenges in managing farmer groups, lack of electricity and low purchasing power to buy batteries affected access and use of information for adaptation to climate change and variability.

Youth people were not willing to learn innovations or to be educated about IK by elders. Elders explained that youth were busy with other activities and were not ready to learn from them about the use of IK. Youth's willingness to adopt IK and participate in training is

important in adaptation to climate change and variability. As adaptation is a long-term process, the youth's readiness to acquire existing and new knowledge is of great importance for their active involvement and participation in the adaptation strategies. IK application increases the capacity to mitigate the effects of climate change and variability.

Farmers' cultural barriers were also observed to be barriers to access to, and use of, information on climate change and variability. Such barriers include farmers' ineffective participation in the training programmes designed for them. This factor was found to highly affect farmers' access to, and use of, innovations. Ignorance was another limiting factor in farmers' access to, and use of, information for adaptation to climate change and variability.

Bureaucracy impedes the flow of weather information. This information flows from the Tanzania Meteorological Agency (TMA) to the regional and district council authorities. Thereafter the information is sent to the district extension officers who, in turn, send it to extension officers representing each village. Thus, as the information flows through many practitioners and administrative units, there are high chances that this information can be distorted or delayed in reaching the user. This could prevent timely access to, and use of, the weather information to mitigate effects of climate change and variability.

Attitudes and perceptions affect access to, and use of, information on climate change and variability. Farmers tend to make decisions based on their previous experiences in using, or learning from others concerning, an innovation. If farmers have negative perceptions of an innovation, they will be skeptical about making use of that innovation in farming. In fact, they will hardly be ready to access and use that innovation until they acquire adequate knowledge on the innovation. Farmers will require more time to observe and try the innovation before making a decision on adopting or rejecting it (Rogers 2003).

Farmers' failure to witness and acquire farming experience from other farmers located in other districts or regions limits access to, and use of, information to adapt to climate change and variability. They lack success stories from other farmers on how to apply innovations fruitfully in their local communities. This lack greatly affects farmers' adaptation to innovations. The study indicated that there were other crops such as new varieties of peas and mango which could give greater return to farmers and which had a lower risk and lower rainfall dependability, but these were not adopted by farmers.

While homophily in farmer groups was found to affect farmers' access to, and use of, information on climate change and variability, the results showed that heterophily was not a contributing factor affecting farmers' access and use of information on adaptation to climate change and variability in the study areas.

Few farmers had indicated that the poor timing of broadcasts of information on climate change and adaptation was a limiting factor in their access to, and use of, this information. Their concern was that information on climate change and variability should be broadcast based on farmers' activities in a particular season.

As information was transferred from extension officers to village leaders, it became distorted before it reached the farmers. Despite widely relying on extension officers to disseminate information on climate change and variability, farmers in the two study villages complained about receiving incomplete and inaccurate information. Inadequate knowledge of climate change and variability might be the cause of this observed trend.

7.4 Conclusions

The conclusions of this study have been drawn from the research findings. The study conclusion seeks to associate the study findings with farmers' access to, and use of, information to enhance their capacity to adapt to climate change and variability. The conclusions drawn are based on the research objectives.

7.4.1 Characteristics of the Respondents

Findings presented on the respondents' characteristics showed that individuals in the farmer groups were generally elderly. There were more women than men who had basic primary education in the farmers' groups. From the statistical analysis, age, income levels and level of education were observed to correlate positively with farmers' adoption behaviour. Age, income and level of education did not influence farmers' awareness of climate change and variability. Despite the majority of women being actively involved in farmer groups, the study could not establish any relationship between gender and awareness of climate change and variability. No association was observed between gender and the adoption of innovations. The results were that nearly 60% of farmers had farm sizes above five acres and most were located in Chibelela village.

Age, income, farm sizes and education affected agricultural yield. The Sustainable Livelihood Framework (SLF) (Carney *et al.*, 1999), which describes human capital and financial capital assets should be considered in ensuring that farmers adapt effectively to climate change and variability. As farmers acquire more years of practising farming, they tend to develop more skills, which enhance their resilience to the effects of climate change and variability.

Higher income levels provide farmers with more purchasing power and options to make selection of the innovations. Level of education enhances farmers' ability to make productive farm decisions. Proper decision-making reduces farmers' risk in the adoption of innovations. Findings indicated that the majority of farmers had fairly big farms. Bigger farms are a critical asset in the adaptation process. Farmers can make use of the land and other resources to cultivate the land and to yield more food and increase their income. The size of the land is an important catalyst in farmers coping with and adapting to climate change and variability.

7.4.2 Goals of Information Dissemination to Farmers

The majority of the CCAA project goals had been achieved by the time the project was completed. The major determining factor in achieving the goals was the effective packaging and dissemination of information on climate change and variability by CCAA project experts. Information repackaging and dissemination was effective because experts with relevant knowledge and technical skills on climate change and variability were employed by the project. The presence of a strong technical team to repackage information on climate change and variability was manifest in farmers' levels of understanding and their adoption of new knowledge introduced by the CCAA technical team.

The study concluded, however, that despite most researchers possessing knowledge on climate change and variability, they had insufficient information repackaging and communication skills to pass this knowledge on to farmers. The repackaging of information on climate change and variability needs adequate knowledge, finance and skills. More experts are needed at district level to package and disseminate information on climate change and variability to farmers.

Prior to the CCAA project launch, there was poor collaboration among agricultural stakeholders in the study villages. However, the study concludes that subsequently CCAA project training managed to enhance collaboration between farmers, public and private

sectors. These sectors' close collaboration enhanced farmer's adaptation to climate change and variability successfully. As one of the observable benefit, new weather measuring equipment was installed in each study village to record local weather indicators.

The study concludes that farmer's access to information and knowledge from CCAA experts had changed farming norms and improved annual yields. Not only had the farmers' knowledge been enhanced through CCAA training, but extension officers' knowledge on climate change and variability was improved as well. Farmers' attitudes to, and perceptions of, climate change and variability were observed to have changed compared to when the project was initiated.

The study acknowledges farmers' willingness to learn from experts about new farming methods as a major entry point towards enhancing their adaptation. Farmers' reluctance to learn new farming methods would have undermined the effective knowledge transfer and exchange with agricultural stakeholders. However, adequate sensitisation, awareness and education from CCAA experts enhanced farmers' willingness to actively participate in the learning process.

The goals of information dissemination to farmers were to create awareness, enhance their adaptation capabilities and reduce their vulnerability. Access to new farm implements and farm inputs remains a serious challenge. A more comprehensive strategy is required to ensure that farmers have access to the inputs needed for coping with, and adaptation to, climate change and variability.

It was learned that the presence of the CCAA project enhanced farmers' timely access to innovations and technical information regarding new farming methods and ways of adapting to climate change and variability. Farmers were able to perform field experiments, observe, try out and compare the new knowledge with their existing knowledge. The farmers could generally access experts easily and seek clarification when they encountered barriers. The study concludes that feedback is of great importance to enable farmers' to access and use new knowledge from experts. Feedback managed to reduce their risk levels, increased tolerance levels and minimized negative perceptions of the new farming methods to which farmers were exposed.

In spite of the project meeting most of its goals effectively, the lack of accessibility to the well-established local institutions, to finance, as well as the existence of cultural barriers, reduced the sustainability of farmers' adaptation capacities. To alleviate the key difficulties which hindered farmers' adaptation to climate change and variability, proper institutional arrangements need to be put in place. Institutional capacity building is of major importance in enhancing farmers' effective use of resources designed for them. The study concludes that adaptation is a long-term and complex process, which needs multiple measures and sector collaboration which cannot be achieved by a single project. Projects have specific goals and resources are always a constraint to enhancing sustainability and scaling-up innovations. A key entry point to adaptation in rural areas should be frequent training for local people and capacity-building of local institutions, so that knowledge can be effectively transferred and diffused to farmers by research institutions. Proper institutional policies and frameworks at local level would facilitate access to resources required in the process of adaptation.

Adoption of new knowledge by individuals requires adequate time. In rural communities, such as where this study was conducted, farmers have limited resources which they can use in adapting to climate change and variability. Farmers should be given more time to adopt the innovations using their scarce resources. In addition to adequate time, they should constantly be supplied with the information they need. Failure to make information available to farmers will slow the adoption rate and expose farmers to more vulnerability.

7.4.3 Status of Knowledge Adaptation to Climate Change and Variability

The findings of this study indicate that farmers are aware of climate change and variability, but that they could not clearly understand and directly associate it with the cause of the changes which they observed. They could explain the changes they had observed recently, compared to those they observed in the past. They could also provide information about the new farming methods that they have incorporated in an attempt to adapt to climate change and variability (CCV). Farmers' access to repackaged relevant information on climate change and variability will enhance their knowledge and further motivate them to adopt new knowledge to mitigate adverse effects of climate change and variability.

Farmers perceived that the climate was changing and could explain the observed climate indicators such as temperature, rainfall and wind that had changed compared to the past. The results were confirmed by data analysed from the Tanzania Meteorological Agency, which

also indicated increases in temperature and a decrease in rainfall quantity. Attitude has been emphasised by the Diffusion of Innovations model as critical in farmers' knowledge acquisition, application and adoption. Thus a person's attitude will largely influence his/her sharing and use of knowledge to adapt to climate change and variability.

The results indicate that the majority of farmers have effectively adopted new farming methods as a way of adapting to climate change and variability. Farmer groups and other social networks were effective in imparting new knowledge to farmers to mitigate the adverse effects of CCV (refer to section 7.3.7 of this chapter).

To encourage innovation by farmers, they need to be capacitated by the provision of adequate resources and proper training. The study concludes that, although a few farmers were changing their farming practices from rain-fed to irrigation, the majority still relied on rainfall for agriculture. Farmers should be financially assisted to enhance their ability to adapt to irrigation farming which requires new equipment, more manpower and equipment. Subsequent to acquiring the necessary knowledge, farmers should be empowered by the provision of the appropriate resources which they can make use of in utilising their new farming skills. Inadequate resources will stall the progress that has been made. The shift towards new farming methods such as irrigation farming is attributed to farmers' perceptions of benefit in this practice and its compatibility with their norms and values, as explained by Rogers (2003).

Despite farmers having new farming knowledge imparted to them by experts, the majority shun this new knowledge. Farmers find indigenous knowledge on weather forecasts more practical and reliable in predicting weather. Despite farmers relying on IK to predict weather, the study found they complement IK with conventional weather forecasts from the mass media, in order to make farm decisions.

To enhance adaptation, local weather and climate forecasters and experts should collaborate to ensure that farmers reap the envisaged benefits. The study concludes that timely and accurate access to weather information, information on climate change and variability and relevant climate knowledge is important for farmers' abilities to adopt innovations. Credible information on climate change and variability would assure farmers of bigger harvests. Effective adaptation strategies will further motivate farmers to adopt new innovations.

The study concludes that farmers are changing their attitudes towards better farming practices to improve their food security and increase their income levels. Farmers' knowledge and adaptation capacity should be strengthened to enable them cope with resource constraints facing them.

7.4.4 Access to, and Use of, Information on Climate Change and Variability

The key findings of the study were that informal communication channels enhance quick information sharing, adoption and transfer of knowledge in the study communities. The majority of farmers used village meetings, community gatherings, village leaders and opinion leaders as their major sources of information on climate change and variability. Most farmers tuned in to the radio for updates on new farming practices and weather forecasts, while very few obtained similar information from television. A few farmers expressed the need to streamline the radio broadcasting times to match the farming and other economic activities they engage in within a given season.

