EFFECTIVENESS OF SMALLHOLDER FARMERS' ADAPTATION STRATEGIES IN IMPROVING WELL-BEING IN LIGHT OF CLIMATE CHANGE IN IRINGA DISTRICT TANZANIA

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EXTENDED ABSTRACT

Climate change is happening and poses significant challenges to households, businesses and governments. Different adaptation strategies are carried against impact of climate change by smallholder farmers in semi-arid areas of Iringa District but little is known about their effectiveness in improving smallholders' well-being. The overall objective of this study was to assess the effectiveness of adaptation strategies in a changing climate and climate variability in semi-arid areas of Iringa District. Specifically, the study examined smallholder farmers' perceptions towards climate change, identified smallholder farmers' adaptation strategies against impacts of climate change, explored barriers to smallholder farmers' adaptation strategies, and examined the effectiveness of adaptation strategies as is being reflected in smallholder farmers' well-being. The research design was cross sectional. A multistage sampling procedure was applied to select divisions, wards, villages and households. Ismani and Pawaga Divisions of Iringa District were purposively selected based on their climatic conditions. A total of 240 respondents were drawn randomly from eight villages. Data were collected through household survey, key informant interviews, observation and focus group discussions methods. Meteorological data were collected from Tanzania Meteorological Agency. Quantitative data were analyzed through SPSS and qualitative data through content analysis. Instant Statistical Packages for Agro-climatological data was used in analyzing the 54 years meteorological data of Nduli meteorological station in Iringa District. The findings revealed that smallholder farmers perceived climate change in terms of change in temperature, changes in rainfall, increase in drought condition and increase in malaria and crop pests and diseases. Change in rainfall pattern, temperature pattern and occurrence of pests and diseases had significant impact on smallholder farmers' households whose livelihood depends on rain-fed farming. The findings also show that smallholder farmers were adapting to impact of climate

change through irrigation, crop diversification, planting early maturing maize varieties, planting drought resistant crops, changing of planting dates, and agriculture diversification and non-farm activities. Barriers to smallholder farmers' adaptation strategies identified were unreliability of information on weather forecast, lack of access to agricultural extension services, and limited access to water for irrigation. Other barriers were lack of capital, lack of access to affordable credit institutions, lack of farm assets (plough and tractors), and cost of agricultural inputs. In addition, the results revealed that there were relationships between age, income and barriers to adaptation strategies. Existences of those barriers hindered effective implementation of adaptation strategies in the study area. The findings revealed that some of the adaptation strategies to impact of climate change such as change in planting dates, planting early maturing maize varieties, irrigation, application of fertilizer, and involving in petty business had positive influence on smallholder farmers' well-being ($p<0.05$). This means that those adaptation strategies which had positive influence on smallholder farmers' well-being were effective against impact of climate change. Government and other stakeholders should facilitate adaptation by enabling farmers to overcome barriers reported in this study. The government of Tanzania and other stakeholders should also help smallholder farmers by supporting them in those adaptation strategies which proved to be effective to impact of climate change.

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DEDICATION

This work is dedicated to my beloved late mother Asnath Chanika and my late father Lujabiko Kihupi.

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LIST OF ABBREVIATIONS AND ACRONYMS

ARI	Agricultural Research Institute
CCAA	Climate Change Adaptation for Africa
CEEPA	Centre for Environmental Economics and policy Africa
DFID	Department for International Development
FAO	Food and Agriculture organization
IDRC	International Development Research centre
IPCC	Intergovernmental Panel on Climate Change
NAPA	National Adaptation Programme of Action
NSGRP II	National Strategy for Growth and Reduction of Poverty II
OECD	Organization for Economic Co-operation and Development
PRIDE	Promotion of Rural Initiative and Development Enterprises Limited
REPOA	Research on Poverty Alleviation
SACCOS	Saving and Credit Co operation Societies
SPSS	Statistical Package for Social Sciences
SUA	Sokoine University of Agriculture
TMA	Tanzania Meteorological Agency
UK	United Kingdom
UNDP	United Nations Development Programme
UNEP	United Nations Environmental Programme
URT	United Republic of Tanzania
USAID	United States Agency for International Development
WB	Well-being Index
WMO	World Meteorological Organization

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background Information

The global climate is changing and communities all over the world are affected. It is widely agreed by the global community that the world's climate is changing and will continue to change at unprecedented rates (URT, 2012a). The Intergovernmental Panel on Climate Change (IPCC) shows convincing evidence that the climate is real changing (IPCC, 2007). Countries are already and will continue to be affected by climate variability and climate change (Dinshaw *et al.*, 2014). Negative impacts of climate change are more felt by poor people in developing countries who rely heavily on agriculture and natural resources for their livelihood (Etwire *et al.*, 2013).

Adaptation to adverse impact of climate change has become a necessity globally (Eisenack *et al.*, 2014). Learning how to live with impact of climate change is a priority for human development (Pelling, 2011). Studies show that farmers perceive that climate is changing and also adapt to reduce impacts of climate change (Deressa, 2010). Adaptation to climate change is a two-step process; the first step requires farmers to perceive a change in climate and the second step requires farmers to act through adaptation (Maddison, 2007). Therefore it is important to determine whether smallholder farmers perceive changes in climate and how they react in response to those changes.

Implementation of adaptation is not keeping pace with the ever-increasing need: "the adaptation deficit" is getting wider (Eisenack, 2014). Researchers and policy makers are increasingly acknowledging that neither autonomous nor planned adaptation to climate change is achieving its goals in ways expected or at a pace desired (Shackleton *et al.*,

2015). The Inter-governmental Panel on Climate Change Fourth Assessment Report (Adger *et al.*, 2007), discussed a number of factors which constrain planning and implementation of adaptation options. Some of adaptation constraints (barriers) include lack of resources (e.g. funding, technology, or knowledge), institutional characteristics that impede action, or lack of connectivity and environmental quality for ecosystems (Klein *et al.*, 2014). It is therefore important to identify and analyze constraints (barriers) to adaptation strategies.

Different studies show that climate is changing and will continue to change for several decades due to the past emissions of greenhouse gases (Boko *et al.*, 2007). In this context, it is important to increase society's ability to adapt to a changing climate. Increase in ability to adapt can be achieved through implementation of effective adaptation strategies (Martin-Been and Anderies, 2011).

Agriculture is a major contributor to the current economy of most African countries (IPCC, 2007; Kalunga *et al.*, 2013). It is the economic foundation of many Sub-Saharan Africa countries, employing about 60% of the workforce and contributing to an average of 30% of gross domestic product (USAID, 2007). However, climate change is expected to reduce crop yields by 10-20% by the 2050s with more severe losses in some regions (World Bank, 2011). Climate change affects agriculture through increased temperature and rainfall variability. Increased rainfall variability reduce crop yield and threaten food security in low income and agriculture based economies (Deressa, 2010). It is estimated that about 75% of the population of sub-Saharan Africa lives in arid and semi-arid areas that cover about 75% of sub-Saharan Africa (Majule, 2013). These areas are characterized by low soil chemical fertility and low annual rainfall that is poorly distributed (Mubaya *et*

al., 2010). Under this situation agriculture productivity by smallholder farmers is very low resulting both in food and income insecurity leading to poverty (Majule, 2010).

As is the case with most African countries, agriculture is the dominant sector in the Tanzanian economy, providing livelihood, income and employment to over 80 percent of the population (URT, 2007). Most of farmers in Tanzania are smallholder farmers who mostly practice rain fed agriculture, managing between 0.2 to 2.0 hectares (Tilahi and Hingi, 2006 cited in Mnenwa and Maliti, 2010). This sector is particularly sensitive to climate variability and climate change. Tanzania already experiences climate variability in the form of recurrent drought conditions, *Elnino* floods (1997/1998), receding ice on Mount Kilimanjaro, submergence of Maziwe Island, and intrusion of fresh water by salt in shallow wells in Bagamoyo District (URT, 2007).

Iringa Region has four districts. The districts are Iringa District, Mufindi, Kilolo, and Iringa Urban District. About 90% of the population in Iringa District earn their living from agriculture and livestock production, the majority of farmers in the district are smallholder farmers cultivating 2 – 3 acres, using hand hoe, some oxen-driven plough and few uses tractor power (URT, 2013; Mussei *et al.*, 2012). Rainfall in two divisions (Ismani and Pawaga) out of six is low (< 600mm) and poorly distributed. Based on the Department for International Development UK (DFID) definition of semi – arid regions as areas where annual rainfall regime is between 500 and 800mm (DFID, 2001), Pawaga and Ismani divisions can be categorized as semi-arid area. Arid and semi-arid areas are more vulnerable to impact of climate change than other areas.

Iringa District, specifically the semi-arid areas (Pawaga and Ismani Divisions), like other semi-arid areas of Tanzania has started experiencing climate change/variability in form of

recurrent drought conditions and unreliable rainfall. Meteorological data show that there is slight increase of temperature and decrease in rainfall in the district. Agriculture is the dominant economic activities of the people in Iringa District, and weather conditions continue to be the major determinants of agricultural performance in the District (URT, 2013). This implies that, Iringa District specifically the semi-arid areas is vulnerable to impact of climate change although it was one of the major maize producing districts of Iringa Region up to early 1980s.

There are several adaptation strategies carried by smallholder farmers in semi-arid areas of Tanzania (semi-arid areas of Iringa district being among them) against impact of climate such as: planting drought resistance varieties and crops, irrigation, changed planting dates, diversification from farm to nonfarm activities such as casual labour and moving to other places (Lema and Majule, 2009; Shemsanga *et al.*, 2010; Lyimo and Kangalawe, 2010; Komba and Mchapondwa, 2012). However, little is known about their effectiveness in reducing impact of climate change. Therefore, there is need to understand which adaptation strategies to impact of climate change are effective in reducing consequences of climate change and enhancing society's ability to adapt to the current and future effects of climate change (Dinshaw *et al.*, 2014). This would enable more effort to be applied to adaptation strategies proved to be effective in reducing impact of climate change.

1.2 Problem Statement

Iringa Rural District already experiences climate change and variability in terms of changes in rainfall patterns, (the start and end of rain season is unpredictable, it rains in patches within the same village as opposed to some years back) and changes in temperature (it is becoming warmer). According to rainfall and temperature data recorded from Nduli Ward in Ismani Division by Tanzania Meteorological Agency (TMA) for 44

years (1961 – 2005), (Kihupi, 2010), the mean annual temperatures increased by almost 0.8^0C while the mean annual rainfall declined by about 80 mm.

There are adaptation strategies which are carried out in the study area like irrigation, changing planting dates, planting drought resistant varieties, and involvement in non-farm activities like petty business and making local brew. Nevertheless, there is little empirical information on the effectiveness of those adaptation strategies in a prolonged drought condition in response to climate change, though different studies on vulnerability and adaptation to the impacts of climate change have been conducted in different parts of Tanzania.

Previous studies focused on vulnerability, climate change and variability (Paavola, 2003); climate change contribution to land degradation (Tilya and Mhita, 2006); vulnerability, coping strategies and climate change (Yanda *et al.*, 2006). Other studies focused on smallholder farmers' adaptation to climate change (Komba and Muchapondwa, 2012); climate change, vulnerability, adaptation of rain fed agricultural system in the semi-arid areas, the implication on food security and livelihood (Mongi *et al.*,2010); challenges, opportunities to climate adaptation, sustainable development in Rural Communities (Dungumaro and Hyden, 2010). Likewise studies have been done on the cost of climate change, impacts and adaptations (Shemsanga *et al.*, 2010); sustainable livelihoods, vulnerability and adaptation to impacts climate change (Meena and O'Keefe, 2007); vulnerability, adaptive strategies to impact of climate change and variability (Lyimo and Kagalawe, 2010); livelihood responses to climate variability (Paavola, 2005). Shemdoe (2010) did a study on indigenous strategies on impact of climate variability on food security and health of subsistence farmers in Tanzania. As the above studies show, none of them focused on the effectiveness of adaptation strategies against impacts of climate

change. Therefore, this study sought to address this gap of knowledge by analyzing the effectiveness of adaptation strategies to impact climate change as it is being reflected in smallholder farmers' well-being in semi-arid areas of Iringa District.

1.3 Justification of the Study

Climate is changing and will continue to change for decades to come and human community develops its way of survival (adaptation strategies) in a changing climate. Effective adaptation strategies are expected to improve smallholder farmers' well-being hence increasing capacity to adapt for the current and future impacts of climate change. Through increase in capacity to adapt, individual households and society at large will be increasing their resilience to adverse impact of climate change and hence ensure their well-being. Therefore, it is important to know whether such adaptation strategies adapted are effective in the current or future adverse impact of climate change. As Eisenack and Stecker (2011) argue, ineffective adaptation measures (strategies) might result in poverty traps. This is due to the fact that, smallholder farmers and other poor communities will fail to withstand impact of climate change due to their low capacity to adapt to climate change.

Therefore, this study provides a vital contribution in terms of adaptation strategies to national effort of combating adverse impacts of climate change. It will be useful for policy makers and other stakeholders when planning for adaptation strategies to put more emphasis on those adaptation strategies which have empirically proved to be effective against the impact of climate change. It will also be helpful for other similar studies to be conducted by providing baseline information. Furthermore, it will be helpful in designing planned adaptation strategies to help smallholder farmers' communities against impact of climate change.

This study is in line with Tanzania's Five Year Development Plan (2011/12 – 2015/16) which is meant to implement Tanzania's Vision 2025. The plan aims at increasing average agriculture annual growth to at least six percent; also it aims at working on mitigation and adaptation to the impact of climate change due to its importance in ensuring sustainable growth (URT, 2012b). However, the increase in average agriculture annual growth cannot be achieved in a changing climate if adaptation strategies carried by smallholder farmers against climate change are not effective. The study is likewise in line with Tanzania National Adaptation Programme of Action (NAPA) (URT, 2007), which calls for identification of immediate and urgent climate change adaptation actions that are geared toward long-term sustainable development. These efforts are intended to shield the Tanzania vision 2025 from failure due to the climate change impacts and put into action the Sustainable Development Goals (Goal 13, 1st Target) that is about strengthening the resilience and adaptive capacity to climate change hazards and natural disasters in all countries. The study is also in line with the Tanzania Climate Change Strategy (URT, 2012a). The Strategy's goal is to enable Tanzania to effectively adapt to climate change and participate in global effort to mitigate climate change so as to achieve sustainable development.

1.4 Study Objectives

1.4.1 Overall objective

The overall objective of the study was to assess the effectiveness of adaptation strategies in improving well-being of smallholder farmers in the light of climate change and variability.

1.4.2 Specific objectives

Specifically, the study intended:

i. to assess smallholder farmers' perceptions of climate change;

ii. to identify smallholder farmers' adaptation strategies against impacts of climate change;

iii. to explore barriers to smallholder farmers' adaptation strategies;

iv. to examine the effectiveness of adaptation strategies on smallholder farmers' well-being.

1.5 Research Questions

Research questions were:

i. How do smallholder farmers' perceive climate change?

ii. What are smallholder farmers' adaptation strategies against impacts of climate change?

iii. What are the barriers to smallholder farmers' adaptation strategies?

iv. To what extent adaptation strategies are effective in improving smallholder farmers' well-being?

1.6 Theoretical Framework

The theory which guides this study is resilience. The concept of resilience most commonly used in the study of ecosystem dynamic (Holling, 1973), can also be applied to social systems (Adger, 2000), social ecological systems (Gunderson and Holling, 2002), and the study of global change (Holling, 1997). Resilience theory is one of the major conceptual tools to deal with change (Scheffer 2009) at all levels from local to global (Gunderson and Holling, 2002). Resilience theory deals with system dynamics and envisions ecosystems as continuously changing, sometimes abruptly and unpredictably (Berkes and Ross, 2013).

Adapting to climate change is a process of building resilience of a system. The resilience theory therefore recognizes the role played by the adaptation strategies in building resilience (well-being) of the social system (smallholder farmers in this case). However the theory is inadequate in addressing the power adaptation strategies have in contributing

to the resilience of the social system. The proposed study aims at adding to the resilience theory by disaggregating the adaptation strategies and categorizing them based on effectiveness in contributing to building the resilience (well-being) of the social system (smallholder farmers).

1.7 Conceptual Framework

The conceptual framework is adopted from DFID (2000), and slightly modified to suit the intended purpose of assessing effectiveness of adaptation strategies of smallholder farmers' against climate change as indicated in Figure 1. This framework shows the linkages between smallholder farmers' livelihoods assets and climate variability and change (temperature and rainfall variability, drought, and flood) of which smallholder farmers have limited or no control. Hence smallholder farmers have no choice but to adapt to climate variability and change through different adaptation strategies so as to reduce the impact of climate variability and change. Adaptation refers to all responses to climate change that may be used to reduce vulnerability (Burton *et al.*, 1998). Normally adaptation strategies used are not the same to all smallholder farmers in a community. This is due to the fact that adaptation strategies options depend on assets an individual household own. This means those with more assets tend to have a greater range of options and ability to switch between multiple strategies to secure their wellbeing. However, institutions have a profound influence on access to/and use of assets of which adaptation strategies depend. For example policies or by-laws employed to smallholder farmers if are relevant or useful to smallholder farmers, may lead to adaptation strategies that are effective hence, improvement of their wellbeing and vice versa.

The hypothetical relationships between the independent variables (adaptation strategies) and the dependent variable (wellbeing) were as follows: adaptation strategies such as

planting early maturing maize varieties, planting of drought resistant crops, crop diversification, agricultural diversification, change in planting dates, application of fertilizers and irrigation improve crop products harvested. Improved crop harvested are expected to contribute to smallholder farmers' wellbeing in various ways including direct home consumption of the product and selling some of them to buy other necessities, and pay for social services such as health and education services. Other adaptation strategies such as involving in petty business, local brew and casual labour are expected to improve smallholder farmers' wellbeing levels for example by using income obtained to improve crop production, buy food and meet other necessities. Improvement of farmers' well-being implies that adaptation strategies are effective, and this leads to improvement of capacity to adapt through household livelihood assets which in turn, increases smallholder farmers' resilience to climate change.

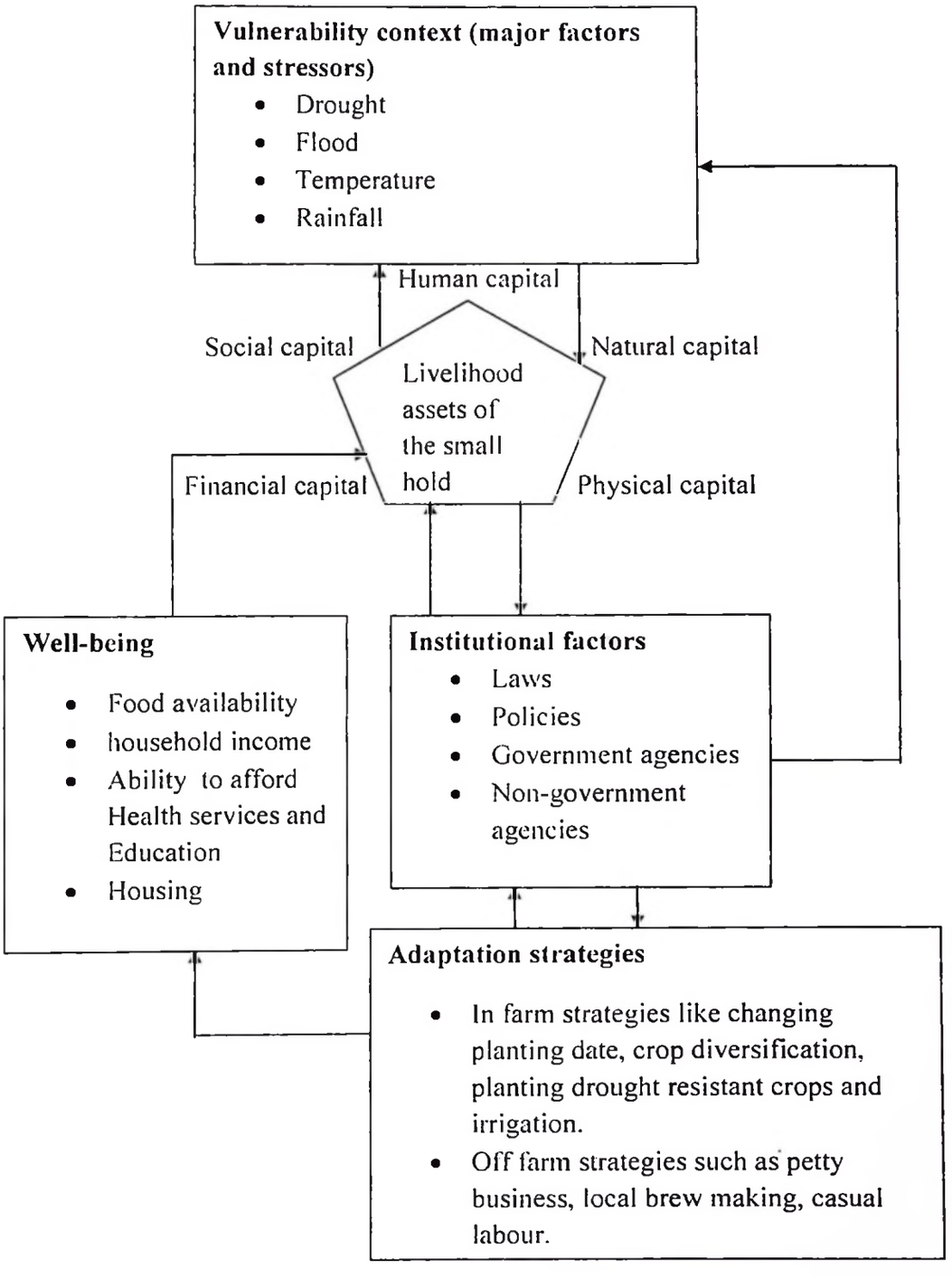

Figure 1: Relationship between vulnerability context, livelihood assets, institutional factors, adaptation strategies and well-being of smallholder farmers

Source: Modified from sustainable livelihood DFID (2000) to fit the intended study

1.8 Organization of the Thesis

This thesis is organized into three chapters. The first chapter gives the introduction of the thesis. It offers description of themes presented in three separate published papers and one publishable manuscript. The second chapter presents two published papers by different journals, one paper submitted for publication and one publishable manuscript. The third chapter presents extended conclusion, implications of the findings, recommendations and area for further studies.

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CHAPTER TWO

LIST OF PAPERS

PAPER ONE

Smallholder Farmers' Perception of Climate Change Versus Meteorological Data in Semi-Arid Areas of Iringa District, Tanzania

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Abstract

The ongoing changes in global climate threaten the sources of livelihood, especially among smallholder farmers in poor parts of the world. Smallholder farmers need to recognize the changes in climate already taking place in their areas and undertake appropriate investments towards adaptation. The coping and adaptation strategies of the farmers are linked to a very large extent with their perception on climate change and its impacts. The main objective of this study is to examine smallholder farmers' perception of climate change vis-á-vis meteorological data. Specifically this paper answers the following research questions: how smallholder farmers perceive climate change, what are the meteorological data of the study area, and how meteorological data link with smallholder farmers' perception to climate change. The study was carried out in semi-arid areas of Iringa District. The research design was cross sectional. A multistage sampling procedure was applied to select divisions, wards, villages and households. Ismani and Pawaga Divisions of Iringa District were purposefully selected based on their climatic conditions. A total of 240 respondents were drawn randomly from eight villages. Data were collected through household survey, key informant interviews, observation and focus group discussions methods. Meteorological data were collected from Tanzania Meteorological Agency. Quantitative data were analyzed through SPSS and qualitative data through content analysis. Instant Statistical Packages for Agro-climatological data was used in analyzing the 54 years meteorological data of Nduli meteorological station in Iringa District. The findings revealed that smallholder farmers perceived climate change in terms of change in temperature, changes in rainfall, increase in drought condition and increase in malaria and crop pests and diseases. Change in rainfall pattern, temperature pattern and occurrence of pests and diseases had significant impact on smallholder farmers' households whose livelihood depends on rain fed farming. Therefore smallholder farmers need to adapt to the changing climate. It is recommended that there is need for development of appropriate adaptation strategies to climate change of which smallholder farmers in semi-arid areas of Iringa District perceived. This can be achieved by helping smallholder farmers use their local knowledge in combination with introduced innovations to enhance adaptation to the impact of climate change.

Key words: perception; climate change; temperature and rainfall; semi arid; Iringa; smallholder farmers; Tanzania

1.0 Introduction

The earth's average surface temperature has increased by almost 0.74^{0}C over the past century (IPCC, 2007a). The consequences of this alteration are now becoming more visible as climatic conditions and ecosystems change (IPCC, 2007b). Climate refers to the characteristic conditions of the earth's lower surface atmosphere at a specific location over long period of time; weather refers to the day–to–day fluctuations in these conditions at the same location (FAO, 2008). Air temperature, precipitation, atmospheric pressure and humidity, wind, and sunshine and cloud cover are variables that are commonly used by meteorologists to measure daily weather phenomena. Climate change refers to changes for at least 30 years in all the essential climate variables (FAO, 2008). Climate variability refers only to the year–to–year variations of atmospheric conditions around a mean state (WMO, 1992). The change in climate is a natural phenomenon as it has been changing since the origin of earth (FAO, 2008). The natural rate of climate change is so slow that species would have time to adapt the changes (Darwin, 1959 cited in Lamichhane, 2010). However, change accelerated by anthropogenic activities takes place at a high rate not allowing species to adapt to that change. This finally creates adverse impacts on lives, people's livelihood and development of the society.

Developing countries are more vulnerable to impact of climate change due to the fact that they have low income

and high dependence on natural resource sectors for their livelihoods and incomes (Leary and Kulkarni, 2007; Shemsanga *et al.*, 2010; Yanda and Mubaya, 2011). The impacts of climate change are likely to severely damage social and economic systems of most developing countries (Yanda and Mubaya, 2011). The ongoing changes in global climate threaten the sources of livelihood, especially in poor parts of the world (Hisali *et al.*, 2011). Agriculture is negatively affected by climate change (Desanker and Magadza, 2001). It has been said that climate change is set to hit the agricultural sector the most in Sub-Saharan Africa (Tanzania being one of them) and cause much suffering, particularly to smallholder farmers (Komba and Muchapondwa, 2012).

Smallholder farmers need to recognize the climatic changes already taking place in their areas and undertake appropriate investments towards adaptation (Komba and Muchapondwa, 2012). Farmers' ability to perceive climate change is a key pre-requisite for their choice to adapt (Maddison, 2007; Gbetiouo, 2009; Acquah and Onumah, 2011; Mengistu, 2011; Moyo *et al.*, 2012; Kitinya *et al.*, 2012). The coping and adaptation strategies of the smallholder farmers depend, to a very large extent on their perception knowledge level and sources of information about climate change available to them (Bello *et al.*, 2013). However, perceptions are influenced not only by actual conditions and changes, but also by other factors (Acquah and Onumah, 2011). Weber (2010) believes that most farmers' knowledge and exposure to climate change have been influenced indirectly by the media reporting various events on climate change occurring elsewhere. Having fertile soil and access to water for irrigation decreases the likelihood that farmers will perceive climate change (Gbetibouo, 2009) due to the fact that perception of climate is based on economic and social impact it has on personal lives (Slegers, 2008).

Several studies have been done in Tanzania on climate change impacts, vulnerability, and adaptation strategies. Only few of them partly focused on perception of local communities on climate change (Lyimo and Kangalawe, 2010; Mongi *et al.*, 2010; Swai and Majule, 2009). However, those studies were done in semi-arid areas of central and western parts of Tanzania. The knowledge of climatic perception is a key entry points for farmers to respond to impact of climate change, also for decision makers and policy makers to learn how and where to enhance adaptive capacity of smallholder farmers. But there is limited knowledge on how smallholder farmers perceive climate change in semi arid areas of Iringa District. It is important to note that local perception cannot be estimated by models (Okonya *et al.*, 2013) and adaptation is place based and needs the use of place specific strategies (Hassan and Nhemachena, 2008; Kurukulasuriya and Mendelsohn, 2008; Lobell *et al.*, 2008; Seo *et al.*, 2008; Deressa *et al.*, 2011). Therefore, this study examined how smallholder farmers in Iringa District semi arid areas perceive climate change and implication of these changes in agriculture production.

This study is in line with the National Climate Change Strategy (URT, 2012) of which, one of its specific objectives aims at building the capacity of Tanzania to adapt to climate change impacts. First first step towards building this capacity is to underline the perception knowledge level of smallholder farmers (Tanzanians) about climate change. Also, the study is in line with the National Adaptation Programme of Action (NAPA) (URT, 2007), which calls for identification of immediate and urgent climate change adaptation actions that are geared toward long-term sustainable development. These efforts are intended to shield both the Tanzania Development Vision 2025 and Millennium Development Goals from failure due to the climate change impacts. As such, perception is a necessary precondition for adaptation. Therefore, smallholder farmers' perceptions of climate change and variability are important in adaptation as they determine decisions in agricultural planning and management.

2.0 Methodology

The study was conducted in Iringa District in Iringa Region Tanzania. The district is one of the four districts of Iringa Region. Iringa District has six administrative divisions. Two divisions namely Ismani and Pawaga out of six were selected for the study basing on their climatic conditions. The area (Ismani and Pawaga) is semi-arid with low mean rainfall ranging from 500 to 600 mm. The temperature in Pawaga Division is over 25 ^{0}C while that in Ismani Division is 20 – 25 ^{0}C.

The rationale for choosing Iringa District for the study was twofold. First, Iringa District was one of the major maize producing districts in Iringa Region until the early 1970s, but now agricultural production is low due to unreliable rainfalls. Secondly, Iringa District especially in Ismani and Pawaga Divisions experiences recurrent drought conditions, therefore, is more vulnerable to impact of climate change than other areas in the region.

The study used a cross-sectional research design. A multistage sampling procedure was applied to select divisions, wards, villages and then households. This procedure allows more than one sampling method to be used. Ismani and Pawaga Divisions were purposifully selected basing on their climatic condition. Four wards in Ismani and Pawaga Divisions were selected randomly. In each selected ward: two villages were randomly selected making a total of eight villages. A total of 240 respondents were drawn randomly.
Both quantitative and qualitative data were collected. Quantitative data were collected through household survey method. A tool for this method was a questionnaire. The questionnaire was pre-tested to ten households in Lwang'a village, Ismani Division and accordingly revised to produce the final questionnaire that was administered to heads of household smallholder farmers through in–depth personal interview approach. Information on smallholders' perception on climate change was gathered through this method. Qualitative data were gathered through focus group discussion, key informant interview and field observation methods. Secondary data were collected from Tanzania Meteorological Agency whereby temperature and rainfall year to year data from 1961 – 2013 from Nduli meteorological station in Iringa district were gathered. Meteorological data were collected so as to establish the extent to which climate has changed (through rainfall and temperature).

Quantitative data collected through household survey method were analyzed using Statistical Package for Social Sciences (SPSS). The perception of smallholder farmers was organized into three levels. The highest perception had a score of 30; the neutral had a score of 20; the lowest perception had a score of 10. Therefore the lowest perception was represented by 10-19 while the highest perception was represented by 21-30. A score of 20 meant neutral. Descriptive statistics was applied whereby frequency and percentage were calculated. Qualitative data were analyzed using content analysis. Instant Statistical Packages for Agro-climatological data was used in analyzing the 54 years meteorological data of Nduli meteorological station. Daily mean rainfall was computed and cumulative mean daily rainfall curve was used to estimate possible late start and early end of growing season. Maximum and minimum mean temperatures, annual mean temperature were computed. Total rainfalls, number of wet days and a 7-day or more dry spell within 30-day periods in each season were computed for each year and hence simple linear trend analysis for each characteristic was carried out. The dry spells were grouped into three temporal periods of seventeen years each for early, mid and late years i.e. 1961-1977, 1978-1994 and 1995-2011 respectively.