The study found a low usage of print materials by farmers to access information on climate change and variability. Perhaps the low use of print materials could be explained by the fact that farmers had access to more reliable and timely information from researchers in the study villages. The low use could also be explained by an inability to read effectively, or to a culture of people shunning print resources (Meyer 2000; Stefano, Hendriks, Stilwell and Morris 2005).

Access to, and use of, information on climate change and variability from experts was promoted by farmers' access to information sources such as extension officers, researchers, opinion leaders, training, workshops, radio and social networks. Despite trained farmers having direct contact with change agents, the study observed no differences between trained and untrained farmers in terms of adoption of innovations. The study concludes that the scaling-up and spill over effect of the interventions was successful for farmers who were willing to learn in Maluga and Chibeleda villages.

Climate change and variability mitigation requires close collaboration among stakeholders in the packaging and dissemination of information to farmers. Collaboration between extension officers, meteorological experts and researchers is needed to ensure that information is repackaged effectively and timeously and disseminated to farmers. Repackaging would go a long way towards ensuring that farmers' specific agricultural and information on climate

change and variability needs are met to improve their food production and income. The repackaging of information on climate change and variability would contribute to farmers engaging in better decision-making and would provide them with options on ways to respond to the adverse effects of climate change and variability. The key challenge in repackaging of information on climate change and variability would be the availability of funds and the ability of change agents to co-ordinate communication between experts, researchers and extension officers in the quest for maintaining the quality of the content and accuracy of packages produced.

Researchers, the government, NGOs and civil society engage in creating awareness and contributing to farmers' adaptation to climate change and variability to improve annual yield. In the study areas, researchers were well acknowledged and relied upon for training and educating farmers on new farming methods to cope and mitigate climate change and variability. Measures to enhance farmers' coping and adaptation ought to go beyond creating awareness and education and imparting technical knowledge and timely assistance to them to mitigate the effects of climate change and variability.

Findings indicated that extension officers were not reliable in providing advice to farmers. The majority of farmers showed faith in the credibility of the technical information being offered by the extension officers. These findings are consistent with those of Rogers (2003) in the Diffusion of Innovations model. Proper institutional arrangements should be in place to facilitate effective communication between farmers and extension officers. As the SLF (Carney *et al.*, 1999) explains, financial capital and physical capital should be made available for repackaging technical information to farmers.

Indigenous knowledge is mostly possessed by elders and is not documented. As a way to preserve the IK, there is a need to transfer this knowledge from the minds of elders to information centres, where it can be accessed conveniently by the next generation. Failure to transfer this extraordinary knowledge will result in the loss of it, which cannot be accessed anywhere else. It is concluded that IK is currently difficult to access, despite the fact that most elders have the ability to predict weather and climate events indigenously. To enhance wider usage of this IK, proper collection, organisation and storage of this information in a format which can easily be accessed is an urgent requirement.

The study concludes that farmers' access to, and use of, information for adaptation is influenced by timeliness, credibility, relevancy and accuracy. Information repackaging at district level might improve access to, and use of, information by farmers and prevent farmers' information overload and confusion, which discourage usage.

The study established that there was no proper collection, storage and dissemination for information on climate change and variability at district and village levels. Lack of expertise in managing information at district and village levels was observed.

Extension officers in study villages were aware of climate change and variability issues as they were actively involved in the CCAA project. The study underscores the importance of frequent training for extension officers on climate change and variability.

7.4.5 Factors Affecting Access to, and Use of, Information on Adaptation to Climate Change and Variability

The study found that the major constraints facing farmers were institution-related (refer section 7.4.2 of this chapter). These barriers resulted in untimely access to the information which could enhance adaptation to climate change and variability. Farmers complained that they received farm inputs such as seeds and fertilizer too late, when they no longer needed them. They failed to utilise the subsequent information disseminated to them as it was of less value. Barriers to access to, and use of, information of adaptation to climate change and variability were aggravated by the false information farmers received from agricultural inputs providers and advisers in agricultural shops. The agricultural inputs providers and advisers directed farmers on how to use agricultural inputs such as pesticides, fertilizers and seeds. A strong quality assurance organ is needed to ensure farmers have access to viable seeds which have not expired, to strengthen their adaptation capacity.

Access to information by farmers could be enhanced through adequate budgetary allocations to district agricultural offices, so that they could facilitate the dissemination of timely, relevant information on climate change and variability. The district could also find other means, such as collecting taxes from the most popular agricultural activities in the district such as selling crops and livestock, to improve service delivery to farmers.

The unreliability of the information disseminated was viewed as a major constraint to farmers. Results showed that farmers made use of the weather forecast information they

received from the radio, but became discouraged as the forecasts were often not sufficiently precise. The inadequate number of Agricultural Meteorological (AgroMet) stations at village/ward level contributed to farmers' failure to access and use information locally. There is a strong need to strengthen services provided by meteorological agencies to give farmers confidence on the use of weather information. Farmers' previous experience in accessing information contributed largely to the way they used similar information to adapt to climate change and variability.

Farmers expressed concern about information distortion as information moves from extension officers to them. To avoid this, there is a need to ensure information disseminators directly meet farmers and deliver their messages. As information on climate change and variability is dynamic, there is a need to ensure that information from higher levels is repackaged by experts before being released to farmers. Information repackaging will help farmers receive information which suits their needs and is compatible with their farming practices. Failure to curb this challenge may discourage farmers from accessing such information.

Inadequate resources were also cited as critical in accessing and using information on adaptation to CCV. In the study villages, there was no electricity. Farmers thus used other cheap energy mechanisms to access the radio. Farmers who are limited by access to resources cannot spend their limited income on buying batteries if they are not sure of food for tomorrow. Inadequate resources will jeopardise farmers' ability to access and use information for adaptation to climate change and variability.

Findings from the study indicated that age and cultural barriers affected farmers' access to, and use of, information on adaptation to climate change and variability. There was still a problem of farmers not actively adopting innovations introduced. Ignorance and youth's unwillingness to participate seemed to be an impediment towards access to, and use of, information for adapting to CCV. The changes observed where the younger generation detaches itself from agricultural activities could be explained by globalisation, where the youth find other economic activities that have better returns than agriculture. The study concludes that appropriate training is needed to sensitise and create awareness among farmers to break from cultural barriers such as ignorance, unwillingness to actively participate in training programmes and other cultural barriers to change that impede them from utilising

innovations. Learning examples or case studies should be used to motivate farmers on the best farming and adoption practices towards CCV.

The study found that farmers' had low risk tolerance levels, low literacy levels and insufficient information on markets. Access to markets should be a priority if farmers' agricultural produce are to benefit them economically. Lack of information centres was another factor which impacted their access to, and use of, information to adapt to climate change and variability. All these factors can be minimised by designing a vibrant communication strategy which will improve the communication of information on climate change and variability to farmers.

Through consultations, farmers' attitudes to certain innovations could be changed positively. Use of personal sources should be encouraged, as they are effective in breaking strong attitudes in a community (Rogers 2003). The decision to adopt or reject an innovation should emanate from farmers and not be imposed by researchers or extension officers. In this way researchers and extension officers can come up with short-term, medium-term and long-term adaptation strategies which are implementable in the society.

7.4.6 Overall Conclusion about the Research Questions

As a general conclusion about the research questions discussed, the study ascertained that innovations introduced to farmers on best farming practices helped farmers to adapt to climate change and variability. The innovations introduced only partially helped farmers to improve their livelihoods due to three major limitations, namely low levels of literacy, undeveloped local institutions and inadequate longer-term training.

Climate change and variability is a new phenomenon not only for farmers, but also for extension officers and researchers. CCV is a dynamic and multidisciplinary field which needs collaboration between many different types of stakeholders. Frequent awareness and education interventions will keep people updated on climate change and variability issues so as to influence their attitude and behaviour towards adaptation.

Adaptation is a long-term and expensive endeavour which requires huge investment of resources by the government and private sector. The adaptation programmes are mostly effective when the local institutions are well-organized. Farmers should be aware of where they can access reliable information on agricultural inputs, technical information, market

information and weather forecasts. Policy-makers should be sensitised to, and convinced about, the patterns of climate change and variability. Failure of scientists to convince policy-makers on CCV will make the adaptation process more gradual.

Frequent and longer-term training for farmers is of immense importance in ensuring they understand new knowledge and effectively adapt to climate change and variability. Training entails farmers participating in field experiments which are very effective in imparting new skills and reducing risk levels. The training of farmers' training enhances the spill over effect and scaling-up of new knowledge to many farmers.

7.5 Recommendations

The study identified diverse issues which affect effective access to, and use of, information on climate change and variability for adaptation by farmers in Maluga and Chibelega villages in Tanzania. The study makes recommendations as a strategy to address the climate change and variability issues which affect agricultural production and the adaptation of farmers' to climate change and variability in rural areas. The recommendations that follow address each of the study objectives, in turn.

7.5.1 Recommendations on the Characteristics of Farmers

As the majority (75%) of farmers had basic primary education, it is particularly important that farmers should be educated about the new farming practices which will enable them to increase their annual harvests. Considering that physical assets are crucial in adapting to the challenges of climate change and variability, farmers' access to bigger farm sizes would enhance adaptation capacity and improve their annual turnover. By effective utilisation of land for increased yields, the availability of food at household level would be increased, thus contributing to the achievement of greater food security among the communities in the two villages studied. Bengesi, Wambula and Ndunguru (2004) in Tanzania, and Akudugu, Guo and Dadzie (2012) in Ghana showed that farm sizes play a crucial role in farmers' adoption of innovations.

7.5.2 Goals of Information Disseminated to Farmers on Climate Change and Variability

The major goal of the information disseminated to farmers is to improve their livelihoods. It is important to make sure farmers embrace new knowledge, use it to improve their crop production and ultimately change their farming norms. Frequent user training programmes

are needed at this time when climate change and variability has become more evident. Farmers should not be allowed to reach a point where they resist adopting innovations which might have enhanced their farming, as a result of inadequate credibility and poor quality farming inputs and technological barriers. Packaging of information on climate change and variability is important in facilitating sharing and in the transfer of knowledge to farmers and the scaling-up of innovations. The sustainability of programmes should be properly designed and planned if farmers are to continue benefitting from the programmes initiated. Failure to provide farmers with adequate resources and weak supporting institutions will result in weak and inefficient systems to respond to adaptation challenges. It is recommended that the government designs policies which will make adaptation programmes sustainable. Yanda and Mubaya (2011) suggested a need to prepare policies which reflect short-term, medium-term and long-term goals to facilitate and maintain coping and adaptation measures. The authors recommended that the policies be mainstreamed in development plans.

7.5.3 Status of Knowledge Adaptation to Climate Change and Variability

Farmers are adapting to climate change and variability, but much needs to be done to enhance their understanding of climate change and variability. As awareness influences information seeking and knowledge, according to Apata, Samuel and Adeola (2009) and Poole (1985), farmers should be equipped to become life-long information-seekers and not only information recipients. They should be trained to be active information-seekers and users. Adopting information and knowledge-seeking behaviour will keep farmers aware of innovations as they arise. Farmers will also build more confidence in responding to climate change and variability challenges by having access to reliable sources which enhance their knowledge and understanding. However, as it is not certain what direction climate variability will take in the future, it is recommended that farmers should be assisted to have access to up-to-date information and knowledge to enhance their adaptation to climate change and variability. Researchers, extension officers, politicians, private sector and government officers need to devise strategies which will enable the majority of farmers to gain understanding on climate change and variability. There is a need for adequate awareness, and understanding of climate change and variability issues was recommended by Mutekwa (2009) and Corner (2011).