3. Results and Discussion

The main objective of this study was to examine on how smallholder farmers perceive climate change. The level of perception on climate change is very high as shown in Table1. About 99% of respondents perceived changes in climate. The minimum perception was 11 while the maximum perception was 30. The results imply that smallholder farmers had very high perception on climate change. The results were complemented by climatological data from Nduli station, Ismani Division in Iringa District which showed the climate was changing (Figure 1-7).

Table1. Level of Perception on Climate change

	Frequency	Percentage
Low perception	2	0.8
Neutral	1	0.4
High perception	237	98.8
Total	240	100.0

3.1 Smallholder Farmers' Perception of Temperature Change

The study revealed that significant numbers of smallholder farmers perceived that there was an increase in temperature. About 61% of respondents (Table 2) remarked that the temperature has increased today comparing to twenty or more years back. However, 35% did not notice temperature increase. About 59% of respondents claimed that there was extremely high temperature during summer, while 34% opposed that claim. Also respondents were asked whether they agreed that there was an extreme cold weather during winter. About 64% of respondents agreed that there was extreme cold during winter. However, perception of smallholder farmers on increase of temperature was confirmed by the trend of mean annual temperature (Fig. 1) which showed increase in temperature.
The trend of mean annual temperature for Iringa District was increasing and statistically highly significant ($P< 0.01$) (Fig. 1). Both the mean maximum and mean minimum temperature were significantly increasing. But the mean maximum temperature appeared to rise at a higher rate than the mean minimum temperature. These trends

were similar with those of Manyoni District (Mary and Majule, 2009) where mean maximum temperature increased rapidly and mean minimum temperature increased slowly. The results differ from those of Tabora (Mongi *et al.*, 2010) where the minimum temperature increased faster while the maximum temperature increased gradually. Also the results differ from those of Shinyanga Rural District (Lyimo and Kangalawe, 2010) who reported that both minimum and maximum temperature showed significantly increasing trends but the minimum temperature increased sharply while the maximum temperature increased gradually. This implies that different areas experiencing similar climatic conditions can experience changes in climate differently.

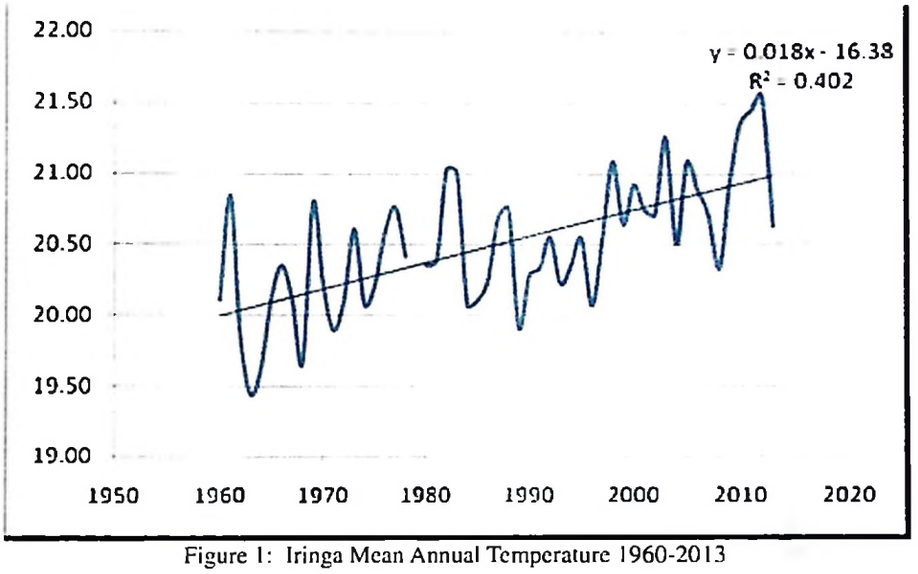

Figure 1: Iringa Mean Annual Temperature 1960-2013

According to IPCC (2007b), increase in average temperature will adversely affect crops, especially in semi arid areas where heat has become a limiting factor for crop production. Increase in temperature also increases evapo-transpiration rate of plants, and increases chances for severe drought. This means farming activities in semi-arid areas of iringa District were affected by the increased temperature. This has impact on food security and smallholder farmers' wellbeing in general.

Table 2: Perception of Climate Change among Smallholder Farmers

Variables	Disagree	Undecided	Agree
There is increase in temperature	35.4	3.3	61.3
There is extremely high temperature during summer	34.1	6.3	59.6
There is extreme cold temperature during winter	27.9	6.7	65.4
Precipitation has decreased	1.2	0.0	98.7
There is change in timings of rains	1.2	0.0	98.8
Frequencies of drought have increased	1.2	0.0	98.8
It rains in patches within the same village	0.8	0.0	99.2
It rains much in short time periods leaving other months dry	2.5	1.3	96.2
There is increase in malaria	28.3	5.8	65.8
There is increase in pests and crop diseases	10.5	5.4	84.2

3.2 Smallholder Farmers' Perception of Changes in Rainfall Pattern

Field results show a decrease in rainfall, whereby 98% of respondents (Table 2) observed that the rain was decreasing comparing to two or more past decades. The meteorological data also show total annual rainfall in Iringa District is decreasing with time (Fig. 2), though the rainfall trend of 54 years shows the decrease is not statistically significant at $P<0.05$. Thus smallholder farmers' perception on decrease in rainfall might be influenced by other factors such as distribution of rainfall. A similar trend has been noted in Usangu Plains in Tanzania (Kihupi *et al.*, 2007), and Shinyanga Rural District (Lyimo and Kangalawe, 2010) that annual rainfall

amount had been in declining trends, but the decrease was not statistically significant. This implies that the area might be receiving the same amount of rainfall, but there are changes in its distribution. Kingamkono *et al* (1994) and Kihupi *et al.*, (2007) argue that the timing and distribution of rainfall determine both the length and quality of the growing season, and hence have important implications for agricultural production and food security

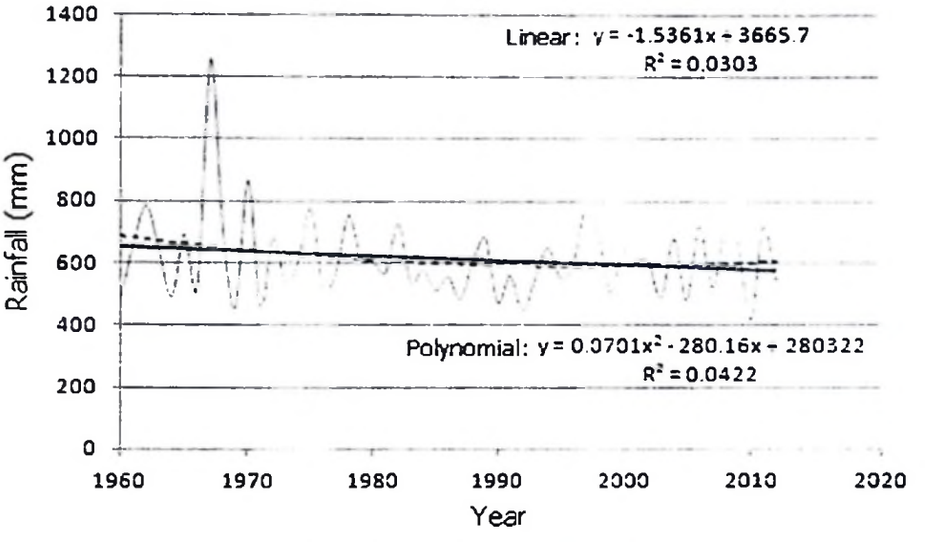

Figure 2: Trend of annual rainfall for Iringa (Solid line = linear; dashed line = polynomial)

Rainfall from farmer's point of view entails the onset, cessation and length of rain season (Kihupi *et al.*, 2007). Field results show that the rain falls much in a short period of time living other months dry during rainy seasons. This was noted by 96% of respondents (Table 2). Also about 98% of respondents (Table 2) agreed that there was change in timing of rains. These results were also confirmed in meteorological data which showed the beginning and ending of rains has changed significantly (Fig. 3 and 4). The trend shows the onset of rains in 1960s and early 1970s was in November but currently has shifted to mid December; the trend was statistically highly significant at $P < 0.01$ (Fig. 3). Also the trend of cessation dates was changing. Rainfall cessation in 1960s and early 1970s was in May, but currently it has shifted to April. The trend of cessation was statistically very highly significant at $P < 0.001$ (Fig.4). These trends (onset and cessation) imply that, the rain season starts late and ends early. This has repercussion on the growing season. The length of growing season has declined with time and the change was statistically very highly significant at $P < 0.001$ (Fig.5). The results were similar to those of Bukita District in Zimbabwe (Simbarashe, 2013) that showed a general increase in temperature and declining in rainfall and shortening of crop growing season. The same had been reported by farmers of Laikipia District in Kenya (Ogalleh *et al.*, 2012) that were experiencing shorter rain than in the past. As Lobell and Marshall (2010) reported, climate was reducing and expected to further reduce growing season length throughout much of the tropics. This has impact to smallholder farmers because traditional seed varieties cannot reach their full maturity under such shortened growing season. The situation calls for attention on adaptation measures, such as planting early maturing seed varieties, drought resistant crops and irrigation so as to improve agriculture production in semi-arid areas of Iringa District.

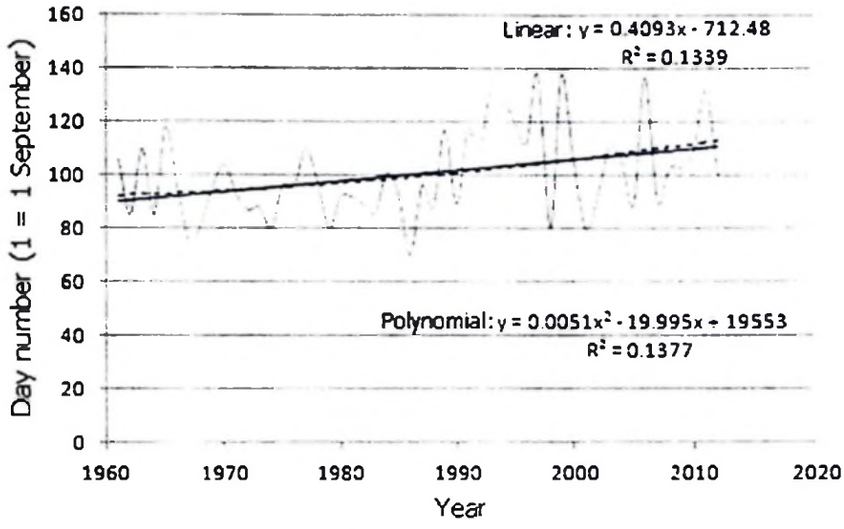

Figure 3: Trend of rainfall onset dates for Iringa (Solid line = linear; dashed line = polynomial)

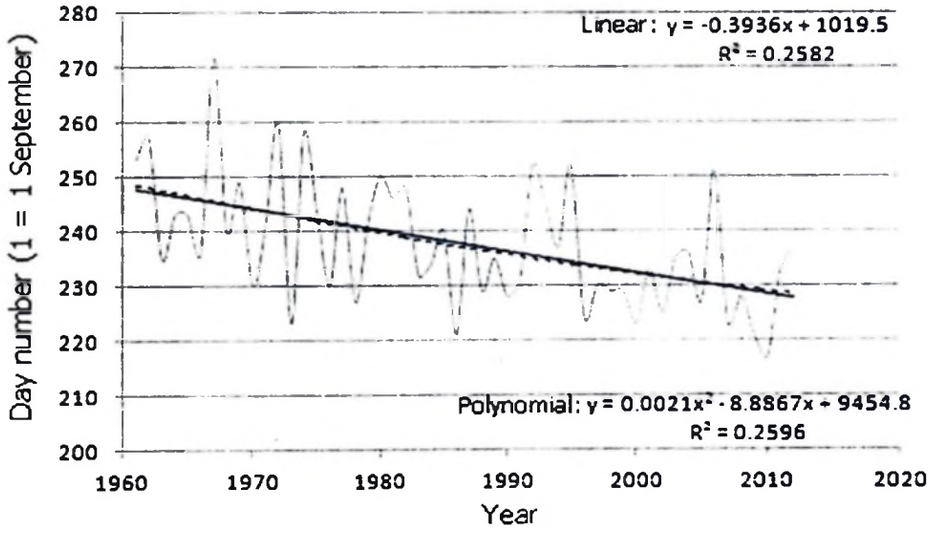

Figure 4: Trend of rainfall cessation dates for Iringa (Solid line = linear; dashed line = polynomial)

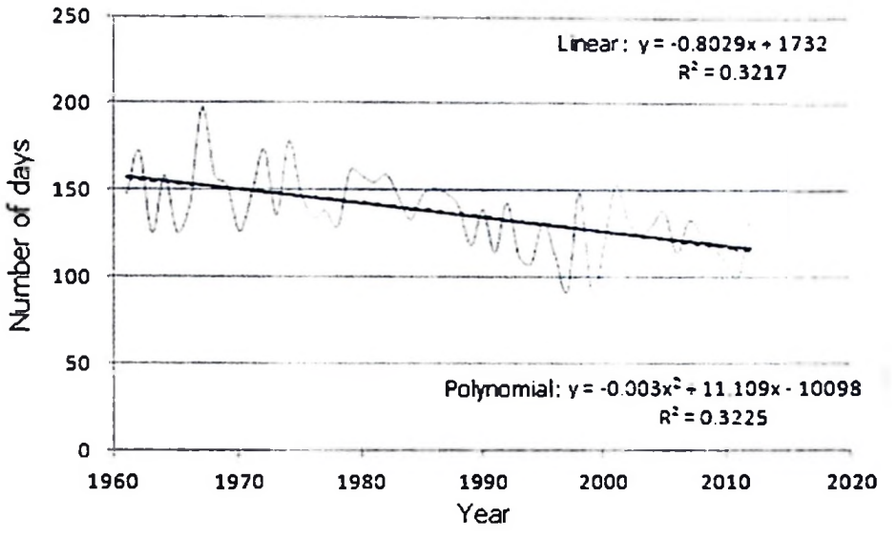

Figure 5: Trend of growing season length for Iringa (Solid line = linear; dashed line = polynomial)

Field results show increase in drought frequency, as reported by 98.8% of respondents (Table 2). These field results are reflected in meteorological data (Fig. 6 and 7). The quality of growing season is influenced by the magnitude of intervening dry spells (Kihupi *et al.*, 2007). The number of wet days within the growing season in Iringa District is decreasing and highly statistically significant at $P < 0.01$ (Fig. 6). Meteorological data shows increase in the occurrence of dry spells during rainy season in Iringa District (Fig. 7). The probability of having a 7-day or more dry spell within a 30-day during growing season is high now comparing to 1961-1977 period. These results are similar to those of Laikipia District in Kenya (Ogalleh *et al.*, 2012) who asserted that farmers in Laikipia District are experiencing increase in frequency of droughts. The same has been noted in Manyoni District in Tanzania (Swai and Majule, 2009) whereby farmers were experiencing increase in dry spells.

During focus group discussion and key informant interview, it was revealed that, there were prolonged dry spells in February which affected crops especially early maturing maize varieties that were said to be intolerant to drought conditions. This means increased risk of crop failure to smallholder farmers due to poor germination, stunted growth and drying of crops before their maturity caused by changes in rainfall pattern. Also focus group discussions and key informant interviews revealed that, smallholder farmers sometimes had to re-plough and re-plant crops due to unpredictability of rainfall, hence, increase in production costs. The results were similar with those of Dodoma in Tanzania (Nelson and Stathers, 2009) whereby farmers had to replant bulrush millet and groundnuts more often due to unpredictable rains. This means that time and seeds were wasted and quality of crops was affected. Farmers also in semi-arid areas of Iringa District reported changes in rainfall pattern, that rains used to fall throughout the entire village or across villages at a time, but nowadays it rains in patches in the same village. This was reported by 99% of respondents (Table 2). All these changes in climate have impacts on crops, food security and wellbeing of smallholder farmers who depend mostly on farming activities.

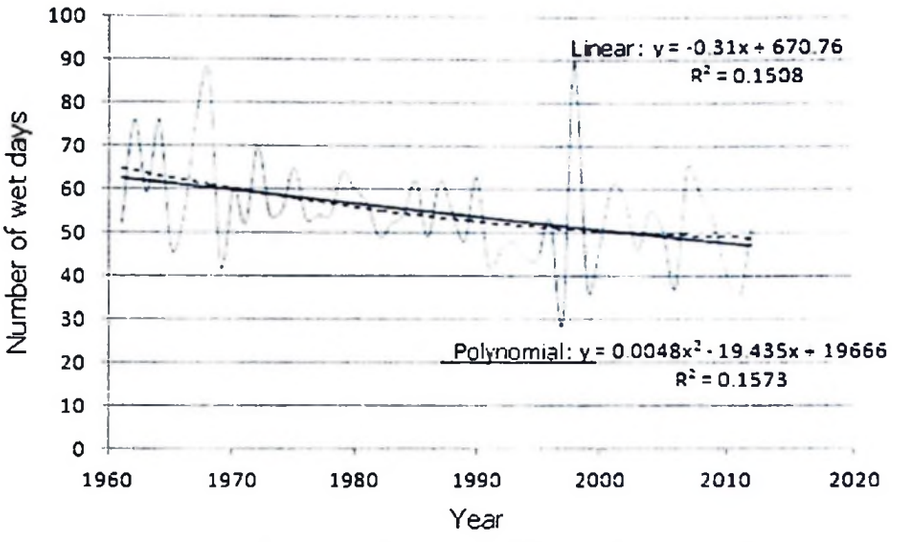

Figure 6: Trend of number of wet days for Iringa (Solid line = linear; dashed line = polynomial)

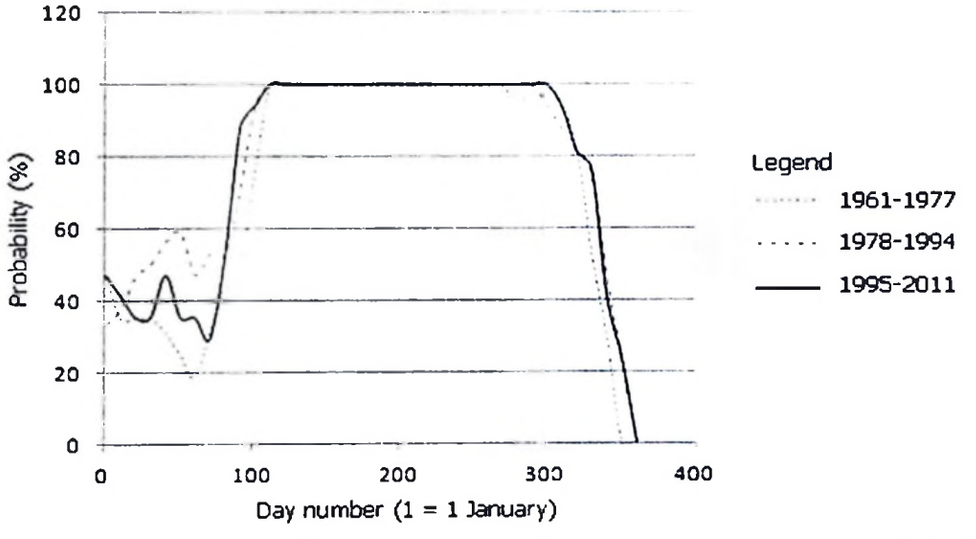

Figure 7: Trend of probability of a 7-day dry spell within a 30-day period following the date indicated on the horizontal axis for Iringa for the respective temporal periods

3.3 Smallholder farmers' Perception on Increase in Diseases and Pests

The study revealed that, there is increase in diseases and pests such as malaria to human being due to increase in temperature favouring environment for multiplication of host insects and pests. About 65% of respondents (Table 2) claimed that there was increase in malaria in the study area. Malaria has been increasing and spreading even in cold areas of Tanzania like Njombe and Arusha where formerly there was no malaria. This is due to increase in temperature creating favourable environment for mosquito (URT, 2012). Mosquito is responsible for spread of vector bone disease malaria. About 28% of respondents (Table 2) did not agree that malaria is increasing. This was complemented with focus group discussions where some members said malaria incidences were decreasing due to provision of free mosquito nets in Tanzania. Also the study revealed that there was increase in crop disease and pests which were not there or were at small scales in two or more past decades as reported by 59% of respondents (Table 1). Crop diseases and pests have impact on crop production, especially to smallholder farmers due to increase in pests and crop diseases; farmers have to buy pesticides which are expensive, hence, increasing production costs.

4. Conclusion and Recommendation

Smallholder farmers have perceived that the climate is changing and it is getting worse over time. There is a concern that the temperature is increasing and rainfall is unreliable and unpredictable; the onset and ending of rain have changed leading to significant reduction in growing season. Also dry spells have increased causing poor germination and drying of crops before reaching a maturity stage. This sometimes led to re-planting of crops adding more cost of production to smallholder farmers. These perceptions on climate change could be influenced by other factors such as availability of irrigation water, soil fertility, and information from media on climate change. Meteorological data trends (from Nduli station in Iringa District) of temperature, rainfall, onset and cessation of rain, growing seasons, number of wet days and probability of occurrence of dry spells provide evidence that the climate is changing. Change in rainfall pattern, temperature pattern and occurrence of pests and diseases has significant impact on household of smallholder farmers whose livelihood depends on rain fed farming. Therefore smallholder farmers need to adapt to the changing climate.

It is recommended that there is a need for development of appropriate adaptation strategies to climate change which was perceived by smallholder farmers in semi-arid areas of Iringa District. This can be achieved by helping smallholder farmers use their local knowledge in combination with introduced innovations to enhance adaptation to the impact of climate change. Joint action among researchers, extension officers, smallholder farmers and policy makers will enable development of adaptations strategies which are more efficient to overcome impact of climate change.

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PAPER TWO

Smallholder Farmers' Adaptation Strategies to Impact of Climate Change in Semi-Arid Areas of Iringa District Tanzania

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Abstract
The current climate is already marginal with respect to precipitation in many parts of Africa, especially in semi-arid areas. Impact of climate change will bring substantial losses especially to smallholder farmers whose main source of livelihood derives from agriculture. Such impacts can be significantly reduced through adaptation. Given the high dependence on rain-fed agriculture and prevailing drought condition of semi-arid areas of Iringa district, the area may be quite vulnerable to the current and future climatic changes. The frequency supply of food relief from the Tanzania government to smallholder farmers in Ismani, emphasizes its vulnerability to climate changes. Therefore, this study determined adaptation measures carried out in semi-arid areas of Iringa District Ismani and Pawaga Divisions in particular. The research design was cross sectional. A multistage sampling procedure was applied in selecting divisions, wards, villages and households. Ismani and Pawaga divisions were purposeful selected basing on their climatic condition. A total of 240 respondents were selected randomly from eight villages. Data were collected through household survey, key informant interview, observation and focus group discussion methods. Quantitative data analysis was done using SPSS whereby descriptive statistics were computed. Qualitative data were analyzed using content analysis. The findings revealed that smallholder farmers in Pawaga and Ismani divisions were adapting to impact of climate change through irrigation, crop diversification, planting early maturing maize varieties, planting drought resistant crops, changing of planting dates, and agriculture diversification and non-farm activities. It can be concluded that the smallholder farmers in both divisions used various adaption strategies against climate change impact. However, the farmers in the two divisions still face the impact of climate change in their livelihoods. Based on the conclusion made in this study, there are required efforts from various stakeholders including government to improve the adaptation strategies to be appropriate and effective.

Key words: Climate change; adaptation strategies; smallholder farmers; semi-arid, Iringa District

1. Introduction

Countries in Sub-Saharan Africa are particularly vulnerable to impact of climate change, given dependence on agriculture production and limited adaptive capacity (Bryan *et al.*, 2013). A number of countries in Africa already face semi-arid conditions that make agriculture challenging (Boko *et al.*, 2007). Climate change adversely affects agricultural production in Africa through reduction in the length of growing season and force large regions of marginal agriculture out of production (Boko *et al.*, 2007). Experts are concerned that the agricultural sector in Africa will be especially sensitive to future climate change and any increase in climate variability (IPCC, 2007). The current climate is already marginal with respect to precipitation in many parts of Africa (Dinar *et al.*, 2008). Further warming in semi-arid areas is likely to be devastating to agriculture. Various climate models suggest median temperature increase between 3^0C and 4^0C in Africa by the end of the 21st century, roughly 1.5 times the global mean response (Schlenker and Lobell, 2010), which is likely to affect agriculture. Even in the moist tropics, increased heat is expected to reduce crop yields (Dinar *et al.*, 2008). As a consequence, staple crops such as maize, sorghum, millet and cassava, are likely to result in significant yield losses of between 8 and 22 percent by 2050 (Schlenker and Lobell, 2010). Projected reductions in crop yield in some countries could fall by as much as 50 percent by 2020, and crop net revenues could fall as much as 90 percent by 2100, with smallholder farmers being the most affected (Boko et al., 2007). Climate may change more rapidly than expected and is projected to have complex, long term effects for the environment, and for Tanzanian production system (URT, 2012). It is clear that climate change will bring about substantial losses especially to smallholder farmers whose main source of livelihood is derived from agriculture (Komba and Muchapondwa, 2012).

Agronomic studies suggest that yields could fall quite dramatically in the absence of costly adaptation measures (Dinar *et al.*, 2008). Empirical studies measuring the economic impacts of climate change on agriculture in Africa show that such impacts can be significantly reduced through adaptation strategies (Kurukulasuriya and Mendelsohn, 2006; Seo and Mendelsohn, 2006). Therefore key investments are needed to improve agricultural productivity under climate risk (Schlenker and Lobell, 2010). Adaptation can be classified either as planned adaptation or as autonomous adaptation. There are various definitions of adaptation to climate change. However, there is slight differences that exist among those definitions and may have some practical implications under certain circumstances.

This study adopted the Intergovernmental Panel on Climate Change (IPCC) definition that adaptation is "adjustments in ecological, social or economic systems in response to actual or expected climatic stimuli and their effect" (Smit and Pilifosova, 2001). Other definitions are as follows; UNDP (2005) refers "adaptation to a process by which strategies to moderate, cope with and take advantage of the consequences of climatic events are enhanced, developed and implemented". Adaptation to climate change also refers to "a process through which people reduce the adverse effects of climate on their health and well-being, and take advantage of the opportunities that their climate environment provides" (Burton, 1992 cited in Smit *et al.*, 2000). "Adaptation involves adjustments to enhance the viability of social and economic activities and to reduce their vulnerability to climate, including its current variability, and extreme events as well as longer term climate change" (Smit, 1993, cited in Smit *et al.*, 2000). "The term adaptation means adjustment, whether passive, reactive or anticipatory that is proposed as a means for ameliorating the anticipated adverse consequences associated with climate change" (Stakhiv, 1993 cited in Smit *et al.*, 2000). "Adaptation to climate change includes all adjustments in behavior or economic structure that reduce the vulnerability of society to changes in climatic system" (Smith *et al.*, 1996 cited in Smit *et al.*, 2000)
Adaptive capacity is the "potential or ability of a system, region or community to adapt to the effects or impacts of climate change" (Smit and Pilifosova, 2001). Adaptation strategies refer to "all responses to climate change that may be used to reduce vulnerability" (Burton *et al.*, 1998).

Adaptation can be autonomous that does not constitute a conscious response to climatic stimuli, but triggered by ecological changes in natural systems and by market or welfare changes in human systems. It is also referred to as spontaneous adaptation (IPCC, 2001). On the other hand, adaptation can be planned, that is the result of deliberative policy decision, based on an awareness that conditions have changed or are about to change and that action is required to return to, to maintain, or to achieve a desired state (IPCC, 2001). Autonomous adaptations are usually reactive. They are also widely considered initiated by private actors (individuals, households or private companies) (IPCC 2001) instead of government. Planned adaptations refer to as public adaptations (initiated and implemented by government at all levels) (IPCC 2001). Most of adaptation measures carried in Tanzania are autonomous adaptations.

Agriculture is a dominant sector in Tanzanian economy providing livelihood, income and employment to over 80 percent of the population. Nevertheless it experiences vulnerability in terms of decrease in crop production of different crops exacerbated by climatic variability and unpredictability of seasonality (URT, 2007). Climate change and variability threatens the livelihood of smallholder farmers who depend on subsistence agriculture, which is almost entirely rain fed. Also over 70% of population depends on agriculture (mostly carried by smallholder farmers) (Mary and Majule, 2009). However, rain fed agriculture is particularly sensitive to climate change (Lyimo and Kangalawe, 2010; Boko *et al.* 2007). Therefore dealing with climate change is an economic necessity to avoid serious disruption to global and national socio-economic development. Adaptation is an overriding priority for developing countries like Tanzania (URT, 2012).

Smallholder farmers in different parts of Tanzania have adapted to impact of climate change through planting drought resistant seed varieties and crops, intercropping, irrigation, changed planting dates, increased use of water and soil conservation techniques, diversification from farm to non-farm activities such as casual labour and moving to other places (Shemsanga, *et al.*, 2010; Komba and Mchapondwa, 2012; Lyimo and Kangalawe, 2010; Mary and Majule, 2009). However, there is little empirical evidence of adaptation strategies in semi-arid areas of Iringa District. Given the high dependence on rain-fed agriculture and prevailing drought condition of semi-arid areas of Iringa district, the area may be quite vulnerable to the current and future climatic changes. The frequency supply of food relief from the Tanzania government to smallholder farmers in Ismani, emphasizes its vulnerability to climate changes. In addition to that, adaptation strategies depend on agro-climatic zone and

indigenous knowledge (Hisali *et al.*, 2011) which, vary even among different semi-arid agro-ecological zones. Therefore, this study determined adaptation strategies carried out in semi-arid areas of Iringa District Ismani and Pawaga Divisions in particular.

This study is in line with Tanzania's Vision 2025, which, aims at attaining high quality livelihood for its people and develop a strong and competitive economy among other things. These aims may not be attained if climate change adaptation concerns are not factored in development process in the context of sustainable development. It is in this context that climate change is one of the priority areas in the second National Strategy for Growth and Reduction of Poverty (NSGRP II) (URT, 2010). Also, the study is in line with the National Adaptation Programme of Action (NAPA) (URT, 2007), which calls for identification of immediate and urgent climate change adaptation actions that are geared toward long-term sustainable development. These efforts are intended to shield both the Vision 2025 and Millennium Development Goals from failure due to the climate change impacts.

2. Research Methodology

The study was conducted in Iringa District in Iringa Region, Tanzania. The District is one of the four districts of the Iringa Region. Iringa District has six administrative divisions. Two divisions (Ismani and Pawaga) out of six were selected for the study basing on their climatic condition. Rainfall in Pawaga Division is 500 – 600 mm, in Ismani Division is below 600 mm. Temperature in Pawaga Divisions is over 25 ^{0}C and 20 – 25 ^{0}C in Ismani Divisions (Mussei *et al.*, 2012). Most households in Iringa District depend on agricultural sector for their livelihood. Agricultural activities mostly are carried out by smallholder farmers. About 90 percent of its population earns their living from agriculture and livestock production (Mkavidanda and Kaswamila, 2001; URT, 2005). Weather condition is the major determinant of agricultural performance in the study area.