Indigenous knowledge (IK) is deteriorating at a high rate in the Maluga and Chibelela villages. It is high time that IK is documented and preserved to ensure easy access to and use

of it, now and in the future. IK should not be seen as outdated and senseless, compared with modern scientific knowledge. Scientific knowledge has also recently failed to give solutions to a number of existing human problems and diseases such as cancer, HIV/AIDS, climate change and variability and food security. This scenario has prompted scientists to turn to IK in order to fill the gaps which could not be filled by modern scientific knowledge. Thus, change agents, in seeking to mitigate the effects of climate change and variability, should consider farmers' existing local knowledge on farming and the environment. Green and Raygorodetsky (2010) suggested that mitigation and adaptation strategies can only be effective when peoples' indigenous knowledge and scientific knowledge are incorporated. Awareness campaigns should be increased at local, district and village level, to enhance the restoration of the environment which hosts the local indicators which farmers mostly use to interpret and predict weather in a given season.

The study established that access to water is critical in the adaptation process, there is a need for the government to take necessary steps to ensure that farmers in dry, semi-arid and arid areas have access to water reservoirs. Access to water will save farmers time and resources which could be used for other agricultural activities. The study established that access to reliable sources of water for agriculture motivates farmers to practise new farming methods from experts and promotes farmers to adapt to innovations on climate change and variability.

Farmers should be encouraged to practise irrigation as an adaptation strategy to improve their livelihoods and incomes. Irrigation will ensure that farmers harvest many times in a year, rather than depending on rain fed agriculture. Farmers who have more income and resources are in a better position to adapt to climate change and variability, provided they have the knowledge. These suggestions on enhancing farmers access to reliable water for agriculture, such as designing irrigation schemes, were also made by Mutekwa (2009), Mengistu (2011) and Yanda and Mubaya (2011).

7.5.4 Access to, and Use of, Information on Climate Change and Variability

Despite being seen as unreliable (Kadi, Njau, Mwikya and Kamga 2011), extension officers remain a major link to disseminate information on climate change and variability to farmers. Most extension officers have inadequate technical knowledge to deal with innovations discovered from research institutions on climate change and variability. Researchers should train extension officers to enhance their awareness and understanding of the new challenges

and opportunities emanating from climate change and variability. Extension officers' access to relevant knowledge will give them confidence in dealing with issues related to climate change and variability. Ngigi (2009) recommended that private and extension officers who provide technical assistance on innovations should have their skills upgraded, in order to help farmers cope and adapt to climate change and variability. The Ministry of Agriculture should design strategies to promote extension services in the country, to enhance farmers' knowledge on climate change and variability issues. In this regard, there is a strong need to make sure that knowledge on these issues is communicated effectively from higher to lower levels. Much investment is needed in research institutions to ensure farmers reap the benefits of climate research. Manda (2000) suggested a need to improve research institutes and extension services in Tanzania to foster agricultural development.

In order to enhance farmers' use of the information disseminated to them, there should be mechanisms to guarantee that this information is up-to-date, credible and accurate. Repackaging information on climate change and variability at district level is needed to mitigate against information overload and confusion in farmers. Farmers tend to first evaluate the new information they receive and compare it with their prior information. To be utilised, the information provided should be sufficiently credible, in order to convince farmers of the relative advantage it offers. This advantage should be observable in a specific period of time. Only less complex, compatible and triable innovations are likely to be adopted by farmers based on their merits (Rogers 2003).

The study recommends extending farmers' weather risk insurance schemes. The schemes might improve farmers' access to, and use of, information on climate change and variability. Kandji and Verchot (2007) suggested effective use of crop insurance schemes for farmers in order to protect them from exposed risks which might be caused by bad decisions due to incorrect seasonal predictions. Weather risk insurance may improve farmers' risk tolerance and enhance confidence in farming and effective adoption innovations.

Packaging and the dissemination of information on climate change and variability requires adequate human capital and physical and financial resources. Appropriately targeted packaging assists researchers in choosing effective methods to deliver information to users. This might be a combination of the use of audio-visual learning materials, local radio, mobile phones, print and social networks. These sources are useful in changing individuals' attitudes

towards and enhancing innovations and their adaptation capacity. It is recommended that packaging of information be dealt with accordingly by the government and private sector, by combining different sources and channels of information to facilitate timely access to, and use of, information to farmers. These suggestions were also raised by scholars such as Rogers (2003), Ofuoku and Agumagu (2008) and Shetto (2008).

The study recommends close consultation between researchers, extension officers and farmers. Close collaboration will help researchers become vigilant in assessing the innovations they introduce to farmers, which is an important step towards farmers' access and use of information on climate change and variability. Through collaboration, researchers will have a chance to see practically how the technology introduced works in the field. Thereafter, researchers can have a chance to clarify and re-research the problems raised by farmers with regard to innovations introduced. Close collaboration also entails adequate training of experts, regular site visits, seminars and workshops, to keep users abreast with new information on climate change and variability. Researchers and extension officers need to learn how to effectively communicate their research findings and new knowledge to farmers. Similar recommendations were provided by Sturdy, Jewitt and Lorentz (2008).

The study argued that access to information was key to the adoption of innovations, as the study could not find a major difference between trained and untrained farmers applying information disseminated on adaptation to climate change and variability. The study established that access to relevant information and knowledge on climate change and variability, to promote usage. If farmers have accurate and relevant information, they are more likely to try to adopt innovations than those who lack adequate information. Usage of the disseminated knowledge also largely depends on the qualities of a farmer (Rogers 2003).

To enhance access to information by farmers, proper collection and dissemination mechanisms are needed to provide a conduit for information from the national and regional to village level. There should be a strategic way of co-ordinating and managing information on climate change and variability from local to national levels. Failure to co-ordinate the information disseminated to farmers may result in skepticism among community members in adopting that information. To facilitate access to, and use of, information on climate change and variability, farmers require effective and timely practical field training to enable them to observe the farming challenges, so as to minimise risks and uncertainty.

IK is perceived to be reliable by the majority of farmers in Maluga and Chibelela villages. However, since there was no proper mechanism designed to preserve this vast knowledge, accumulated over many years, the study recommends that IK be integrated in the school syllabuses. Older farmers should ensure they teach young farmers IK to increase their adaptation capacities. Researchers, knowledge experts and farmers should collaborate to make this recommendation a reality. Speranza, Kiteme, Ambenje, Wiesmann and Makali (2010) similarly recommended incorporating IK in the education curriculum and linking it with formal climate change and variability research as a way to ensure indigenous knowledge is preserved and continues to be used by local people in mitigating the impacts of climate change and variability.

7.5.5 Factors affecting Access to, and Use of, Information on Adaptation to Climate Change and Variability

Farmers need credible content from extension officers, researchers, agricultural inputs providers and advisers and the Tanzania Meteorological Agency (TMA). They also need proper broadcasting times for information on climate change and variability. To enhance easy access to credible information for farmers, the study recommends improvement in budgets to districts, frequent monitoring of agricultural shops, credit schemes, reliable markets and farmers' support networks. Other improvements include regular training of agricultural officers, access to affordable agricultural inputs, infrastructure (roads and telecommunication), use of local radios and capacity-building for farmers at local level. Improvements will enhance farmers' access to relevant knowledge, agricultural input, and avoid farmers being misled by agricultural inputs providers and advisers. Agwaru, Matsiko and Delve (2004); Orindi and Murray (2005) and Adejuwon, Odekunle and Omotayo (2008) recommended improving the content of information to enhance farmers access to, and use of, agricultural information for adaptation to climate change and variability.

Specifically, adequate budgets will facilitate service provision to farmers and increase the number of extension officers at ward and village levels to train farmers. To promote the use of new practices adopted by farmers, concerted government engagement and investment in agriculture is required. The study by Agrawal (2008) and Yanda and Mubaya (2011) suggested a need for government intervention to deal with institutional factors, which largely limit adaptation to climate change and variability.

7.6 Originality of the Study

Timely access to, and utilisation of scientific information on climate change and variability, is a critically important topic, globally, and in Africa, where food security is at risk. The provision of such access is predicated on well-packaged and disseminated information. This study investigated the extent to which the scientific information and knowledge generated on climate change and variability is appropriately packaged and disseminated to farmers to enhance crop production in a situation of climate change and variability. Through the research project based in Maluga, Sanjaranda, Laikala and Chibeleda villages in the central regions of Tanzania, farmers have been trained and provided with information on agricultural innovation systems to enhance adaptation to climate change and variability (CCAA 2009). However, it was not evident to what extent the farmers had received and utilised the knowledge disseminated to them. There has not been a study carried out to monitor and evaluate the use of knowledge to mitigate and adapt to climate change and variability and improve farmers' agricultural production. This study therefore was conducted to monitor and evaluate the use of new knowledge in adapting to climate change and variability and improving agricultural production.

There was a paucity of studies on how the information generated through research and training on adaptation to climate change and variability was packaged, accessed, disseminated and utilised by farmers. This study investigated how information on adaptation to climate change and variability generated from the Climate Change Adaptation in Africa project (CCAA) was packaged, disseminated and utilized by farmers in central Tanzania. The study was partly motivated by suggestions from Meyer (2000) in South Africa, who found that training was an important aspect in promoting effective transfer of scientific agricultural information to farmers, who are mostly illiterate. A similar study which demonstrated the role of farmers' training was done in South Africa by Sturdy, Jewitt and Lorentz (2008), who sought to understand agricultural innovation adoption processes through farmer-driven experimentation.

The present study demonstrated that the packaging of information was crucial in the delivery of critical information on climate change and variability and is key to farmers' adaptation. In this regard it builds on other studies like those of Sturges and Chimseu (1996b) and Morris and Stilwell (2003) who emphasised the role of repackaging of information in formats usable

to the local communities. This study, however, applies the practice of packaging specifically to climate change and variability information and the findings have a considerable depth.

Packaging of information on climate change and variability will enhance farmers' effective use of information. Other benefits of packaging information on climate change and variability includes helping to identify farmers' needs and increase credibility and authoritativeness of the communicated information to farmers. As a result, farmers' confidence on the use of information is improved and perceived risks towards innovations are reduced. Mutekwa (2009) and Mowo *et al.* (2011) recommended proper packaging of information on natural resource management research to reach highest potential. The study by Mowo *et al.* (2011) further suggested assessing farmers' needs and capacity to communicate their needs, creating partnerships and capacity-building to information providers as crucial in packaging information on natural resource management research to facilitate effective adaptation.

Packaging information on climate change and variability depends on the availability of information content, adequate training, expertise, collaboration, finance and capacity-building for information disseminators to enhance farmers' effective usage of information. Repackaged information should strive to achieve accuracy, the desired content and format, timeliness, appropriateness, proper channels and relevance qualities (Morris and Stilwell 2003). Therefore, with the complexities of climate change and variability the challenge will be to organise, document and convert information from sources such as IK, print and electronic sources, the usable formats accepted by farmers. Experts and researchers should therefore have adequate skills and knowledge to enhance proper collection, generation, repackaging and dissemination of information on climate change and variability to farmers. This capacity will enhance the production of quality packages, which meet users' needs. Experts and researchers should also not only aim at providing farmers with information on climate change and variability, but also consider other attributes such as the quality of information and indigenous knowledge which promote farmers' use of an innovation.

In spite of few studies having been conducted focusing on IK farmers use for adaptation to climate change and variability in Tanzania, the investigation could not isolate a study which has been conducted previously in Maluga and Chibelela villages which explored, in detail, the use of knowledge on local indicators to predict weather in the next season. This study therefore addressed the need for documenting and preserving IK, so that it could be used

effectively by farmers in adaptation to climate change and variability. The study investigated farmers' possession of IK and the reliability and use of IK local indicators for predicting weather at village level.