The rationale for choosing Iringa District for the study is twofold. First, Iringa District was one of the major maize producing districts in Iringa Region until the early 1970s, but in recent years, the agricultural production has been increasingly becoming low due to unreliable rainfalls. According to Mussei *et al.* (2012), food availability is not sufficient in four divisions (Ismani, Kalenga, Pawaga and Idodi) out of six of Iringa District. Secondly, Iringa District especially in Ismani and Pawaga Divisions experiences recurrent drought conditions, therefore, it is more vulnerable to impact of climate change than other areas in the region.

The study used a cross – sectional research design which involved collection of data at a single point in time (Babbie, 1990; Bailey, 1998). The nature of study objective dictated this study to adopt this study design. A multistage sampling procedure was applied to select divisions, wards, villages and then households. This procedure allows more than one sampling method to be used. Two divisions out of six were purposeful selected basing on their climatic condition to make a comparative study so that variability of study area could be addressed. A total of four wards were randomly selected from the two divisions. In each selected ward; two villages were randomly selected making a total of eight villages. A total of 240 respondents were drawn randomly.

Both quantitative and qualitative data were collected. Quantitative data were collected through household survey method. A tool for this method was a questionnaire formulated of both open- ended and closed-ended questions. The questionnaire was pre-tested on ten households in Lwang'a village, Ismani Division and accordingly revised to produce the final questionnaire that was administered to heads of household smallholder farmers through in – depth personal interview approach. Information such as crop diversification, agricultural diversification, and nonfarm activities; and other adaptations were gathered through this method. Qualitative data were gathered through focus group discussion, key informant interview and field observation methods.

Quantitative data collected through household survey method were analyzed using descriptive statistics. Multiple responses were conducted using descriptive statistics where measures of central tendency such as frequency, and percentage were calculated through Statistical Package for Social Sciences (SPSS). Qualitative data collected through focus group discussions, key informant interviews and observations methods were analyzed using content analysis.

3. Results and Discussion

Smallholder farmers in semi-arid areas of Iringa district are affected by impact of climate change through

unpredictable rainfall, increased temperature and prolonged dry spells. This led to low crop yield/crop failure. In response to the prevailing climatic condition, households in Pawaga and Ismani Division used different adaptation strategies to reduce the impact of climate change. These are on farm adaptation strategies (irrigation, planting early maturing maize varieties, planting drought resistant crop such as sorghum, changing planting dates and application of fertilizer); and non-farm strategies (petty business, casual labour and making local brew) (Table 1).

Table 1. Smallholder Farmers Adaptation Strategies in Ismani and Pawaga Division (n=240)

	Ismani		Pawaga	
Adaptation strategies	**Frequency**	**Percentage**	**Frequency**	**Percentage**
Drought resistant crop	176	97.8	-	-
Crop diversification	172	95.6	7	11.7
Change in planting dates	172	95.6	2	3.3
Early maturing maize varieties	165	91.7	-	-
Agriculture diversification	148	82.2	26	43.3
Application of fertilizer	99	55.0	2	3.3
Petty business	82	45.6	26	43.3
Casual labour	67	37.2	3	5.0
Making local brew	53	29.4	3	5.0
Moving to different area	12	6.7	1	1.7
Irrigation	7	3.9	60	100
Furniture making	4	2.2	2	3.3
Building activities	4	2.2	3	5.0
Change from farming to non-farming activities	2	1.1	1	1.7
Hair dressing	2	1.1	1	1.7
Sewing clothes	2	1.1	5	8.3
Application of pesticides	1	0.6	4	6.7
Fishing	1	0.6	1	1.7

3.1 Drought Resistant Crops

Smallholder farmers in Ismani, adapted drought resistant (98%) of respondents by introducing sorghum as a substitute for maize (Table 1). In Pawaga smallholder farmers do not plant drought resistant crops. However, it was revealed that, sorghum had been forced by local government through by-laws that required every individual in Ismani to plant two acres of sorghum. Failure to do so: a household was supposed pay 50,000 Tanzanian shillings as a fine. The crop had been performing badly and the production was very low. Among other factors, smallholder farmers in Ismani have not been putting more effort in production of sorghum comparing to maize. Most of smallholder farmers in Ismani normally cultivate sorghum after cultivation of maize when the planting season is almost over. Policies to promote adaptation to impact of climate change and risks often rely on the cooperation of the intended beneficiaries at their own will. If these beneficiaries disagree with policy makers about the need for adaptation, or effectiveness of the measures they are being asked to undertake, then implementation of the policy is likely to fail (Patty and Schroter, 2008). That is the case with sorghum in Ismani division.

During focus group discussions and key informant interviews, it was revealed that, majority of household did not like sorghum for food as opposed to maize. Some said "sorghum is not for us but for '*wagogo*' (a tribe from Dodoma region in Tanzania)". Others said, "We cultivate sorghum for government". Also during focus group discussions it was revealed that sorghum has low market value in Ismani. Lobell and Marshall (2010) claimed that local consumer taste preferences are likely to inhibit adaptation among crops. Therefore, sorghum may be one of the drought resistance crops, especially in semi arid areas like Ismani Division, but adaptation of this crop (sorghum) is likely to fail in Ismani. This may be due to taste preference among Ismani people (they prefer maize to Sorghum). It may also be due to the fact that sorghum has low market value.

3.2 Crop Diversification

Crop diversification was another adaptation measure taken in Ismani whereby 96% of respondents (Table 1)

admitted to have been planting different crops in their field such as maize, sunflower, cowpeas, sesame, and groundnuts. In Pawaga about 12% of respondents (Table 1) claimed to cultivate more than one crop in their fields. However, crop diversification in Pawaga is done during dry season through irrigation, whereby maize, tomatoes and different types of vegetables are grown in the field for food supplement as well as for sell. The growing of more than one crop is an insurance against total crop failure, thus reducing the risk of complete failure since different crops are affected differently by climate event. These findings are in line with those reported by Orindi and Murray (2005), and Hassan and Nhemachena (2008).
Generally, in Tanzania, maize is grown mainly for food consumption although sometimes it is sold so that farmers can get money to fulfill their other needs. Sunflower, cowpeas and groundnuts are mainly for commercial purpose so as to increase smallholder farmers' household income. These results concur with that of Nelson and Stathers (2009) for Kongwa and Bahi Districts in Dodoma Tanzania that claimed, groundnuts, bambara nuts and cowpeas are being grown in Dodoma more widely to earn cash.

Crop diversification is one among promising adaptation strategies. Smallholder farmers take advantage of the different maturing times of crops, to strengthen their resilience to impacts associated with climate change and variability (Simbarashe, 2013). Crop diversification to some extent guarantees at least small harvest in case of worse year (Ogalleh et al., 2012). Nevertheless, there are years which farmers in Ismani reported to have total crop failure and being supported with food relief. This implies that crop diversification in spite of its advantages and assurance of crop harvest was not enough to overcome impact of climate change and variability in Ismani Division. Such adaptation strategy at farm level can become insufficient when droughts are more widespread and severe, particularly when consecutive drought years lead to loss of seed stocks combined with low capital reserves and other economic and social stresses to the food system.

3.3 Changes in Planting Dates

Almost 96% and 3% of respondents (Table 1) in Ismani and Pawaga respectively admitted that they have changed planting dates as one of strategies to cope with unpredictability and unreliability of rainfall. During focus group discussion, respondents said that they used to put seed in the ground before rain, so that when rain comes the seeds germinate. But nowadays if you do the same, you will end up replanting seeds. This is because; rainfall may come but not enough to reach the seed in the ground. Therefore most smallholder farmers wait for the rain to plant their seeds. These findings resemble those reported by other studies done in Dodoma, Kongwa and Bahi Districts Tanzania (Nelson and Stathers, 2009) and in Manyoni Tanzania (Majule, 2008). Although 96% of respondents claimed to change planting dates to cope with unreliability of rainfall, the study revealed that maize yield to majority is still low in the study area. This may be due to lack of ploughing tools that causes smallholder farmers to plough the land late or other factors that hinder this adaptation strategy hence harvesting low. Therefore this strategy will be efficient if smallholder famers are equipped with ploughing tools such as oxen drawn plough; this will allow them to maximize use of the shortened planting season.

3.4 Early Maturing Maize Varieties

Farmers are choosing different early maturing maize varieties, because the rainy season is now so short that their traditional varieties cannot mature in time. About 92% (Table 1) of respondents in Ismani said they used early maturing maize varieties but in Pawaga smallholder farmers do not cultivate maize nowadays, they switched to paddy. This result concurs with that of Nelson and Stathers (2009), that farmers use different fast maturing sorghum varieties due to the fact that the traditional varieties cannot mature in time in the light of the shortened rainy season. Also the findings agree with that of ActionAid (2006) in Malawi, that farmers opt for short –season hybrid maize varieties because the growing season in Malawi has become shorter in such a way it cannot support long-season local indigenous maize varieties. Though early maturing maize varieties has high yield, they can be affected by the long drought spell in February and lead to crop failure. This was due to the fact that, early maturing varieties grown in Ismani were not drought resistance. This was revealed during focus group discussions and key informant interviews conducted in Ismani. Nevertheless, maize yield in Ismani Division is still low. This implies that, there are factors that affect this promising adaptation measure

Hybrid maize (early maturing varieties) is capital intensive (ActionAid, 2006) in terms of seeds and fertilizer. Although 92% of respondents said they used early maize maturing varieties, only 55% of respondents use fertilizer (Table 1). This means, some of smallholder farmers in Ismani do not use fertilizer though their soil fertility is depleted. Also it was revealed during focus group discussions that, the majority of those who claimed to use fertilizer did not apply it in all of their fields. They only use fertilizer in fields which seem to be more

depleted. Only 3% of respondents (Table 1) use fertilizer in Pawaga.

However, there was a challenge on fertilizer itself "*minjingu*" which was brought in Ismani in reduced price "*vocha*" as an incentive to farmers; "*Minjingu*" fertilizer produced in Tanzania seem not to be favourable in Ismani division. There were complains that "minjingu" fertilizer takes long time to decompose and also needs a lot of water, therefore, such fertilizer is not suitable in Ismani where rainfall is little and unreliable. In other words, this fertilizer discourages farmers from using it, hence low harvest and hindrance to adaptation measures.

3.5 Agriculture Diversification

In addition to cropping, smallholder farmers kept livestock such as cow, donkey, duck, chicken, pig, sheep, and goat. About 82.2% of respondents in Ismani and 43.3% of respondents in Pawaga (Table 1) claimed to keep livestock. In case of total crop failure, they sell part of their livestock to meet their food insufficient situation as well as cater for other necessities such as health services, and education. During focus group discussions and key informant interview in Pawaga, It was revealed that livestock keeping serve as insurance in case of market price failure as it was the case in the year 2012/2013 in Pawaga Division. The price of paddy was very low in such a way that it could not recover the production cost. These findings agree with those of Simbarashe, (2013) who found that, rural communities in Zimbabwe sale their household assets like livestock in an attempt to cope with the effect of climate variability. Also livestock such as cows are used in ploughing the land helping farmer to cultivate in time hence maximizing the shorted rain season in Ismani. Donkey carries water and other goods from a far distance, helping farmers in adapting to impact of climate change. However, in case of severe drought conditions many livestock such as cow, got and donkey may die due to drought stress. Selling of livestock in case of total crop failure or crop market failure is a coping strategy.

3.6 Irrigation

Irrigation was the major adaptation strategy in Pawaga division. All respondents (100 %) depended on irrigation for their paddy fields and agriculture in general (Table 1). There were only 4% of respondents in Ismani used to irrigate their crops specifically vegetables. Though Pawaga and Ismani divisions experience unreliable rainfalls, Pawaga smallholder farmers have access to Ruaha river water. Therefore farmers mainly depend on irrigated farms along Ruaha River (URT. 2005). The major crop under irrigation is paddy and to a lesser extent vegetables during dry season. Before 2002, smallholder farmers in Pawaga were also cultivating maize and sorghum in highlands in additional to paddy, but later on after establishment of irrigation scheme, all smallholder farmers have been involving in paddy cultivation. This is because paddy is a high value crop.

During focus group discussions it was revealed that, smallholder farmers in Pawaga division depend on rains falling elsewhere up the river source. One of respondent said," we do not count on rains falling in Pawaga for cultivation, this is because the rains in our area is very little and unpredictable. So we cultivate our fields when the river is full due to rains falling in highlands such as Dabaga and Iringa municipal". During key informant interviews, one respondent said that "we thank this irrigation scheme because; people are prospering building nice houses, others are demolishing the traditional ones (thatched with mud walls and soil on top of the roof) and building modern ones". Also he said "there is development in general, people use solar energy and watch televisions because of the irrigation scheme". The key informant interview's declaration was complemented by field observation method whereby new buildings were viewed and the use of solar energy was common in Itunundu and Kimande villages. It should be noted that the national grid has not reached the area yet for power supply. Field observation also revealed fruit trees in the area and there was no problem on availability of domestic water.

These findings are quite contrary to those found in Ismani division although both divisions experience semi-arid conditions. This implies that irrigation is an important strategy in overcoming impact of climate change. As it was stated in the Tanzania national water policy (URT, 2002) irrigation provides protection against drought and ensures availability of food reserve. It also contributes to the reduction of poverty since it can facilitate many farmers to cultivate high value crops such as paddy, fruits and vegetables. The findings also agree with those of Gbetibouo, (2009) and Deressa *et al.*, (2009) which indicated that, water for irrigation increases farmers' resilience to climate change and variability. Therefore, there is need for greater investment on potential areas for irrigation. This strategy will help smallholder farmers to overcome impact of climate change in semi arid areas like Ismani and Pawaga division.

3.7 Non-farm Strategies

Non-farm strategies against impact of climate change in Ismani are petty business, casual labour and local brew making (46%, 37% and 29% of respondents respectively) (Table 1), while in Pawaga mostly is petty business whereby 43% of respondents (Table 1) claimed to be involved so as to increase their household income. Petty business in Pawaga and Ismani divisions mostly was based on agricultural product such as buying and selling paddy or rice, selling vegetables and tomatoes in Pawaga, while in Ismani smallholder farmers were involved in buying and selling sunflower, maize, and tomato. In case of casual labour, most of activities for casual labour are available during rainy season; these are planting, weeding and harvesting. People involved in casual labour mostly are poor, they use more time in casual labour so that they can get money to buy food and other necessities, hence, spending little time in their own fields. This may lead to the situation whereby, food insecurity becomes persistence in their households.

Local brew making is mostly being practiced by women in Ismani and Pawaga divisions so as to increase income in their households and buy food supplement in case of crop failure. These findings concur with those of Simbarashe (2013) who mentioned that brew of traditional beer "*Ndari*" in Bukita District, Zimbabwe is one of adaptation strategies to impact of climate change which provide an alternative source of income for many people who brew it commercially. The problem with local brew in Ismani commonly known as '*komoni*' is that, it uses a big amount of maize therefore it may subject the households to food insecurity.

Gbetibouo (2009) argue that non-farm income sources increase the probability to afford adaptation measures. Simbarashe (2013) also argues that diversification of livelihood activities such as petty trading, commercial brick moulding, firewood trading and beer brewing among other activities widened the smallholders' source of income and hence enhancing sustainable livelihoods and food security. Diversification or working in different activities helps to spread risk and manage uncertainty. Ellis (2000) asserts that livelihood diversification has become an effective and reliable survival strategy for rural households in developing countries. This is so because, due to the effects of climate change and variability, farming on its own is failing to provide a sufficient means of survival in rural areas.

Lobell and Mashall (2010) argue that diversifying income to non-farm income sources which are less climate sensitive is a good strategy against impact of climate change, but it might not help because rural non-farm economy is linked to agricultural productivity. If most people in a village are farmers, and all experience a yield decline simultaneously, then demand for both agricultural wage labour and non-farm goods and services will certainly fail and thus income (Jayachandran, 2006; World Bank, 2008). This is the case with Ismani and Pawaga, where most of non-farm strategies carried out were related to agriculture. This means Ismani and Pawaga people's economy is tightly linked to agricultural sector and whenever this sector is deeply affected by impact of climate change, income from non-farm activities will be affected too. Therefore, non-farm activities adaptation strategies against impact of climate change in rural areas especially Ismani and Pawaga divisions are less promising.

4. Conclusion and Recommendation

Smallholder farmers in Ismani division are adapting to the impact of climate change using various strategies such as crop diversification, use of early maturing maize varieties, planting drought resistant crops, changing of planting dates, and agriculture diversification. Other strategies are petty business, casual labour and making local brew. In Pawaga adaptation strategies include irrigation, agriculture diversification, and petty business. Smallholder farmers in Ismani seem to have various adaptation strategies; however, they are the ones who mostly receive government food aid due to crop failure as a result of drought. Meanwhile, Pawaga has mainly three adaptation measures and irrigation being the major one that the whole population in Pawaga depends.

Sorghum being one of the drought resistant crop in Ismani, does not perform well, in spite of the force imposed by the local government, therefore, smallholder famers and local government executives have to reach an agreement on the importance of sorghum or replacing sorghum with another relevant crop in overcoming impact of climate change. Otherwise, smallholder farmers will continue to waste their effort and resource on the crop that does not pay back. Policies for adaptation to impact of climate change should involve smallholder farmers; this is due to the facts that, they are the ones who are supposed to implement those strategies.

Although adaptation strategies taken by smallholder farmers in Ismani and Pawaga do not differ from those

mentioned by different studies done in different parts of Africa, sub-Saharan Africa and other parts of Tanzania, the problem of low harvest leading to food insecurity is persistent in semi-arid areas of Iringa district. Therefore, there is need for further studies on the effectiveness of those adaptation strategies carried in the semi-arid areas of Iringa district.

Adaptation is one of the policy options for reducing the negative impact of climate change. Therefore, the government and other stakeholders should help smallholder farmers in implementing appropriate and effective adaptation strategies. Investment in large scale irrigation schemes can help smallholder farmers to fight against impact of climate change.

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PAPER THREE

Barriers in Implementation of Climate Change Adaptation Strategies among Smallholder Farmers in Semi-Arid Areas of Iringa District Tanzania

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BARRIERS IN IMPLEMENTATION OF CLIMATE CHANGE ADAPTATION STRATEGIES AMONG SMALLHOLDER FARMERS IN SEMI-ARID AREAS OF IRINGA DISTRICT TANZANIA

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Abstract

Smallholder farmers in semi-arid areas of Iringa District apply various adaptation strategies against impact of climate change. However, these smallholder farmers especially in Ismani Division are frequently receiving food relief from the Government. Ideally, adaptations are expected to reduce adverse impacts of climate change and to enhance beneficial impacts. Continued food relief from the government implies existence of barriers that hinder effective implementation of adaptation strategies. This paper explores barriers that hinder effective implementation of adaptation strategies. Two divisions namely Ismani and Pawaga in Iringa District were purposeful selected based on their climatic conditions. A cross – sectional research design was used. A multistage sampling procedure was employed to select divisions, wards, villages and households. Wards, Villages and household were selected randomly whereby a sample of 240

household respondents was obtained. Quantitative data were collected through a household survey whereas qualitative data were gathered through focus group discussion and key informant interview. Quantitative data were analyzed through descriptive statistics using Statistical Package for Social Sciences (SPSS) while qualitative data were analyzed using content analysis. The results revealed several barriers to smallholder farmers' adaptation strategies. Such barriers were unreliability of information on weather forecast, lack of access to agricultural extension services, and limited access to water for irrigation. Other barriers were lack of financial resources, lack of access to affordable credit institutions, lack of farm assets (plough and tractors), and cost of agricultural inputs. In addition, the results revealed that there were relationship between age, income and barriers to adaptation strategies. Existence of those barriers hinders effective implementation of adaptation strategies in the study area. Government and other stakeholders should facilitate adaptation by enabling farmers to overcome barriers reported in this study.

Key words: Climate change, barriers, adaptation strategies, semi-arid areas, Tanzania

1.0 Introduction

The ongoing changes in global climate conditions are exposing communities to ever increasing risk threatening sources of livelihood especially in developing countries (Hisali *et al.*, 2011). Climate change impacts are being felt today and greater impacts are unavoidable tomorrow (Legesse *et al.*, 2012). Previous studies show that the impact of climate change can be significantly reduced through adaptation strategies (Kurukulasuriya and Mendelsohn, 2006; Seo and Mendelsohn, 2006). However, there are various barriers that impede adaptation strategies, such barriers include; competing priorities that place demand on scarce resources, poverty that limits capacity to adapt, lack of knowledge, weak institutions, degraded natural resources, inadequate infrastructure, insufficient

financial resources, distorted incentives and poor governance (Leary and Kulkarni, 2007; Adger *et al.*, 2007; Deressa *et al.*, 2009). Other barriers are related to technology and culture (Adger *et al.*, 2007). The Intergovernmental Panel on Climate Change (IPCC) in its fifth assessment report categorizes adaptation barriers (constraints) in eight groups: 1)knowledge, awareness, and technology barriers, 2) physical barriers, 3) biological barriers, 4) economic barriers, 5) financial barriers, 6) human resource barriers, 7) social and cultural barriers, 8) governance and institutional barriers (Klean *et al.*, 2014). Barriers like these severely constrain what people can adapt and are observed to adapt against impact of climate change.

The concept of barriers is increasingly used to describe the obstacles that hinder the planning and implementation of climate change adaptation strategies (Eisenak *et al.*, 2014). The IPCC Fifth Assessment Report characterizes adaptation barriers as "factors that make it harder to plan and implement adaptation actions or that restrict options" (Klein *et al.*, 2014). Moser and Ekstrom (2010) define barriers as "obstacles that make adaptation less efficient, less effective or may require changes that lead to higher costs". Generally, barriers to adaptation are defined as challenges, obstacles, constraints or hurdles that impede adaptation. Some scholars (e.g. Adger, 2009; Laube *et al.*, 2012) use the term 'limits' and 'barriers' interchangeably. But more often limits and barriers have different meanings. Barriers are considered surmountable or mutable while limits are seen to be absolute or unsurpassable.

Smallholder farmers in Tanzania including semi-arid areas of Iringa District are adapting to impact of climate change through different adaptation strategies such as planting early maturing maize varieties, planting of drought resistant crops, crop diversification,

agriculture diversification, application of irrigation, involving in casual labour, petty business and local brew (Nelson and Stathers, 2009; Lema and Majule, 2009; Shemsanga *et al.*,2010; Lyimo and Kagalawe, 2010; Mongi *et al.*, 2010; Komba and Mchapondwa, 2012; Kihupi *et al.*, 2015a). Adaptation strategies are expected to improve smallholder farmers' well-being. In spite of all adaptation strategies against impact of climate change carried in semi-arid areas of Iringa District, smallholder farmers especially of Ismani Division experience food insecurity. This situation is partly caused by presence of barriers that hinder effective implementation of adaptation strategies by smallholder farmers in the study area.

Few studies have been done that partly focus on barriers to smallholder farmers' adaptation in Tanzania (Slegers, 2008; Paavola, 2008). However, there is limited evidence that shows specific studies focused on barriers of smallholder farmers' adaptation to adverse impact of climate change in semi-arid areas of Iringa District. According to Matasci *et al.* (2014), policies, programs and measures designed to overcome barriers to adaptation need to be context specific. In view of that, this study explored barriers to adaptation strategies of smallholder farmers in semi-arid areas of Iringa District. It specifically answers the following questions; what are the barriers that hinder effective implementation of adaptation strategies? How do these barriers affect adaptation strategies of smallholder farmers against impact of climate change? And what is the association between barriers to adaptation strategies and socio-economic characteristic of households?

This study is in line with the National Adaptation Programme of Action (NAPA) (URT, 2007), which calls for identification of immediate and urgent climate change adaptation actions for long-term sustainable development. Identification and ensuring of climate

change adaptation on its own right is not enough without addressing the constraints in the practical operationalisation of the adaptation actions. The knowledge from the study will contribute in making adaptation strategies effectively implemented specifically among smallholder farmers through identifying barriers that impede effectively implementation of adaptation strategies.

2.0 Methodology

The study was conducted in Iringa District, Tanzania. The District is one of the four districts of the Iringa Region. Iringa District has six administrative divisions. Two divisions namely Ismani and Pawaga out of the six were selected for the study based on their climatic condition. The area (Ismani and Pawaga) is semi-arid with low mean rainfall ranging from 500 – 600 mm. Temperature in Pawaga Division is over 25 ^{0}C while in Ismani Division it is between 20 and 25 ^{0}C (Mussei *et al.*, 2012).

The rationale for choosing Iringa District for the study is twofold. First, Iringa District was one of the districts in Iringa Region which used to produce surplus maize, Ismani Division being one of the major producers. Currently, the area (especially Ismani and Pawaga divisions) experiences recurrent drought conditions, making it more vulnerable to impact of climate change than other areas in the region. Secondly, like other smallholder farmers in semi-arid areas of Tanzania, smallholder farmers in Pawaga and Ismani divisions use different adaptation strategies against impact of climate change. Adaptation strategies are expected to improve smallholder farmers' well-being as well as their resilience against impact of climate change, but those adaptation strategies seem to be constrained by some factors as substantiated by the fact that smallholder farmers especially in Ismani have been receiving food relief frequently from the Tanzania Government (Kihupi *et al.*, 2015a) even

though they apply different adaptation strategies such as planting early maturing maize varieties, change in planting dates, planting drought resistant crops and crop diversification.

A cross – sectional research design was used for this study. The design was suitable because it allowed collection of data from multiple cases in a single point of time (Babbie, 1990; Bailey, 1998). A multistage sampling procedure was applied to select divisions, wards, villages and then households. This procedure allowed more than one sampling method to be used. Ismani and Pawaga divisions were purposively selected based on their climatic condition (semi-arid). Wards and villages in Ismani and Pawaga divisions were selected randomly. A total of 240 respondents based on of Cochran's formula were drawn randomly so that each individual household had an equal chance of being selected (Cochran, 1977).

Quantitative and qualitative data were collected. Quantitative data were collected through household survey. A tool for this method was a questionnaire. The questionnaire was pre-tested in Lwang'a village, Ismani Division and revised to produce the final questionnaire that was administered to heads of household smallholder farmers. Information on barriers to adaptation against adverse impact of climate change by smallholder farmers was gathered through this method. Qualitative data on barriers to adaptation strategies were gathered through focus group discussion guided by a checklist of question whereby two groups (one of young smallholder farmers 18-40 years and other of more than 40 years) of seven to twelve participants (selected purposeful) per each village were conducted and key informant interview (that included experienced smallholder farmers in terms of years of working in farm and extension agricultural officers) methods. A multiple response, cross

tabulation and correlation was carried out using a Statistical Package for Social Sciences (SPSS) in analysis of quantitative data. Qualitative data were analyzed using content analysis whereby qualitative data coding and conclusions were drawn based on themes of the study.

3.0 Results and Discussions

3.1 Barriers to adaptation strategies

3.1.1Lack of access to affordable credit institution and lack of capital

Lack of capital constrained adaptation strategies in the study area. About 97% of the respondents (Table 1) argued that lack of capital was one of the major constraints to adaptation against adverse impact of climate change. Although the study area had credit institutions like FINCA, PRIDE and SACCOS, 78% of the respondents (Table 1) mentioned lack of access to credit as one of the barriers to adaptation against impact of climate change. During focus group discussion and key informant interviews, it was revealed that most of the credit institutions in the area had high interest rates. One participant made the following comment (which was echoed by most of participants) during the Focus Group Discussion in Nyang'oro village, Ismani Division;

> "*The interest rate is high therefore we are afraid of the risk of our land being confiscated whenever we fail to pay back the loan. There are some villagers whose land has been confiscated as they failed to pay back the loan and now they have no land to cultivate.*"

This implies that having credit institution in the area does not mean access to those credit institutions. Therefore, credit institutions should aim at helping these smallholder farmers by putting interest rate that is affordable. Low interest rate will enable smallholder farmers

involve in different adaptation strategies against adverse impact of climate change such as buying agricultural inputs, farm assets and diversifying their livelihood activities.

Table 1: Barriers to adaptation strategies in semi-arid areas of Iringa District (n = 240)

Barriers	Frequency	Percentage
Lack of capital	233	97.1
Lack of access to affordable credit Institution	188	78.3
Limited of access to water for irrigation	171	71.2
Lack of access to agricultural extension services	156	65.0
Cost of inputs	156	65.0
Lack of farm assets	147	61.2
Unreliability of weather forecast	142	59.2

The findings revealed that, 82% of the respondents (Table 2) who had no access to affordable credit institutions did not practice irrigation farming. This may be due to the fact that, having access to credit institutions can help the respondents in buying pumps and other irrigation facilities especially those who have access to water for irrigation. This means lack of affordable credit institutions impeded use of irrigation as one of the strategies against impact of climate change. The findings also revealed significant relationship between lack of access to affordable credit institutions and involving in petty business adaptation strategy. About 85% of the respondents (Table 2) who had no access

to credit institutions were not involved in petty business. This implies that lack of access to affordable credit institutions impede smallholder farmers to involve in petty business as one of the strategies against impact of climate change. The findings in this study are in line with previous studies (Deressa *et al.*, 2009; Dungumaro and Hyden, 2010; Aquah and Onumah, 2011; Maponya and Mpandeli, 2012). Those studies were done in the Nile basin of Ethiopia, Tanzania, Ghana and South Africa that reported availability of financial resources and access to credit helps smallholder farmers to diversify their livelihood strategies like getting involved in non-farm activities such as, petty business so as to overcome adverse impact of climate change.

3.1.2 Limited access to water for irrigation

Limited access to water for irrigation was mentioned as barrier to adaptation strategies by majority (71%) of the respondents (Table 1). As expected, majority (96%) of the respondents (Table 2) who had limited access to water for irrigation were not involved in irrigation agriculture. This implies that lack of access to water for irrigation hinders the possibility of optimizing irrigation agriculture strategy. Since semi-arid areas of Iringa District experience frequent drought condition and long dry spells during crop growing season, thus water for irrigation could have supplemented inadequate rains. Smallholder farmers also could have made the best use of irrigation agriculture, hence, increasing food security and their income. The findings are similar to those of a study by Acquah and Onumah (2011) in Ghana who argue that lack of access to water for irrigation constrains irrigation which is one of adaptation strategies.

3.1.3 Lack of access to agricultural extension services

The findings revealed that 65% of the respondents (Table 1) observed that lack of access to agricultural extension services affected effective implementation of various adaptation

strategies against impact of climate change. Those adaptation strategies were: planting early maturing maize varieties, planting drought resistant crops, crop diversification, agriculture diversification, change in planting dates and application of fertilizer. It was revealed that 90% of the respondents (Table 2) who had no access to agricultural extension services had not adopted early maturing maize varieties.

Table 2: A Summary of Cross Tabulation results on adaptation strategies and its barriers (n = 240)

Variables	Percentage	X^2	P-value
Lack of access to affordable credit Vs irrigation	82.1	5.138	0.024
Lack of access to affordable credit institution Vs involvement in petty business	85.3	4.321	0.038
Limited access of water for irrigation Vs irrigation	96.5	$1.934*10^2$	0.000
Lack of access to agricultural extension services Vs planting of early maturing maize varieties	90.4	30.465	0.000
Lack of access to agricultural extension services Vs planting of drought resistant crops	90.6	25.19	0.000
Lack of access to agricultural extension services Vs crop diversification	89.8	21.244	0.000
Lack of agricultural extension services Vs agricultural diversification	78.1	6.909	0.009
Lack of agricultural extension services Vs change in planting dates	84.8	15.764	0.000
Lack of agricultural extension services Vs application of fertilizer	76.3	18.404	0.000

It was also revealed that, about 91% of the respondents (Table 2) who had no access to agricultural extension services had not adopted drought resistant crops. Similarly, about 89% of the respondents (Table 2) who had no access to agricultural extension services had not adopted crop diversification as one of the strategies against impact of climate change.