7.7 Implications of the Research for Theory

Information behaviour research is primarily guided by research models all working together towards a theory of information behaviours. One aspect of information behaviour research is the dissemination of information which has received scant attention thus far. This study is valuable for the insights it offers in this regard (Anonymous external examiner 2014). It has implications for the agricultural, climate and information science disciplines, which have a bearing on one way of enhancing effective access to, and use of, information to mitigate impacts of climate change and variability. The study made the following contributions:

7.7.1 Access to, and use of, Information on Climate Change and Variability

The study makes an important contribution to knowledge of Rogers (2003) Diffusion of Innovations model (DOI). It shows that, in the provision of access to timely and credible information to rural farmers, perceived relative advantage, complexity, compatibility, trialability, attitude, resource availability, simplicity and observability of an innovation contribute highly to shaping farmers' knowledge and decision to adopt innovations. This research further extends the wider theoretical perspective on information and knowledge management, by incorporating the original findings related to access to, and use of, relevant knowledge for adapting to the critical area of climate change and variability. The study reveals the importance of access to relevant knowledge as an entry point towards farmers' adoption and use of innovations on climate change and variability. The information should be easily accessible and in a format which is understandable to all users. Complex innovations will hardly be used by farmers, as most of them lack adequate formal education which facilitates better decision-making. These attributes are crucial in influencing farmers towards making use of adaptation strategies designed for them.

Despite many scholars explaining that adaptation to climate change and variability is influenced by specific factors, the study learned that adaptation is broad and complex. The complexity increases, as there are many factors which are social, economic, political and cultural, which shape farmers' adoption behaviour and influence adaptation. Therefore, for adaptation plans to be effectively implemented by farmers, these factors should be

consolidated, together with the proper communication of information when designing for coping and adaptation strategies.

This study contributes further to the body of knowledge on the DOI model, by suggesting areas for amendment. It demonstrates that the body of knowledge on access to, and the use of, information by suggesting that the process of disseminating, transferring and sharing information on climate change and variability should not be viewed as unidirectional, as presented in the DOI model, but rather a cyclical process. The flow of information in a cyclical form gives an opportunity for users to have access to credible information and to be able to seek clarification from the source. Researchers who act as an important link in disseminating scientific information to extension officers and farmers should learn to communicate effectively and report back their findings to farmers. The reporting back of research outputs will enhance the use of scientific information by farmers. The study recognises and encompasses users' feedback as an important aspect in the communication process between farmers and researchers and public and private extension officers. Sturges and Chimseu (1996b) confirm the role of feedback and explain that information packages disseminated should be followed by assessing users' feedback. In addition, the study recommends that, to enhance usage, information and knowledge disseminated to farmers should be channelled through the proper means with which farmers are more familiar.

Contrary to many studies which applied DOI in agriculture and information science fields (refer to Chapters One, Three and Four of the thesis), this study applied DOI in studying climate change and variability research in rural areas of Tanzania. The study largely adopted qualitative research methods to study issues related to adoption of adaptation information on climate change and variability. Many other studies which adopted DOI used quantitative methods (refer to Chapters One, Three and Four of the thesis) and hence this study can be seen to have added a more qualitative dimension to the research, which would be more in keeping with information behaviour research at the current time. As a contribution to broad theoretical perspectives, the study showed that the Diffusion of Innovations model can be applied in climate change and variability studies. The study contributes to the theory by suggesting attributes such as timely and simplified access to information, economic benefits, farmers' previous experience of an innovation, social-economic factors, collaboration between farmers and experts and the use of Information and Communication Technologies,

specifically mobile phones, to inform farmers on issues related to climate change and variability. These variables were not discussed in the DOI model by Rogers (2003).

7.8 Implications of the Research for Policy

The current study contributes to policy in various ways:

Improving ways to enhance farmers' access to, and use of, information on climate change and variability through repackaging of information. Farmers need timely, current, easily comprehensible information, which responds to their needs. Articles 34, 35 and 39 of the Tanzania National Environmental Policy (NEP) of 1997 express the need to involve the public in creating awareness and education on environment issues. However, these articles lack an effective means to be used to disseminate information on climate change and variability. Article 35 describes the necessity to apply a bottom-up approach, to identify the problem and reflect needs of the local people. The articles further state that most environmental actions by national institutions are large-scale, rigid and practised outside peoples' local surroundings. Article 39 emphasises the need for the availability of timely, up-to-date and accurate information for sustainable management of environmental resources. The clause stresses the need to ensure that environmental information is generated, gathered and disseminated for managing the environment. Thus, despite these articles showing the necessity for people to have access to timely information, the policy falls short of adequately describing ways to implement methods to improve the effective use of this information by farmers.

Emphasising the development and implementation of a policy framework which guides documentation and preservation of Indigenous Knowledge (IK) on weather prediction. Proper policy would enhance access to, and use of, indigenous knowledge for adaptation to climate change and variability by using established knowledge management practices. Documenting and preserving IK is important in designing effective plans on adaptation to climate change and variability. Mainstreaming IK into formal coping and adaptation strategies will help researchers come up with mitigation strategies which are participatory, cost-effective and sustainable. The policy should address ways to strengthen and support institutions technically and financially in documenting and preserving IK. Well-developed institutions will facilitate farmers' access to timely, credible and relevant information and knowledge on adaptation.

One of the goals of the Tanzanian National Adaptation Programme of Action (URT 2007) is to increase public awareness of climate change and variability impacts and adaptation activities in communities, civil societies and government officials. Among the potential adaptation plans emphasised by NAPA include promoting IK; making better use of climate and weather data and weather forecasts; creating awareness of the adverse impacts of climate change and variability; and reinforcing early warning systems. The NAPA strategies did not recognise documentation and preservation of IK as critical in the adaptation to climate change and variability strategies. Orindi and Murray (2005) and Chang'a, Yanda and Ngana (2010) acknowledged a need for documenting, preserving and integrating IK into conventional adaptation plans in Tanzania. Scholars such as Mahoo and Mpetta (2011) and Yanda and Mubaya (2011) suggest that IK should not compete with scientific knowledge, but rather complement it.

Enhancing the communication of climate change and variability information between disseminators and users. The Tanzania National Strategy for Growth and Reduction of Poverty II (NSGRP II) of 2010 came up with 25 strategies aimed at promoting the growth of the agricultural sector by 2015. The tenth strategy describes mitigation and adaptation to climate change and variability as critical in promoting agricultural development. The strategy emphasises the importance of strengthening research programmes to improve and develop new technologies, quality seeds, pest control and agronomic practices, irrigation and information collection and dissemination for early warning. Unlike many past development plans, the NSGRP II shows its commitment in supporting initiatives to enhance adaptation to climate change and variability. The policy gap this study attempts to fill contributes to designing policy measures which promote the effective usage of innovations produced from research programmes. The study recommends a policy to guide the communication process which facilitates effective transfer and sharing of knowledge from researchers to users in desired content, appropriate format, up-to-date and packaged to specific users. These information attributes are important in promoting usage of information for adapting to climate change and variability. Ngigi (2009) also emphasises the importance of the availability of timely and reliable information in designing successful drought plans and policies.

The study suggests that the new communication policy should stress regular and long-term training for farmers, researchers and extension officers to improve their communication

skills. This training could help promote the effective flow of research findings on climate change and variability to reach farmers. Adequate training and the collaboration of these experts with farmers will help in the designing of farmer support programmes which can be effectively adopted and accepted in the community. The Ministry of Agriculture should design and implement policies which foster collaboration between researchers and government officials and government and private extensions workers when introducing innovations to farmers. A recommendation on collaboration between researchers, farmers and government and private sectors was described by Kaliba, Verkuijl and Mwangi (2000).

Providing appropriate policy at district level might motivate agricultural service providers to provide services to farmers effectively. Policy could underpin channelling more income from the central government to the local district levels. Adequate budget and incentives will enhance easy access to, and use of, agricultural inputs such as farm implements, fertilizers and seeds, at village level. Yanda and Mubaya (2011) recommended supporting informal and formal seed systems as a critical adaptation plan. Strengthening seed production and delivery systems will facilitate farmers' timely access to seeds, which play an important role in mitigating climate change and variability.

Adjusted government policies as a result of the recommendations made in this research could be of great value to farmers, as it could help promote effective diffusion and adoption of innovations to farmers. Adoption of innovations will enhance farmers' ability to cope and adapt to climate change and variability. The policies will facilitate access to improved seed and drought resistant varieties, improve access to credits, improve access to and use of agricultural inputs, improved farming methods, facilitate access to reliable, understandable and relevant information on climate change and variability and increase use of irrigation schemes.

7.9 Implications of the Research for Practice

The current study contributes to practice in various ways:

The study underscores the need to deal with cultural and institutional barriers to enhance farmers' adoption of innovations. Agrawal (2008) noted that most National Action Plans for Adaptation (NAPA) lacked a link between local institutions, local people and national policies towards adaptation to climate change and variability. The study further showed that NAPA had concentrated more on providing technical and infrastructural assistance to people

than ensuring that local institutions and local people were in place to accommodate the innovations. Farmers are constrained by a number of factors which limit their ability to access and use information on climate change and variability. Ability to reduce the barriers will facilitate the adaptation process and reduce farmers' exposure to climate-related risks. Article 36 of the NEP stresses the role of government institutions and NGOs in assisting local communities become aware of their own environment and support them in environment actions. The clause explains that local communities' participation is a factor of convincing, having incentives and access to relevant knowledge and skills. Farmers' should have access to updated information, incentives, relevant and reliable information on climate change and variability to promote the adoption of innovations.

Frequent training and collaboration between extension officers, meteorological experts, researchers and farmers is of major importance at this time, when farmers have experienced the adverse impacts of climate change and variability. However, climate change and variability is a new phenomenon, not only for farmers, but also for extension officers and researchers. Frequent training and collaboration between researchers and extension officers, predicated on multidirectional knowledge flows, will build capacity on effective ways to help farmers adapt to climate change and variability. Training will also improve farmers' confidence and promote adoption of adaptation strategies in place.

The Tanzania Meteorological Agency should provide timely forecasts to enable farmers to use the information in planning for the next season's farming activities. Farmers should be given adequate time to make decisions for the forthcoming season. Late issuing of forecasts will result in inadequate utilisation of the information to mitigate adverse impacts of climate change and variability. The forecasts would be of great value if they provided options for farmers on how to respond to the forecasted weather. Unless the information has value, farmers will be less likely to use it in farming.

The communication channels used to inform farmers about climate change and variability should be both mass media and interpersonal sources. Effective use of these two communication channels to inform farmers on issues of climate change and variability is critical in creating awareness, understanding and influencing use of information. Mass media sources such as radio, print and television are useful in influencing peoples' weak attitudes, while interpersonal sources are effective in influencing peoples' strong attitudes (Rogers

2003). Mass media sources introduce information to farmers while interpersonal sources, such as social networks, farmer groups, public gatherings and village meetings, provide information and enhance interaction between farmers and information disseminators. Through interaction, farmers learn, observe and get feedback from the sources. Observation and feedback reduce farmers' risk and prompt decision to adopt an innovation. The combination of use of the mass media and interpersonal communication channels helps in the adoption of innovations aimed at mitigating effects of climate change and variability. The use of both mass media and interpersonal communication sources in fostering adoption of agricultural innovations which enhance adaptation to climate change and variability was recommended by Shetto (2008). Researchers should thus devise, provide and maintain effective communication strategies with farmers regarding to innovative farming ways for mitigating the impacts of climate change and variability.