The findings also show that 78% of the respondents (Table 2) who had no access to agricultural extension services had not adopted agricultural diversification (i.e. practising both livestock keeping and crop production) as one of the strategies against impact of climate change. Likewise, about 85% of the respondents (Table 2) who had no access to agricultural extension services had not adopted change in planting date as one of the adaptation strategies against impact of climate change.

It was also revealed that 76% of the respondents (Table 2) who had no access to agricultural extension services had not adopted application of fertilizers as one of the strategies against impact of climate change. It was expected that, farmers with access to extension services will be more likely to adopt different adaptation strategies, since they will have more knowledge of adaptation strategies to address climate change. Therefore, lack of access to agricultural extension services hindered effective implementation of various adaptation strategies against climate change impact. A study by Gbetibouo (2009) along the Limpopo River in South Africa revealed that access to extension services in rural areas increases the likelihood of adopting to different adaptation strategies. Similarly, in their study in Nile Basin of Ethiopia, Deressa *et al.* (2009) revealed that having agricultural extension services increases the likelihood of using different crop varieties and other adaptation strategies against climate change.

3.1.4 Cost of agricultural inputs

Majority (65%) of the respondents (Table 1) reported that high cost of inputs (seeds and fertilizer) hindered adaptations. Although the government of Tanzania subsidizes smallholder farmers through agricultural inputs, majority of smallholder farmers in the study area during focus group discussion said that the cost of inputs was still high. As

such, it was revealed that majority of smallholder farmers do not buy hybrid seeds but use seeds collected from part of previous harvest of early maturing maize variety. This implies that adaptation of hybrid early maturing maize varieties as means to overcome impact of climate change was restrained by the cost of inputs. This could partly be a reason for smallholder farmers in Ismani Division harvesting low yields although most of them claimed to have adopted early maturing maize variety. Based on maize harvested in Ismani 2013, the mean harvest for respondents was 2.5 bags per acre (each bag weighs 115kgs). According to the agricultural extension officer of Uhominyi Village in Ismani Division, farmers who apply fertilizer and plant in time and who use early maturing maize varieties are expected to harvest eleven to twelve bags of maize per acre.

3.1.5 Lack of farm assets (tractors and oxen-driven plough)

About 61% of the respondents (Table 1) viewed lack of ownership of farm assets (such as oxen-driven ploughs and tractors) as an impediment towards adaptation especially with the increasing unpredictability of rainfall in the study area. Usually, smallholder farmers in semi-arid areas of Iringa District observe the onset of rain seasons so as to be sure of harvest (Kihupi *et al.*, 2015a). They start planting immediately after the beginning of rains so as to maximize the shortened growing season (Kihupi *et al.*, 2015b). Due to lack of ownership of farm assets, farmers were forced to sow seeds towards the end of rain seasons when owners of farm assets have finished preparing their fields. This was revealed during focus group discussion and key informant interviews that the wealthier owners of oxen-driven plough prepare their own fields first thus maximizing the shortened rain season for crop production. This implies that those who did not own oxen driven plough or tractor, cultivate their fields late and this can lead to low harvest due to stunt growth or drying of crops before their maturity. Therefore owning oxen-driven plough or tractor is

very important in improving smallholders' ability to adapt against impact of climate change. One participant made the following comment (which was confirmed by most participants) during the focus group discussion in Uhominyi Village in semi-arid areas of Iringa District;

> "*When it rains, owners of oxen driven plough prepare their fields first, then when the rains stop, these owners of plough work in fields of other farmers who do not own oxen driven plough for cash so that they can use the money to hire labour for weeding in their fields. At the end of the day plough owners get good harvest while we non-owners of plough get low or no harvest*".

The above quotation shows that lack of farm assets hindered smallholder farmers from timing the onset of rainy season. In agreement with findings from this study, Hassan and Nhemachena (2008), argue that ownership of farm assets (machinery) improves farmers' ability to adapt.

3.1.6 Unreliability information on weather forecast

Findings from this study show that majority (87%) of the respondents received information on weather forecasts from Tanzania Meteorological Agency (TMA) mainly through media such as radio. However, the findings show further that most of the information received was not reliable as was reported by 59% of the respondents (Table 1). These findings were confirmed during focus group discussions and key informant interviews. One participant made the following comment (which was echoed by most of the participants) during the Focus Group Discussion in Chamdindi Village;

> "*Weather forecast reports can show that there will be enough rain, and in response to such information we plant our traditional maize varieties that require*

plenty of rain, but on the contrary, less rain below average is actually received. Sometimes the weather forecast reports predict that there will be scarcity of rain, but on the contrary, it rains a lot".

From the quotation above it implies that unreliability of weather information makes farmers uncertain about appropriate planting dates and affects their decision as to whether or not they should plant early maturing maize varieties. These findings are similar to those of Okonya *et al.* (2013) who found that most farmers in Uganda had no confidence in the weather forecasts received because they were unreliable. The findings are likewise similar to those of Penaranda *et al.* (2013) who reported that farmers in Kwamankese District, Central Region of Ghana, do not trust weather forecasts reports because they are not reliable. According to Simbarashe (2013), accessibility to climate change information and timely weather forecasts is critical to assist farmers in timing the planting period to coincide with onset of the rains. Therefore, provision of reliable weather forecasts reports will enable farmers to fully exploit seasonal rainfall distribution to improve and stabilize crop yields. In other words, unreliable weather forecast is an obstacle to smallholder farmers in their implementation of adaptation strategies.

3.2 Association of Barriers to Adaptation Strategies and Socio-economic Characteristics of Households

The findings revealed that there was association between socio-economic characteristics of respondents and barriers to adaptation strategies. Those socio-economic characteristics of respondents that showed associations with barriers were age and income of household head. Barriers associated with those socio-economic characteristics of household were farm assets (oxen-driven ploughs and tractors) and cost of inputs.

3.2.1 Age of household head

A Spearman's rho correlation coefficient was computed to assess the relation between age of the household head and ownership of farm assets (level of measurement of age was ratio and farm assets was dichotomous). There was negative correlation between the two variables, ($r = -0.167$, $n = 240$, $p = 0.01$) (Table 3). This means that an increase in years of the household head was correlated with decrease in ability of acquiring farm assets. This implies that as an individual becomes old, the ability to work becomes low as a result he/she cannot acquire farm assets. Therefore lack of farm assets is more likely to be a barrier to older smallholder farmers than younger, energetic smallholder farmers. A Spearman's rho correlation coefficient was also computed to assess the relation between age of the household head and affordance of cost of agricultural inputs. There was no statistical significant association between the two tested variables. This means that age of the household head did not have significant influence on ability of household head to afford cost of agricultural inputs.

3.2.2 Income of head of household

A Spearman's rho correlation coefficient was computed to assess the relation between income of the household head and owning of farm assets. There was a positive correlation between the two variables, ($r = 0.201$, $n = 240$, $p < 0.01$) (Table 3). This means an increase in income of the household head was correlated with increases in ability of the household head to acquire farm assets (e.g. tractor or oxen driven plough).

A Spearman's correlation coefficient was also computed to assess the relation between income of the household head and cost of input. There was also a positive correlation between the two variables, ($r = 0.389$, $n = 240$, $p < 0.001$) (Table 3). This means as income of household head increased, the ability of household to afford cost of agricultural inputs

also increased. This implies that as ones income increases, he/she will be able to own farm assets as well as afford cost of agricultural inputs. This is due to the fact that the wealth of this individual will improve hence, enabling him/her to own tractor or oxen-driven plough as well as afford agricultural inputs in rural areas. In other words, well-off smallholder farmers were less likely to face lack of farm assets and inability to afford cost of agricultural inputs as barriers to adaptation strategies against impact of climate change.

Table 3: Relationship between socio-economic characteristics and barriers to adaptation strategies (n = 240)

			Age of respondent	Education of respondent	Sex of the head of household	Marital status of respondent	Income of respondent per month
Spearman's rho	owning of farm assets	Correlation Coefficient	-.167**	.075	.001	.034	.201**
		Sig. (2-tailed)	.010	.246	.986	.596	.002
		N	240	240	240	240	240
	agricultural inputs	Correlation Coefficient	-.123	.119	.032	.012	.389**
		Sig. (2-tailed)	.057	.065	.626	.849	.000
		N	240	240	240	240	240

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

In agreement with this study, Lyimo and Kagalawes' study (2010) shows that well-off smallholder farmers are able to own tractors and oxen driven ploughs.

3.2.3 Education of household head

A Spearman's rho correlation coefficient was computed to assess the relationship between education of the household head and ownership of farm assets. Although level of

education has influence on adaptation strategies undertaken by individual (Deressa *et al.*, 2010), the findings revealed no statistically significant association between the two variables (Table 3). This means that level of education of the household head did not have a significant influence on ability of the household head to acquire farm assets. A Spearman's rho correlation coefficient was also computed to assess the relation between education of the household head and cost of input. The findings also revealed that there was no statistically significant association between the two variables (Table 3). This means the level of education of the household head did not significantly influence the ability of the household head to afford cost of farm inputs. Therefore, level of education of household head did not have a significant influence on affordability of farm assets or agricultural inputs barriers.

3.2.4 Sex of the household head

A Spearman's rho correlation coefficient was computed to assess the relation between sex of the household head and ownership of farm assets. Although male headed household has high probability of implementing adaptation strategies (Deressa *et al.*, 2010), the findings revealed no statistically significant association between the two variables (Table 3). This means sex of the household had no correlation with ability of the household head to acquire farm assets. This is perhaps contributed by the fact that the majority of respondents (82%) were male. A Spearman's correlation coefficient was also computed to assess the relation between sex of the household head and ability to afford cost of agricultural inputs. The findings revealed no statistically significant association between the two variables (Table 3). This means sex of the household head had no significant correlation with ability of the household head to afford cost of agricultural inputs. Therefore sex of household head had no significant influence on lack of farm assets and on ability to afford agricultural inputs barriers.

3.2.4 Marital Status of the household head

A Spearman's rho correlation coefficient was computed to assess the relation between marital status of the household head and ownership of farm assets. The findings revealed no statistically significant association between the two variables (Table 3). This means marital status of the household head did not significantly influence the ability of the household head to acquire farm assets. A Spearman's rho correlation coefficient was also computed to assess the relation between marital status of the household head and cost of input. The findings revealed no statistically significant association between the two variables (Table 3). This means marital status of the household head did not significantly influence the ability of the household head to afford cost of farm inputs. Therefore marital status of household head had no significant influence on lack of farm assets and inability to afford cost of agricultural inputs barriers.

4.0 Conclusion and Recommendations

Smallholder farmers in semi-arid areas of Iringa District apply various adaptation strategies to overcome the impact of climate change and variability. Such adaptation strategies were planting of early maturing maize varieties, change in planting dates, applications of fertilizer, irrigation agriculture and non-farm income generating activities. But the study found various barriers that hinder those adaptation strategies from being effective. Those barriers were unreliability of weather forecast information, lack of access to agricultural extension services and limited access to water for irrigation. Other barriers were lack of capital, lack of access to affordable credit institutions, lack of farm assets (plough and tractors), and cost of agricultural inputs. Also the findings revealed that there were relationships between socio-economic characteristics of households and barriers to adaptation strategies. Existence of these barriers has impact on effective implementation of adaptation strategies against impact of climate change.

Smallholder farmers should join together to form their own credit institutions such SACCOS and "vikoba". This will help smallholder farmers to have access to affordable credit institutions. Because access to water for irrigation increases farmers' resilience to climate variability and change, then greater investment in irrigation as one of adaptation strategies is needed to overcome impact of climate change. Iringa District council should invest in irrigation schemes as an adaptation strategy to impact of climate change. This will help smallholder farmers to build resilience to impact of climate change. Extension services need to be expanded with highly qualified personnel so as smallholder farmers should have reliable knowledge on adaptation strategies against adverse impact of climate change.

Tanzania Meteorological Agency (TMA) should ensure smallholder farmers receive reliable and up-to-date information about rainfall patterns in forthcoming seasons. This will help smallholder farmers to make well-informed decision on their planting dates. Though the government of Tanzania subsidizes its smallholder farmers, the input cost seems to be unaffordable to many smallholder farmers in semi-arid areas of Iringa District. Therefore, the government should provide the subsidies basing on smallholder farmers' financial situation.

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PAPER FOUR

EFFECTIVENESS OF SMALLHOLDER FARMERS' CLIMATE CHANGE ADAPTATION STRATEGIES IN IMPROVING WELL-BEING IN SEMI-ARID AREAS OF IRINGA DISTRICT

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Abstract

Climate change poses significant challenges to smallholder farmers; therefore their responses towards climate change and variability has an important implication on their well-being. Different adaptation strategies are carried out by smallholder farmers in the semi-arid areas of Iringa District. However, there is inadequate knowledge on their effectiveness in improvement of smallholder farmers' wellbeing. The main objective of this study was to analyze the effectiveness of adaptation strategies adopted by smallholder farmers in the semi-arid areas of Iringa District. Specifically the study answers the following questions: What are the smallholder farmers' adaptation strategies? How effective are the adaptation strategies in improving smallholder farmers' well-being? Ismani and Pawaga divisions of Iringa District were purposefully selected for the study

due to their semi-arid characteristics. The study used a cross-sectional research design. Multistage sampling technique was applied in selection of divisions, wards, villages and households. Wards, villages, and households were selected randomly whereby a sample of 240 respondents was obtained. Quantitative data were collected through household survey and qualitative data through focus group discussion and key informant interview. Quantitative data were analyzed through descriptive and inferential statistics using Statistical Package for Social Sciences (SPSS). Qualitative data were analyzed through content analysis. The findings revealed that some of adaptation strategies against impact of climate change such as change in planting dates, planting early maturing maize varieties, irrigation, application of fertilizer, and involving in petty business were effective against impact on climate change through improvement of smallholder farmers' well-being. The government of Tanzania and other stakeholders should help smallholder farmers by supporting them in those adaptation strategies which were found to be effective in improving smallholder farmers' well-being.

Key words: adaptation, effectiveness, smallholder farmers, well-being, semi-arid areas

1.0 Introduction

1.1 Background Information

Climate change poses significant challenges to households, businesses and governments. Responses from these groups towards climate change and variability have important implications for their well-being (Productivity Commission, 2012). Adaptation strategies to climate change have the potential to reduce adverse impacts of climate change to agriculture and other sectors (Smit and Plifosova, 2001). Adaptation strategies to climate change also help farmers achieve their food, income and livelihood security objectives under extreme weather conditions such as drought and floods (Hassan Nhemachena,

2008). However, it is important to understand which adaptation strategies are effective in reducing negative impact of climate change (Dinshaw *et al.*, 2014). This will help smallholder farmers in prioritizing their scarce resources against impact of climate change basing on the effectiveness of adaptation strategies.

According to Adger *et al.* (2005) effectiveness in adaptation refers to the capacity of an adaptation action to achieve its expressed objectives. Therefore, analyzing effectiveness is important in adaptation because it helps to learn what are the most effective adaptation strategies, under what circumstances and why (PROVIA, 2013). It helps also in making decisions on which adaptation strategies to put more effort on as climate impacts intensify (Spearman and McGray, 2011). Effective adaptation strategies against impact of climate change improve households' well-being, groups, as well as communities. Improved wellbeing through financial, social, and human capital enables smallholder farmers to invest in farm and non-farm production thereby strengthening their capacity to adapt (Dinshaw *et al.*, 2014). Effectiveness of smallholder farmers' adaptation strategies in this study is reflected in the improvement of smallholder farmers' well-being and is measured by a well-being index.