Proper collection and storage of information on climate change and variability at local levels is crucial in facilitating easy and timely access to information. Well documented and preserved information can easily be retrieved by users. With the improvements in Information and Communication Technologies (ICTs), farmers can have access to weather information, market and commodity prices information, indigenous knowledge and other, better extension advisory services concerning ways to cope and adapt to climate change and variability from one generation to another.

7.10 Benefit to Society

The following are study benefits to society:

The study is important for agricultural experts, namely extension officers, researchers and government officials, in enhancing access to, and use of, information on climate change and variability. Effective communication, dissemination and destroying the barriers to access to information on climate change and variability will enhance farmers' use of the information. Experts can make use of the study findings and recommendations to come up with user programmes which reflect the needs of users of a particular community. Proper use of this information is of great importance in mitigating the effects of climate change and variability, reducing farmer vulnerability and improving food security at household level.

The policy issues raised are of great importance in designing responsive adaptation frameworks which could be used by the government to enhance effective adaptation at local

level. Policy-makers such as politicians, government officials and researchers have a major role to play in ensuring effective coping and adaptation policies and farmers' access to relevant and timely information on climate change and variability is fundamental. Lack of awareness and adequate knowledge in policy-makers will aggravate the existing and projected effects associated with climate change and variability at local level, where mostly resource-poor farmers reside.

The new knowledge developed from this research study contributes to the climate change and variability discourse and to having effective adaptation plans in place. As was indicated previously in this chapter (refer to sections 7.4.2 and 7.7.1), climate change and variability adaptation is a long-term process which requires multi-disciplinary initiatives to mitigate the impacts. The study highlighted issues on effective access to, and use of, information on climate change and variability which adds onto the body of knowledge towards proper ways of enhancing adaptation.

7.11 Limitations of the Research

The current study was a case study of farmers in Maluga and Chibelela villages in central Tanzania. Yin (1981), Stake (1998) and Case (2002) observed that case studies enhance rigour and the researchers' confidence through the use of varied qualitative and quantitative sources of evidence. This study did not study researchers and research institutions, as it would have made the study too broad in scope and hence too demanding, in terms of time and human and financial resources for a doctoral study.

Another limitation is the external validity of the study, which is the ability to draw inferential or descriptive conclusions on generalising the study findings from a small sample to a larger representative group in other settings. However, despite the research study being a case study conducted in the two villages, the findings explain broader challenging issues with regard to adaptation to climate change and variability.

The other limitation of the study is partly the type of methods used to sample respondents, which was purposive sampling and snowballing. The two non-probability methods do not provide a chance for each member of a society potentially to participate in the study. As a result, the study findings to a great extent depend on the credibility of the person being interviewed. Snowballing sampling is thus subjected to the truthfulness of a person providing information about the next person to be interviewed.

The sample drawn from this study was among the limitations of this study. This study specifically focused on the CCAA project, which trained a group of experimental farmers who then trained their fellow farmers. As the study was an initial exploratory study the sample was restricted to the two groups of farmers and the study did not seek to represent the heterogeneity of the populations in the two villages. In this study, the geographic location and the economic activity of farmers was another limitation to finding respondents in time. Explicitly, the economic constraints refer to the study being conducted on farmers who depended on farming to earn their livelihood. It was found that identifying such farmers was a challenging task in the study areas as farmers were working on their respective farms and engaging in other income-generating activities during the potential interview time.

Despite these limitations the study was able to fulfil its purpose and answer the research questions posed.

7.12 Suggestions for Further Research

This study investigated the relationship between information packaging and dissemination and adaptation to climate change and variability by farmers in the semi-arid Maluga and Chibelela villages of central Tanzania. The study identified a number of issues which could be further researched by other scholars in the field. The following discussion draws attention to some of the areas which require further investigation by researchers.

As the research study investigated the role of information in adaptation to climate change and variability, the focus was on two villages which received training from the Climate Change Adaptation in Africa project. The study suggests that research be done in other villages which were not part of the CCAA training, to establish adoption of information on adaptation to climate change and variability.

As the study could not ascertain any efforts to document and preserve IK, it is recommended that a study be conducted in each ward and district in the study regions of Dodoma and Singida to identify and compare local indicators used by farmers to predict weather and climate. Thereafter the findings should be documented and preserved to promote accessibility to this IK for future generations. Indigenous knowledge documentation and preservation is important in mitigating impacts of climate change and variability.

It is also advisable that a study be conducted on other user groups to investigate issues related to access, understanding and adoption of information on climate change and variability. These user groups may include journalists, pastoralists and politicians.

Mass media information reaches many people simultaneously and has the potential to influence changes of attitude. A comparative research study should be conducted on areas which have access to local radio and NGOs against those which do not have local radio and NGOs, to explore farmers' adoption of improved innovations on adaptation to climate change and variability. The study should also assess the content, use and effectiveness of farmer programmes and the broadcasting times of new farming knowledge to farmers.

The purpose of this study was to assess the link between information packaging and dissemination and adaptation to climate change and variability by farmers in the semi-arid Maluga and Chibelela villages of central Tanzania. The study's major research question was to investigate how information on adaptation to climate change and variability is packaged and disseminated to farmers in Maluga and Chibelela villages in central Tanzania. The impact of information in mitigating the adverse effects of climate change and variability was critically investigated. As a way forward, areas for further research have been identified to build on the base that this study has provided.

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P.O.Box 35092
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Dear Respondent,

Re: Informed Consent Letter

Researcher: Emmanuel Elia

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Please allow me to introduce myself. My name is Emmanuel Elia – a PhD candidate in the Information Studies Programme, University of KwaZulu-Natal, South Africa. As part of the requirements towards the fulfillment of my PhD programme, I am required to carry out research. I am carrying out my research on the information dissemination for adaptation to

climate change and variability in the Agriculture Sector in Maluga and Chibelela villages, Central Tanzania.

The study focuses on farmers in the two villages of Maluga and Chibelela in Iramba and Bahi districts. The purpose of the study is to investigate adaptation to climate change and variability by farmers through information dissemination. The study also aims at exploring the goals of information disseminated to farmers on climate change and variability, assess the status of knowledge adaptation to climate change and variability by farmers in the villages, determine access and use of information on climate change and variability farmers and investigate the limiting factors affecting access and use of information on adaptation to climate change and variability. Copies of the interview guide are available should you wish to review them in advance. The interview is expected to take about forty five minutes.

I am writing to request you to participate in the study. Please note that participation is purely voluntary and that you may withdraw at any time during the research process with no consequences whatsoever. Your participation will help improve your agricultural production through effective package and dissemination of information on climate change for adaptation in the district.

There will be no monetary gain from participating in this research project. Information provided during interviews will be treated in utmost confidence and only the researchers will have access to the information collected. Your name will not appear in the dissertation, publications or oral presentations made. Information collected and back-ups of electronic data will be securely stored and be used for research purposes only. After completion of the study, data and information collected will be filed and safely locked up in cabinets for a minimum of five years. Thereafter all the data collection instruments have spacing and formatting with regard to the lines provided for responses to be recorded. Please do not hesitate to contact the researcher's supervisors or the researcher should you require any additional information or clarification regarding the research. Contact details are provided above.

I look forward to your cooperation.

Yours sincerely
Emmanuel Elia
(PhD candidate)

Signature

Date

I hereby consent to participate in the above study.

Name: Date: Signature:

APPENDIX 1: SEMI-STRUCTURED INTERVIEW GUIDE FOR TRAINED FARMERS

A. General

Date: _____ Name of Interviewer: _____
Code: _____ District: _____ Village: _____ Household
number: _____

B. Personal Profile

1. Sex:

Male { } Female { } Household number { }

2. Level of Education:

{ } No formal education
{ } Primary
{ } Secondary
{ } University
{ } Other _____

3. Age:

15-25 { } 26-35 { } 36-45 { } 46-50 { } 51-60 { } >60 { }

4. a. What is your primary occupation?

b. What is your secondary occupation? _____

5. How long have you been living in this village? _____

C. Farming practices

6. Can you please explain the farming activities you are involved in? (*Probe for cultivation, selling crops, storing grain, livestock keeping and selling*) _____

7. Can you please recall, for how long have you been practicing farming?

28. If your answer in 25 is *no*, please explain why?

29. How reliable is the indigenous knowledge on weather prediction?

- a. Not reliable b. Less Reliable c. Neutral d. Reliable e.
Very Reliable

30. If your answer in 29 is not reliable, may you please explain why? (*Probe among other reasons on climate change and variability as contributing to the reliability*)

31. Can you please advise me about the best method to preserve/store the indigenous knowledge to be accessed by many people from one generation to another?

E. Training

32. When did you receive training on adaptation to climate change and variability from CCAA trainers? (cf. research question 5)

33. Why were you chosen for training?

34. What was the training about? _____

35. Were you able to understand and apply new knowledge from trainers?

- a. Not able b. Less Able c. Neutral d. Able e. Very able

36. If your answer in 35 is not able, why?

37. How has the training been useful to you? (*Probe for increase in harvesting, new planting methods, grain/seed preservation, use of insecticides, water conservation, use of new drought resistant seeds, weather forecast measuring equipment, early farm preparation and planting, burning of harvested residues*)(cf. research question 4, 5 and 6)

38. After receiving training, were you able to use new knowledge?

- a. Yes b. No

39. If your answer in 38 is no, please explain why?

40. Apart from CCAA trainers, who else trained you on how to improve farming practices through adaptation to climate change and variability? (cf. research question 5)

F. Innovation and Adoption

41. How have you adapted to any new innovation/technology/practices based on information you have received from your CCAA trainers? (cf. research question 5)

a. Improved seed growth b. New technology c. High value crops d.

Improved farming methods

e. Other please specify _____

42. How do you rate yourself in terms of adoption to the application of the training you have undergone? (cf. research question 5)

a. Highly adopted b. Adopted c. Neutral d. Fairly adopted e. Haven't adopted

43. Can you tell me a bit more about why this is the case? (*Probe the reason for level of adoption*) _____

44. What services/innovations have you learned through extension services on adaptation to climate change and variability to improve agricultural production? (cf. research question 4, 5 and 6) (*Probe on new knowledge acquired to improve agricultural production*) _____

45. Have you tried to apply an innovation from an expert and failed?

a. Yes b. No

46. May you please state what happens when you apply an innovation from experts and fail? _____

47. Do you take time to observe the impact of applying an innovation to improve your agricultural practices? _____

48. How compatible were the innovations introduced to you by trainers when compared your normal agricultural practices?

a. Not compatible b. Fairly compatible c. Neutral d. Compatible

e. Very compatible

G. Information Dissemination

49. Please explain the type/kind of information on climate change and variability disseminated to you? (*Probe for seasonal forecast information such as timely planting, type of crop to grow, seed variety (late or early maturing varieties), drought resistant crops, early warning information, rainfall pattern, crop rotation, type of fertilizer to apply, soil characteristics*) (cf. research question 2)

50. Can you describe the type of information on climate change and variability you need to fulfill your primary agricultural practices? (*Probe for timely access of seasonal rainfall information, crop diseases, timely planting, drought resistant crops, type and quantity of fertilizer to apply, seed variety to grow, type of crop to grow, crop rotation, soil characteristics etc.*) (cf. research question 2)

51. How is the information prepared/packaged and disseminated to you from CCAA trainers, extension officers or researchers with regard to climate change and variability? (*Probe for use of pictures, drawings (symbols, signs), medium, language used, participatory learning*) (cf. research question 3)

52. Can you suggest a better way to make this information understandable and available?

53. Can you please elaborate how you disseminate information to untrained farmers on climate change and variability? (cf. research question 3) (*Probe for oral communication, field practical, meetings*)

54. From your experience as a farmer, which sources of information do you rely upon most for knowledge on climate change and variability? (*Probe for researchers, person to person, community based organizations, civil societies, extension*) (cf. research question 2 and 3) _____

55. Can you explain why you prefer these sources in 54 above? (cf. research question 2 and 3) _____

H. Access to and Use of Information

56. Can you explain how you gain access to information on climate change and variability? (*Probe for media such as Radio, mobile phones, fliers, brochures, TV, NGOs*) (cf. research question 3 and 6)
-
57. In your opinion, how useful is the information disseminated to you on climate change and variability? (cf. research question 6)
- a. Very Useful b. Useful c. Neither useful nor not useful d. Fairly Useful e. Not useful
58. If your answer in 57 above is *useful*, how does the information you access help you in your farming activities to lessen the effects of climate change and variability? (*Probe for increase in harvesting, new planting methods, grain/seed preservation, use of insecticides, water conservation, use of new drought resistant seeds, weather forecast measuring equipment, early farm preparation and planting, burning of harvested residues*) (cf. research question 6)
-
59. Are untrained farmers willing to learn from you the knowledge you have acquired from CCAA trainers?
- a. Highly willing b. Willing c. Neutral d. Fairly willing e. Not willing
60. Please explain how knowledge and information generated and shared by the key agricultural partners (*extension, research, education, private sector*) in the village is helpful in addressing your Climate information needs? (cf. research question 2 and 6)
-
61. How do you find extension officers as a source of information for climate change and variability? (cf. research question 2, 3 and 6)
- a. Highly reliable b. Reliable c. Neutral d. Fairly reliable e. Not reliable
62. If your answer in 61 above is *reliable*, what information do you access on climate change and variability which help you in your farming activities? (cf. research question 6)
-

63. Other than Extension officers, how do you gain access to information on farming? (cf. research question 2, 3 and 6) _____

I. Attitude and Perception on Climate Change and Variability

64. How do you compare the rainfall pattern and temperature pattern now and in the last decade? (cf. research question 7) _____

65. How often do you experience drought and/or erratic rainfall patterns? (cf. research question 7)

- a. Very rarely b. Rarely c. Neither rarely nor often d. Often e. Very often

66. Can you recall years you experienced drought and/or floods in the last ten years?

67. Please, outline in your opinion factors that contribute to erratic rainfall pattern and temperature change? (cf. research question 7)

68. Please explain the challenges you face in farming?(*Probe for climate change, inadequate farm implements, unreliable seasonal rainfall forecast, untimely seed availability, poor extension services, quality of hybrid seeds, inadequate farm inputs, tools*) (cf. research question 7) _____

69. In your view, how do you address the challenges in 68 above? (*Probe for means to such as seeking technical assistance from an expert, loan*)

70. How is the climate change and variability affecting your way of living? (*Probe for off-farm and on-farm activities a farmer is engaged in coping*) (cf. research question 7) _____

71. Can you please explain if the food you grow is adequate to feed your family and for sale?

72. What do you consider to be your level of preparedness with respect to drought and floods? (cf. research question 4, 5 and 6)

a. Highly prepared b. Prepared c. Neutral d. Fairly prepared e. Not prepared

73. For an answer in 72 above, can you explain why?

J. Barriers to Access and Use of information on Climate Change and Variability

74. Can you please explain barriers in getting access to and use of information for adaptation to climate change and variability? (*Probe for timely access and use of seeds, extension services, seasonal rainfall information, pesticides, hybrid seeds, fertilizers*) (cf. research question 8)

75. Apart from barriers mentioned in 74 above on access to and use of information, what are other major barriers to adaptation to climate change and variability? (*Probe for timely access and use of seeds, poverty/wealth, loans, market information, level of education, level of literacy, local government inadequate services, extension services, seasonal rainfall information, pesticides, hybrid seeds, fertilizers*)

76. Do you think that the difference in the level of education, social status, or belief(s) between you and those involved in disseminating information on climate change and agriculture acts as a barrier in accessing and using information?

- a. Yes b. No

77. If your answer in 76 above is *yes*, explain how? _____

78. Is there anything you would like to add? _____

Thanks for Your Time



P.O.Box 35092
Dar es Salaam
Tanzania

Dear Respondent,

Re: Informed Consent Letter

Researcher: Emmanuel Elia

Institution: University of KwaZulu-Natal

Telephone number: +255754567143

Email: 211550436@stu.ukzn.ac.za/mklmakala@yahoo.com

Supervisor(s): Prof. Stephen Mutula (PhD),

University of KwaZulu-Natal,

Email: mutulas@ukzn.ac.za

Tel : +27(0)332605572

Prof. Christine Stilwell (PhD),

University of KwaZulu-Natal,

Email: stilwell@ukzn.ac.za

Tel : +27(0)332605095007

Please allow me to introduce myself. My name is Emmanuel Elia – a PhD candidate in the Information Studies Programme, University of KwaZulu-Natal, South Africa. As part of the requirements towards the fulfillment of my PhD programme, I am required to carry out

research. I am carrying out my research on the information dissemination for adaptation to climate change and variability in the Agriculture Sector in Maluga and Chibelela villages, Central Tanzania.

The study focuses on farmers in the two villages of Maluga and Chibelela in Iramba and Bahi districts. The purpose of the study is to investigate adaptation to climate change and variability by farmers through information dissemination. The study also aims at exploring the goals of information disseminated to farmers on climate change and variability, assess the status of knowledge adaptation to climate change and variability by farmers in the villages, determine access and use of information on climate change and variability farmers and investigate the limiting factors affecting access and use of information on adaptation to climate change and variability. Copies of the interview guide are available should you wish to review them in advance. The interview is expected to take about forty five minutes.

I am writing to request you to participate in the study. Please note that participation is purely voluntary and that you may withdraw at any time during the research process with no consequences whatsoever. Your participation will help improve your agricultural production through effective package and dissemination of information on climate change for adaptation in the district.

There will be no monetary gain from participating in this research project. Information provided during interviews will be treated in utmost confidence and only the researchers will have access to the information collected. Your name will not appear in the dissertation, publications or oral presentations made. Information collected and back-ups of electronic data will be securely stored and be used for research purposes only. After completion of the study, data and information collected will be filed and safely locked up in cabinets for a minimum of five years. Thereafter all the data collection instruments have spacing and formatting with regard to the lines provided for responses to be recorded. Please do not hesitate to contact the researcher's supervisors or the researcher should you require any additional information or clarification regarding the research. Contact details are provided above.

I look forward to your cooperation.

Yours sincerely

Emmanuel Elia
(PhD candidate)

Signature

Date

I hereby consent to participate in the above study.

Name: Date: Signature:

APPENDIX 2: SEMI-STRUCTURED INTERVIEW GUIDE FOR UNTRAINED FARMERS

A. General

Date: _____ Name of Interviewer: _____
Code: _____ District: _____ Village: _____ Household
number: _____

B. Personal Profile

1. Sex:
Male { } Female { }
2. Level of Education:
{ } No formal education
{ } Primary
{ } Secondary
{ } University
{ } Other _____
3. Age:
15-25 { } 26-35 { } 36-45 { } 46-50 { } 51-60 { } >60 { }
4. a. What is your primary occupation?

- b. What is your secondary occupation? _____
5. How long have you been living in this village? _____

C. Farming practices

6. Can you please explain the farming activities you are involved in? (*Probe for cultivation, selling crops, storing grain, livestock keeping and selling*)

7. Can you please recall, for how long have you been practicing farming?

8. In your view, why are you involved in these farming activities?

20. What methods can be used to address climate change and variability? (*Probe for methods such as tree planting, proper recycling, use carbon fuels, pollutants such as aerosols*)

21. In your view, how is climate change and variability affecting your farming norms and practices? (*Probe for how he/she has been farming previously*) (cf. research question 7)

22. What farming methods do you apply/use to mitigate the effects of climate change and variability? (*Probe for farming methods used to combat drought, diseases, strong winds and floods such as cultivating early maturing varieties, proper timing of planting, drought resistant crops, agroforestry, planting trees, use of fertiliser, insecticides, rain water harvesting*) (cf. research question 4)

23. Can you explain the activities you engage in to cope with the climate change and variability? (*Probe for activities such as opting to viosk, petty trading, selling livestock, casual labour, selling charcoal, urbanization, assistance/borrowing from colleague etc.*)

24. What indigenous knowledge have you been using to combat drought, floods and grain preservation in your farming activities? (*Probe for what farmers do during bad year(s) eg. grain preservation/storage, mixed cropping, crop rotation, using ridges, contour farming, using ash, burning farm residues*)

25. Do you think indigenous knowledge on weather prediction exists in your community?

- a. Yes b. No

26. If your answer in 25 is yes, do you possess that indigenous knowledge?

- a. Yes b. No

27. If the answer in 26 is yes, can you please elaborate type of indigenous knowledge you possess with regard to weather forecast? (*Probe for use of birds, insects, plant phenology, wind direction, animals, high/ low temperature (July-November), moon structure, star, sun in identifying a good or bad year*)

28. If your answer in 25 is *no*, please explain why?

29. How reliable is the indigenous knowledge on weather prediction?

- a. Not reliable b. Less Reliable c. Neutral d. Reliable e.

Very Reliable

30. If your answer in 29 is *not reliable*, may you please explain why? (*Probe among other reasons on climate change and variability as contributing to the reliability*)

31. Can you please advise me about the best method to preserve/store the indigenous knowledge to be accessed by many people from one generation to another?

E. Training

32. Are you aware that there are farmers who have been trained by climate change and Adaptation for Africa project in this village?

- a. Yes b. No

33. Did you receive any training on adaptation to climate change and variability from your fellow farmers? (cf. research question 5)

- a. Yes b. No

34. If your answer in 33 above is *yes*, when did you receive training?

35. What was the training about?

36. Were you able to understand and apply new knowledge from your fellows?

- a. Not able b. Less Able c. Neutral d. Able e. Very able

37. If your answer in 36 is not able or less able, why?

38. How has it been useful to you? (*Probe for increase in harvesting, new planting methods, grain/seed preservation, use of insecticides, water conservation, use of new drought resistant seeds, weather forecast measuring equipment, early farm preparation and planting, burning of harvested residues*) (cf. research question 4,5 and 6)

39. After receiving training, were you able to use new knowledge?

- a. Yes b. No

40. If your answer in 39 is *no*, please explain why?

41. Apart from your fellow farmers, who else trained you on how to improve farming practices through adaptation to climate change and variability? (cf. research question 5) _____

F. Innovation and Adoption

42. How have you adapted to new innovation/new technology/practices based on information you have received from your CCAA trainers? (cf. research question 5)

- a. Improved seed growth b. New technology c. High value crops d. Improved farming methods
e. Other (specify)

43. How do you rate yourself in terms of adoption to the application of the training you have undergone? (cf. research question 5)

- a. Highly adopted b. Adopted c. Neutral d. Fairly adopted e. Not adopted

44. Can you tell me a bit more about why this is the case? (*Probe the reason for level of adoption*) _____

45. What services/innovations have you read through extension services on adaptation to climate change and variability to improve agricultural production? (cf. research question 4, 5 and 6) (*Probe on new knowledge acquired to improve agricultural production*) _____

46. Have you tried to apply an innovation from an expert and failed?

- a. Yes b. No

47. May you please state what happens when you apply an innovation from experts and fail? _____

48. Do you take time to observe the impact of applying an innovation to improve your agricultural practices? _____
49. How compatible were the innovations introduced to you by trainers when compared with your normal agricultural practices?
- a. Not compatible b. Fairly compatible c. Neutral d. Compatible e. Very compatible

G. Information Dissemination to Farmers

50. Please explain the type/kind of Information on climate change and variability disseminated to you?*(Probe for seasonal forecast information such as timely planting, type of crop to grow, seed variety (late or early maturing varieties), drought resistant crops, early warning information, rainfall pattern, crop rotation, type of fertilizer to apply, soil characteristics)* (cf. research question 2)
-
51. Can you describe the type of information on climate change and variability you need to fulfill your primary agricultural practices? *(Probe for timely access of seasonal rainfall information, crop diseases, timely planting, drought resistant crops, type and quantity of fertilizer to apply, seed variety to grow, type of crop to grow, crop rotation, soil characteristics etc.)*(cf. research question 2)
-
52. From your experience as a farmer, which sources of information do you rely upon most for knowledge on climate change and variability?*(Probe for researchers, person to person, community based organizations, civil societies, extension)* (cf. research question 2 and 3)
-
53. Can you please explain why you prefer these sources in 52 above? (cf. research question 2 and 3)
-
54. In your view, how is the information being disseminated to you from your fellow farmers on climate change and variability prepared? *(Probe for use of oral communication, field practical, meetings pictures, drawings (symbols, signs), medium, participatory learning)* (cf. research question 3, 5 and 6)
-

55. Can you suggest a better way to make this information understandable and available?

56. Please elaborate how information is packaged and disseminated to you by extension officer, or other researchers, NGOs? (*Probe for use of pictures, drawings (symbols, signs), medium, language used, participatory learning*) (cf. research question 3)

H. Access to and Use of Information

57. Can you explain how you gain access to information on climate change and variability? (*Probe for media such as Radio, mobile phones, fliers, brochures, TV, NGOs*) (cf. research question 2 and 6)

58. Which sources of information do you rely upon most for knowledge on climate change and variability? (*Probe for researchers, person to person, community based organizations, civil societies, extension*) (cf. research question 2 and 3)

59. In your opinion, how useful is the information disseminated to you on climate change and variability? (cf. research question 6)

- a. Very Useful b. Useful c. Neither useful nor not useful d. Fairly useful
e. Not useful

60. If your answer in 59 above is *useful*, how does the information you access help you to adapt to climate change and variability? (*Probe for increase in harvesting, new planting methods, grain/seed preservation, use of insecticides, water conservation, use of new drought resistant seeds, weather forecast measuring equipment, early farm preparation and planting, burning of harvested residues*) (cf. research question 4, 5 and 6)

61. Are trained farmers willing to share information and knowledge they have received?

- a. Highly willing b. Willing c. Neutral d. Fairly willing e. Not willing

62. Please explain how knowledge and information generated and shared by the key agricultural partners (*extension, research, education, private sector*) in the village helpful in addressing your climate change information needs? (cf. research question 2 and 6) _____
63. How do you find extension officers as a source of information for climate change and variability? (cf. research question 2, 3 and 6)
- a. Highly reliable b. Reliable c. Neutral d. Fairly reliable e. Not reliable
64. If your answer in 63 above is *reliable*, what information do you access on climate change and variability? (cf. research question 6)
- _____
65. Other than Extension officers, how do you gain access to information on farming? (cf. research question 2, 3 and 6) _____

I. Attitude and Perception on Climate Change and Variability

66. How do you compare the rainfall pattern and temperature pattern now and in the last decade? (cf. research question 7) _____
67. How often do you experience drought and/or erratic rainfall patterns? (cf. research question 7)
- a. Very rarely b. Rarely c. Neither rarely nor often d. Often e. Very often
68. Can you recall years you experienced drought and/or floods in the last ten years?
- _____
69. Please, outline in your opinion factors that contribute to erratic rainfall pattern and temperature change? (cf. research question 7)
- _____
70. Please explain the challenges you face in farming? (*Probe for climate change, inadequate farm implements, unreliable seasonal rainfall forecast, untimely seed availability, poor extension services, quality of hybrid seeds, inadequate farm inputs, tools*) (cf. research question 7) _____
71. In your view, how do you address the challenges in 70 above? (*Probe for means to such as seeking technical assistance from an expert, loan*)
- _____

72. How is the climate change and variability affecting your way of living? (*Probe for off-farm and on-farm activities a farmer is engaged in to cope*) (cf. research question 7) _____

73. Can you please explain if the food you grow is adequate to feed your family and for sale? _____

74. What do you consider to be your level of preparedness with respect to drought and floods? (cf. research question 4, 5 and 6)

- a. Highly prepared b. Prepared c. Neutral d. Fairly prepared e. Not prepared

75. For an answer in 74 above, can you explain why?

J. Barriers to Access and Use of information on Climate Change and Variability

76. Can you please explain the barriers in getting access to and use of information for adaptation to climate change and variability? (*Probe for timely access and use of seeds, extension services, seasonal rainfall information, pesticides, hybrid seeds, fertilizers*)(cf. research question 8)

77. Apart from barriers mentioned in 76 above on access to and use of information, what are other major barriers to adaptation to climate change and variability? (*Probe for timely access and use of seeds, poverty/wealth, loans, market information, level of education, level of literacy, local government inadequate services, extension services, seasonal rainfall information, pesticides, hybrid seeds, fertilizers*)

78. Do you think that the difference in the level of education, social status, or belief(s) between you and those involved in disseminating information on climate change and agriculture act as a barrier in accessing and using information?

- a. Yes b. No

79. If your answer in 78 above is *yes*, explain how? _____

80. Is there anything you would like to add?

Thanks for Your Time



P.O.Box 35092
Dar es Salaam
Tanzania

Dear Respondent,

Re: Informed Consent Letter

Researcher: Emmanuel Elia

Institution: University of KwaZulu-Natal

Telephone number: +255754567143

Email: 211550436@stu.ukzn.ac.za/mklmakala@yahoo.com

Supervisor(s): Prof. Stephen Mutula (PhD),

University of KwaZulu-Natal,

Email: mutulas@ukzn.ac.za

Tel : +27(0)332605572

Prof. Christine Stilwell (PhD),

University of KwaZulu-Natal,

Email: stilwell@ukzn.ac.za

Tel : +27(0)332605095007

Please allow me to introduce myself. My name is Emmanuel Elia – a PhD candidate in the Information Studies Programme, University of KwaZulu-Natal, South Africa. As part of the requirements towards the fulfillment of my PhD programme, I am required to carry out research. I am carrying out my research on the information dissemination for adaptation to

climate change and variability in the Agriculture Sector in Maluga and Chibeleda villages, Central Tanzania.

The study focuses on farmers in the two villages of Maluga and Chibeleda in Iramba and Bahi districts. The purpose of the study is to investigate adaptation to climate change and variability by farmers through information dissemination. The study also aims at exploring the goals of information disseminated to farmers on climate change and variability, assess the status of knowledge adaptation to climate change and variability by farmers in the villages, determine access and use of information on climate change and variability farmers and investigate the limiting factors affecting access and use of information on adaptation to climate change and variability. Copies of the interview guide are available should you wish to review them in advance. The interview is expected to take about two hours.

I am writing to request you to participate in the study. Please note that participation is purely voluntary and that you may withdraw at any time during the research process with no consequences whatsoever. Your participation will help improve your agricultural production through effective package and dissemination of information on climate change for adaptation in the district.

There will be no monetary gain from participating in this research project. Information provided during interviews will be treated in utmost confidence and only the researchers will have access to the information collected. Your name will not appear in the dissertation, publications or oral presentations made. Information collected and back-ups of electronic data will be securely stored and be used for research purposes only. After completion of the study, data and information collected will be filed and safely locked up in cabinets for a minimum of five years. Thereafter all the data collection instruments have spacing and formatting with regard to the lines provided for responses to be recorded. Please do not hesitate to contact the researcher's supervisors or the researcher should you require any additional information or clarification regarding the research. Contact details are provided above.

I look forward to your cooperation.

Yours sincerely

Emmanuel Elia

(PhD candidate)

Signature

Date

I hereby consent to participate in the above study.

Name: Date: Signature:

APPENDIX 3: IN-DEPTH INTERVIEW GUIDE FOR EXTENSION OFFICERS

A. Personal Profile

1. Level of Education:

- No formal education
- Primary
- Secondary
- University
- Other _____

2. Sex:

- Male Female

3. Age:

- 15-25 26-35 36-45 46-50 51-60 >60

4. Please state your job position?

5. Please explain how your job works?

6. How long have you been in this position?

7. What are the goals of extension work?

8. What has been the impact of your job on farmers?

9. How many people do you serve in this village?

B. Information Dissemination

10. What information is available on climate change and variability to farmers?

11. How is this information on climate change and variability packaged and disseminated to farmers? (cf. research question 3)

12. Can you explain which sources of information do farmers rely upon most for knowledge on climate change and variability? (cf. research question 2 and 3)
13. What is the farmers' awareness on the effects of climate change and variability?
14. What roles do you think farmers' groups play in adaptation to climate change and variability information dissemination? (cf. research question 3)
15. In your opinion can you please explain the role of associations and networks in disseminating information on climate change and variability?

C. Access and Use of Information

16. Can you please describe how farmers access information on climate change and variability? (cf. research question 3 and 6)
17. Please explain how farmers use climate change and variability information? (cf. research question 6)
18. From your experience as an extension officer, what is the level of usage of extension services by farmers who have been trained and those who have not been trained?
19. In your view, how does access and use of information on adaptation to climate change and variability improve agricultural practices in this village? (cf. research question 6)

D. Innovation and Adoption

20. Based on your opinion, can you point out the difference between farmers who have been trained versus those who did not receive training through the Climate Change Adaptation for Africa project (cf. research question 5)
21. If comparing, can you please explain the farmers' level of adoption of information on adaptation to climate change and variability at this village? (cf. research question 5)

22. From your experience, what farming methods do farmers use for adaptation to climate change and variability during droughts? (cf. research question 4)

23. Can you please explain how farmers attempt to cope with the effect of climate change and variability?

E. Awareness and Knowledge on Climate Change and Variability

24. Can you please explain your understanding of climate change and variability? (*Probe for causes of climate change*)_____

25. What methods can be used to address climate change and variability? (*Probe for methods such as tree planting, proper recycling, use carbon fuels, other pollutants such as aerosols*) _____

26. In your view, how is climate change and variability affecting your farming norms and practices?(*Probe for how he/she has been farming previously*) (cf. research question 7) _____

27. Do you think indigenous knowledge on seasonal weather prediction exists in this community?

- a. Yes b. No

F. Attitude and Perception on Climate Change and Variability

28. Why was the village chosen for training on climate change and variability? (cf. research question 1)

29. In your opinion, please elaborate on the pattern of climate change and variability in this village from the last decade?

30. How has climate change and variability affected farming in this area? (cf. research question 1 and 7)

31. What strategies does government have to mitigate the effect of climate change and variability to farmers?(cf. research question 1 and 5)

32. How do you plan to achieve the strategies in 31 above?

33. What is the attitude of farmers towards climate change and variability?(cf. research question 7)
34. What is the attitude of farmers toward Climate Change Adaptation for Africa project on information/knowledge on climate change and variability? (cf. research question 7)

G. Barriers to Access and Use of information on Climate Change and Variability

35. In your view, what are the main problems in relation to access to and use of climate change and variability information that farmers' experience? (cf. research question 8)
36. How do you attempt to address the challenges in 35 above, if at all?
37. Apart from barriers mentioned in 36 above on access to and use of information, what are other major barriers to adaptation to climate change and variability? (*Probe for timely access and use of seeds, poverty/wealth, loans, market information, level of education, level of literacy, local government inadequate services, extension services, seasonal rainfall information, pesticides, hybrid seeds, fertilizers*)
38. What challenges do you experience in providing your services to farmers? (cf. research question 8)
39. Is there anything you would like to add?

Thanks for Your Time



P.O.Box 35092
Dar es Salaam
Tanzania

Dear Respondent,

Re: Informed Consent Letter

Researcher: Emmanuel Elia

Institution: University of KwaZulu-Natal

Telephone number: +255754567143

Email: 211550436@stu.ukzn.ac.za/mklmakala@yahoo.com

Supervisor(s): Prof. Stephen Mutula (PhD),

University of KwaZulu-Natal,

Email: mutulas@ukzn.ac.za

Tel : +27(0)332605572

Prof. Christine Stilwell (PhD),

University of KwaZulu-Natal,

Email: stilwell@ukzn.ac.za

Tel : +27(0)332605095007

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climate change and variability in the Agriculture Sector in Maluga and Chibelela villages, Central Tanzania.

The study focuses on farmers in the two villages of Maluga and Chibelela in Iramba and Bahi districts. The purpose of the study is to investigate adaptation to climate change and variability by farmers through information dissemination. The study also aims at exploring the goals of information disseminated to farmers on climate change and variability, assess the status of knowledge adaptation to climate change and variability by farmers in the villages, determine access and use of information on climate change and variability farmers and investigate the limiting factors affecting access and use of information on adaptation to climate change and variability. Copies of the interview guide are available should you wish to review them in advance. The interview is expected to take about two hours.

I am writing to request you to participate in the study. Please note that participation is purely voluntary and that you may withdraw at any time during the research process with no consequences whatsoever. Your participation will help improve your agricultural production through effective package and dissemination of information on climate change for adaptation in the district.

There will be no monetary gain from participating in this research project. Information provided during interviews will be treated in utmost confidence and only the researchers will have access to the information collected. Your name will not appear in the dissertation, publications or oral presentations made. Information collected and back-ups of electronic data will be securely stored and be used for research purposes only. After completion of the study, data and information collected will be filed and safely locked up in cabinets for a minimum of five years. Thereafter all the data collection instruments have spacing and formatting with regard to the lines provided for responses to be recorded. Please do not hesitate to contact the researcher's supervisors or the researcher should you require any additional information or clarification regarding the research. Contact details are provided above.

I look forward to your cooperation.

Yours sincerely
Emmanuel Elia
(PhD candidate)

Signature

Date

I hereby consent to participate in the above study.

Name: Date: Signature:

11. From your experience, how was the training conducted with farmers? (cf. research question 1)

12. What did the training achieve?

13. What is the expectation of farmers who did not undergo training?

14. What challenges do you experience in providing your services to farmers? (cf. research question 8)

15. How is the programme sustained?

C. Information Dissemination

16. What information is available on climate change and variability to farmers?

17. How is this information on climate change and variability packaged and disseminated to farmers? (cf. research question 3)

18. Can you explain which sources of information do farmers rely upon most for knowledge on climate change and variability? (cf. research question 2 and 3)

19. What is the farmers' awareness on the effects of climate change and variability?

20. What roles do you think farmers' groups play in adaptation to climate change and variability information dissemination? (cf. research question 3)

21. In your opinion can you please explain the role of associations and networks in disseminating information on climate change and variability?

D. Access and Use of Information

22. Can you please describe how farmers access information on climate change and variability? (cf. research question 3 and 6)

23. Please explain how farmers use climate change and variability information? (cf. research question 6)

24. In your view, how does access and use of information on adaptation to climate change and variability improve agricultural practices in this village? (cf. research question 6)

E. Innovation and Adoption

25. Based on your opinion, what is the difference between farmers who have been trained versus those who did not receive training through the Climate Change Adaptation for Africa project (cf. research question 5)

26. Can you please explain the farmers' level of adoption of information on adaptation to climate change and variability at this village? (cf. research question 5)

27. Based on your opinion, can you point out the difference between farmers who have been trained versus those who did not receive training through the Climate Change Adaptation for Africa project (cf. research question 5)

28. If comparing, can you please explain the farmers' level of adoption of information on adaptation to climate change and variability at this village? (cf. research question 5)

29. From your experience, what farming methods do farmers use for adaptation to climate change and variability during droughts? (cf. research question 4)

F. Attitude and Perception on Climate Change and Variability

30. In your opinion, please elaborate on the pattern of climate change and variability in this village from the last decade?

31. How has climate change and variability affected farming in this area? (cf. research question 1 and 7)

32. What is the attitude of farmers towards climate change and variability? (cf. research question 7)

33. What is the attitude of farmers toward Climate Change Adaptation for Africa on information/knowledge on climate change and variability? (cf. research question 7)

G. Barriers to Access and Use of information on Climate Change and Variability

34. In your view, what are the main problems in relation to access to and use of climate change and variability information that farmers' experience? (cf. research question 8)

35. Apart from barriers mentioned in 34 above on access to and use of information, what are other major barriers to adaptation to climate change and variability? (*Probe for timely access and use of seeds, poverty/wealth, loans, market information, level of education, level of literacy, local government inadequate services, extension services, seasonal rainfall information, pesticides, hybrid seeds, fertilizers*)

36. How do you attempt to address the challenges in 34 above, if at all?

37. Is there anything you would like to add?

Thanks for Your Time



P.O.Box 35092
Dar es Salaam
Tanzania

Dear Respondent,

Re: Informed Consent Letter

Researcher: Emmanuel Elia

Institution: University of KwaZulu-Natal

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Prof. Christine Stilwell (PhD),

University of KwaZulu-Natal,

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Please allow me to introduce myself. My name is Emmanuel Elia – a PhD candidate in the Information Studies Programme, University of KwaZulu-Natal, South Africa. As part of the requirements towards the fulfillment of my PhD programme, I am required to carry out research. I am carrying out my research on the information dissemination for adaptation to

climate change and variability in the Agriculture Sector in Maluga and Chibelela villages, Central Tanzania.

The study focuses on farmers in the two villages of Maluga and Chibelela in Iramba and Bahi districts. The purpose of the study is to investigate adaptation to climate change and variability by farmers through information dissemination. The study also aims at exploring the goals of information disseminated to farmers on climate change and variability, assess the status of knowledge adaptation to climate change and variability by farmers in the villages, determine access and use of information on climate change and variability farmers and investigate the limiting factors affecting access and use of information on adaptation to climate change and variability. Copies of the interview guide are available should you wish to review them in advance. The interview is expected to take about two hours.

I am writing to request you to participate in the study. Please note that participation is purely voluntary and that you may withdraw at any time during the research process with no consequences whatsoever. Your participation will help improve your agricultural production through effective package and dissemination of information on climate change for adaptation in the district.

There will be no monetary gain from participating in this research project. Information provided during interviews will be treated in utmost confidence and only the researchers will have access to the information collected. Your name will not appear in the dissertation, publications or oral presentations made. Information collected and back-ups of electronic data will be securely stored and be used for research purposes only. After completion of the study, data and information collected will be filed and safely locked up in cabinets for a minimum of five years. Thereafter all the data collection instruments have spacing and formatting with regard to the lines provided for responses to be recorded. Please do not hesitate to contact the researcher's supervisors or the researcher should you require any additional information or clarification regarding the research. Contact details are provided above.

I look forward to your cooperation.

Yours sincerely
Emmanuel Elia
(PhD candidate)

Signature

Date

I hereby consent to participate in the above study.

Name: Date: Signature:

APPENDIX 5: FOCUS GROUP DISCUSSION GUIDE

1. Are you aware of climate change and variability? If Yes How?
2. Can you please explain your understanding with regard to climate change and variability?
3. In your view, how has climate change and variability affected your farming activities?
4. What farming methods do you apply/use to mitigate the effects of climate change and variability? (cf. research question 4)
5. Can you explain the activities you engage in to cope with the climate change and variability?
6. What indigenous knowledge have you been using to combat drought, floods and grain preservation in your farming activities? (*Probe for what farmers do during bad year(s) eg. grain preservation/storage, mixed cropping, crop rotation, using ridges, contour farming, using ash, burning farm residues*)
7. Do you think indigenous knowledge on weather prediction exists in your community?
8. How many of you possess that indigenous knowledge? (*Probe the reason for those who don't have indigenous knowledge*)
9. Can you please elaborate type of indigenous knowledge you possess with regard to weather forecast? (*Probe for use of birds, insects, plant phenology, wind direction, animals, high/ low temperature (July-November), moon structure, star, sun in identifying a good or bad year*)
10. How reliable is the indigenous knowledge on weather prediction? (*Probe on climate change and variability as contributing to the reliability*)

11. Can you please advise me about the best method to preserve/store the indigenous knowledge?
12. How is the information packaged and disseminated to you? (*Probe for use of pictures, drawings, medium, language used, participatory learning*) (cf. research question 3)
13. From your experience as a farmer, which sources of information do you rely upon most for knowledge on climate change and variability and *Why?*(*Probe for media such as Radio, mobile phones, brochures, TV, NGOs*) (cf. research question 2 and 3)
14. How do you compare the rainfall pattern and temperature pattern now and in the last decade? (cf. research question 7)
15. How often do you experience drought and/or erratic rainfall patterns? (*Probe for bad years with drought and floods, diseases*) (cf. research question 7)
16. Can you please explain factors that contribute to erratic rainfall pattern and temperature change? (cf. research question 7)
17. Can you please explain barriers in getting access to and use of information for adaptation to climate change and variability? (*Probe for timely access and use of seeds, extension services, seasonal rainfall information, pesticides, hybrid seeds, fertilizers*) (cf. research question 8)
18. A part from barriers mentioned in 75 above on access to and use of information, what are other major barriers to adaptation to climate change and variability? (*Probe for timely access and use of seeds, poverty, loans, market information, level of education, level of literacy, local government inadequate services, extension services, seasonal rainfall information, pesticides, hybrid seeds, fertilizers*)
19. Is there anything you would like to add?

Thanks for Your Time

APPENDIX 6: GLOSSARY

Local Names	Details
Bodaboda	- Motorcycle
Chidongha	- Grain baskets used in food preservation
Keo	- Grain baskets used in food preservation
Kiindi	- Grain baskets used in food preservation
Kinkiingoma	- Bird species used to forecast weather pattern
Kyungu	- Grain pots used in food preservation
Mbilazi	- An insect whose change in colour is used to forecast weather pattern
Mgole	- Tree species used to predict weather pattern
Mkunguu	- Tree species used to predict rainfall onset
Mkuyu	- Tree specie used to forecast rainfall onset
Mlandala	- Tree species used to predict rainfall onset
Mlilyanondo	- Insects used to predict rainfall onset
Mngooli	- Tree species used to predict rainfall onset
Mnkola	- Tree species used to forecast rainfall onset
Msalumbi	- Tree species with fruits used to forecast rainfall onset
Msonankanga	- Tree species which used to predict weather pattern by changing
Mtamba	- Tree species used to predict rainfall onset
Mtulu	- Tree species used to forecast rainfall onset
Nangakavuji	- A star used to predict rainfall pattern

Nhoto	-	Grain baskets used in food preservation
Nhungu	-	Grain baskets used in food preservation
Nimila	-	A star used to predict rainfall onset
Nkuunguza	-	Bird species used to predict weather pattern
Nsigu	-	Bird species used to predict weather pattern
Nyungu	-	Grain pots used in food preservation
Nyungu	-	Grain pots used in food preservation
Shakasaka	-	Grain baskets used in food preservation
Viosk	-	Small retail shops