The concept of well-being is difficult to define precisely, in part because people understand well-being differently in different contexts (White, 2009). Chambers (2005) describes well-being as the experience of good quality of life. OECD (2011) argues that most experts and ordinary people around the world would agree that well-being requires meeting various human needs, (some of which are essential) as well as the ability to pursue ones goals to thrive and feel satisfied with their life. In this study well-being refers to food security (in terms of availability throughout the year from individual household), housing condition (in terms of building materials) and income of household and ability to acquire social services such as health, education and water services.

Lobell and Burke (2010) observed that little research has been done to assess the effectiveness of adaptation strategies in recurrent drought condition as a result of climate change/variability. Similar observations have been reported in Tanzania where different studies on adaptation strategies against impact of climate change have been done. For example, Komba and Muchapondwa (2012) did a study on smallholder farmers' adaptation to climate change; Dungumaro and Hyden (2010) study covered challenges and opportunities to climate adaptation. Likewise a study on the cost of climate change, impacts and adaptations was done by Shemsanga *et al.* (2010). Meena and O'Keefe (2007), Lyimo and Kagalawe (2010), and Mongi *et al.* (2010) who studied vulnerability, adaptive strategies/adaptation to impact of climate change and variability. Shemdoe (2010) did a study on indigenous strategies on impact of climate variability on food security and health of subsistence farmers in Tanzania. Nevertheless, little is known about effectiveness of adaptation strategies. As the above studies show, only one of them (Shemdoe, 2010) focused partially on the effectiveness of adaptation strategies against impacts of climate change. Therefore, this study aimed at reducing this gap through assessing the effectiveness of smallholder farmers' adaptation strategies in the semi-arid areas of Iringa District. Specifically this study intended to answer the following questions: What are the smallholder farmers' adaptation strategies? And how effective are these adaptation strategies in improving smallholders' well-being?

The study is in line with Tanzania Climate Change Strategy (URT, 2012). The strategy's goal is to enable Tanzania to effectively adapt to climate change and participate in global effort to mitigate climate change so as to achieve sustainable development. However, sustainable development will not be achieved in a changing climate if the adaptation strategies applied to impact of climate change are not effective. Therefore, this study has added knowledge on effectiveness of adaptation strategies to impact of climate change in agriculture as they are reflected in smallholder farmers' wellbeing.

1.2 Theoretical Framework

Resilience theory is one of the major conceptual tools to deal with change (Scheffer, 2009) at all levels from local to global (Gunderson and Holling, 2001). Resilience theory deals with system dynamics and envisions ecosystems as continuously changing, sometimes abruptly and unpredictably (Berkes and Ross, 2013). Resilience is not only concerned with maintaining the ability to respond to disturbances, but also considers a distinction between incremental adjustments and system transformation (Nelson *et al.*, 2007).Keck and Sakdapolrak (2013) define resilience as "a system's capacity to persist in its current state of functioning while facing disturbance and change to adapt to future challenges and to transform in ways that enhance its functioning". Béné *et al.* (2012), conceptualize resilience as "the ability to deal with adverse changes and shocks".

The resilience theory therefore recognizes the role played by the adaptation strategies in building resilience (well-being) of the social system (smallholder farmers in this case). However the theory is inadequate in addressing the power the adaptation strategies have in contributing to the resilience of the social system. What is seen as a resilient system is a product of positive contributions resulting from implementation of diverse multiple adaptation strategies. Contribution of these adaptation strategies in making a resilient system are nonetheless heterogeneous and with various degrees in terms of their power (effectiveness). The proposed study therefore aims at adding to the resilience theory by disaggregating the adaptation strategies and categorizing them based on their effectiveness in contributing to building the resilience (well-being) of the social system (smallholder farmers).

1.3 Conceptual Framework

The conceptual framework of this paper is presented in Fig. 1 This framework establishes linkages among demographic characteristics as background variables, adaptation strategies

as independent variables and smallholder farmers' wellbeing as dependent variable. Adaptation strategies such as planting early maturing maize varieties, planting of drought resistant crops, crop diversification, agricultural diversification, change in planting dates, application of fertilizers and irrigating crops potentially enhance crop products harvest (Nelson and Stathers, 2009; Shemdoe, 2011). In turn, improved crop harvest contributes to smallholder farmers' well-being in various ways including direct home consumption of the product and selling some of them to buy other necessities, and pay for social services such as health and education services. Other adaptation strategies such as getting involved into petty business, local brew and casual labour are expected to improve smallholder farmers' well-being levels for example by using income obtained to improve crop production, and buy food and meet other necessities. Improvement of farmers' well-being implies that adaptation strategies are effective, and this leads to improvement of capacity to adapt which in turn, increases smallholder farmers' resilience to climate change.

Demographic characteristics have indirect influence on smallholder farmers' well-being; that is, they directly influence the adaptation strategies. For example, age of household head indicates their experience in farming, that is, the older an individual becomes the more experience he/she gains in farming activities hence the more ready power in term of adaptation strategies against impact of climate change (Hassan and Nhemachena, 2008). Marital status of household head can depict the power at the disposal of a household whether that household may adapt certain strategies or not. For example, households which are headed by married head of household are expected to produce more effectively hence be in a higher well-being level due to the fact that couples could be more capable of adapting to impact of climate change than household which were headed by singles. Regarding education, the level of education of household head potentially influences the

well-being due to the fact that more formal education help people to be rational in adapting to various adaptation strategies and effectively (Hassan and Nhemachena, 2008). On the other hand, sex of household head for example, is expected to save as an indicator of wellbeing level of a household and hence a probability of that household to adapt certain strategies such as adapting agricultural technologies and a degree of adapting to climate change impacts (Hassan and Nhemachena, 2008; Deressa *et al.*, 2010; Gatiso, 2015).

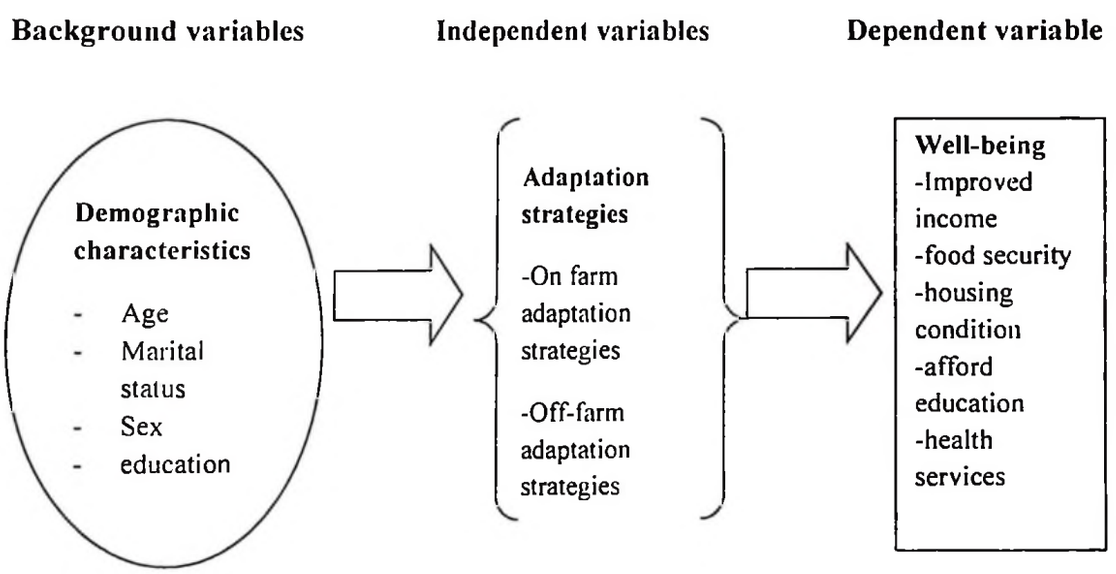

Figure 1: Conceptual framework on relationship between demographic characteristics, adaptation strategies and well-being

2.0 Methodology

2.1 Study Area

The study was conducted in Iringa District, Tanzania. The District is one of the four districts of the Iringa Region. Iringa District has six administrative divisions. Two divisions (Ismani and Pawaga) out of six were selected for the study basing on their climatic condition (semi-arid). Rainfall in Pawaga Division is 500 – 600 mm while in

Ismani Division is below 600 mm. Temperature in Pawaga Division is over 25 ^{0}C and 20 – 25 ^{0}C in Ismani Division (Mussei *et al.*, 2012).Weather condition is the major determinant of agricultural performance in the study area.

The major economic activity in Iringa District is agriculture. Most of the inhabitants in Iringa District are smallholder farmers. About 90% of its population earns their living from agriculture and livestock production (Mkavidanda and Kaswamila, 2001; URT, 2013).

Iringa District was chosen for the study due to the following reasons: First, Iringa District was one of the major maize producing districts in Iringa Region until the early 1970s, but in recent years, the agricultural production has increasingly become low due to unreliable rainfall. Secondly, Iringa District especially in Ismani and Pawaga Divisions experiences recurrent drought conditions. The repeated drought conditions in the two divisions make the area more vulnerable to impact of climate change than other areas in the region. Thirdly, there is inadequate information regarding effectiveness of adaptation strategies against climate change and variability among smallholder farmers in the study area.

2.2 Research Design and Sampling Procedure

The study used a cross – sectional research design. The design was suitable because it involved collection of data from multiple cases in a single point of time (Babbie, 1990; Bailey, 1998). A multistage sampling procedure was applied to select divisions, wards, villages and then households. This procedure allowed more than one sampling method to be used. Two divisions out of six were purposefully selected basing on their semi-arid climatic condition because the area was more vulnerable to impact of climate change than

other areas in the district. A total of four wards were randomly selected from the two divisions. In each selected ward, two villages were randomly selected making a total of eight villages. A total of 240 respondents based on of Cochran's formula were drawn randomly so that each individual household had an equal chance of being selected (Cochran, 1977).

2.3 Data Collection

Both quantitative and qualitative data were collected. Quantitative data were collected through household survey method. A tool for this method was a questionnaire comprised of both open- ended and closed-ended questions which was administered to heads of household smallholder farmers. Information such as demographic characteristics of households, crop diversification, agricultural diversification, and nonfarm activities; were gathered through this method. Qualitative data were gathered through focus group discussion and key informant interview methods. Data collected through these methods were those on well-being indicators, and adaptation strategies. Well-being indicators mentioned by the respondents based on their locally accepted criteria and perception of well-being.

Income of household, housing condition, food security, education, health services and availability of water were the well-being indicators. These indicators were listed and assessed. The categories are as presented in Table 1. Low status of any component scored one while very high status scored four. Those well-being indicators were later incorporated in the questionnaire for the respondents to rank (Table 1). Information was collected for development of well-being index of smallholder farmers' households during focus group discussion.

Table 1: Indicators of well-being for assessing wellbeing of households in semi-arid areas of Iringa Rural District

Well-being Indicators	Level	Assessment	Ranking
Income per month	Below 100,000	Low	1
	100,000 – 199,999	Relatively high	2
	200,000 – 299,999	High	3
	300,000 and above	Very high	4
Status of food security in terms of availability from individual household production	1-3 months	Low	1
	1-6 months	Relatively high	2
	1-9 months	High	3
	Year around	Very high	4
Housing condition based on construction materials	Mud walls + thatched roofing	Low	1
	Brick walls + thatched roofing	Relatively high	2
	Brick/mud walls + iron sheet roofing	High	3
	Brick/mud walls + iron sheet roofing + cement floor	Very high	4
Education in terms of children's level of education	None	Low	1
	Primary school	Relatively high	2
	Secondary school	High	3
	Post secondary school	Very high	4
Water basing on distance to fetch water	Very long distance (above 3hrs)	Low	1
	Long distance (2-3hrs)	Relatively high	2
	Not so long distance (1-2hrs)	High	3
	Short distance (less than 1hr)	Very high	4

Source: These indicators for well-being were developed during focus group discussion.

2.4 Data Analysis

Well-being index was computed using a formula which was developed by Hortland (1993) as cited by Chingonikaya (2010). Ordinal logistic regression model was used in analysis of quantitative data (SPSS). Content analysis was used in analysis of qualitative data.

2.4.1 Well-being Index

The following formula was used for calculating well-being index (WB):

$WB = \sum (y_{ij}/Y_{max})$ (i = 1, 2....x, j = 1, 2 ....n)

y_{ij} = number of an individual indicator for well-being.

Y_{max} = Maximum number of items considered as indicators for well-being (20)

Y = number of items considered as indicators for well-being (5)

n = sample size (240)

2.4.2 Ordinal Logistic Regression Model

Ordinal logistic regression model was used in analysis of the influence of adaptation strategies and demographic characteristics on smallholder farmers' well-being through Statistical Package for Social Sciences (SPSS). The model was chosen because the dependent variable was recorded in terms of ordered levels of wellbeing (low, moderate, high). Ordinal logistic regression is appropriate when the outcome is ordinal variable with more than two categories and it incorporates the ordinal nature of the dependent variable (Agrest and Finlay, 2009).

$$WB = 1/ [1+e^{-(\beta 0 + \beta 1 AGEHH + \beta 2 MARS + \beta 3 SEXHH + \beta 4 EDLHH + \beta 5 EMVAR + \beta 6 DRCROP + \beta 7 CROPDIV + \beta 8 AGRDIV + \beta 9 CHPL + \beta 10 LAB + \beta 11 IRR + \beta 12 FERT + \beta 13 PBUS + \beta 14 LBREW + ei)}]$$

Where;

WB = Well-being (developed index)

AGEHH =Age of head of household in years

MARITAL = Marital status of head of household (0 = single, 1 = married)

SEXHH = Sex of head of household (0= female, 1=male)

EDUHH = Education level of head of household (0=none, 1=adult education, 2=primary education, 3=secondary education, 4=post secondary)

EMVAR = whether a household plant early maturing maize varieties (0 = NO, 1 = YES)

DRCROP = whether a household plant drought resistant crop (0 = NO, 1 = YES)

CROPDIV = whether a household diversify crops in their farms (0 =NO, 1 = YES)

AGRDIV = whether a household diversify agricultural livelihood (0 = NO, 1= YES)

CHPLANT = whether a household changed planting dates (0 =YES 1 = NO)

LABOUR = whether a respondent involve in casual labour (0 = NO, 1 = YES)

IRRIGATE = whether a household apply irrigation agriculture (0 =NO, 1 = YES)

FERTIL = whether a household apply fertilizer in their crops (0 = NO, 1 =YES)

PBUSINES = whether a household involve in petty business (0 =NO, 1 = YES)

LBREW = whether a household involve in local brew (0 = NO, 1 = YES)

β_0 = Intercept

β_{1-14} = Parameters to be estimated

e_i = error term

3.0 Results and Discussion

The overall model fit containing all the predictors was statistically significant, ($P < 0.001$). This indicates that the model gave better predictions of the outcome. Goodness-of-Fit measures have large observed significance levels, 0.997 for Pearson and 1.000 for Deviance; this indicates that the model fits. The Cox and Snell R^2 was 0.524 and

Nagelkerke R^2 was 0.610, implying that independent variables entered in the model explained 52.4% and 61% respectively of the variance in the respondents' well-being (Table 3).

3.1 Adaptation Strategies Influencing Well-being of Smallholder Farmers in Semi-arid Areas of Iringa District

There were several adaptation strategies carried by smallholder farmers in the study area which were: planting early maturing maize varieties, drought resistance crop such as sorghum, changing planting dates, irrigation and application of fertilizer. Other strategies include petty business, casual labour and making local brew (Table 2). The adaptation strategies variables found to influence smallholder farmers' well-being significantly were: planting early maturing maize varieties, planting of drought resistant crops, change in planting dates, irrigation, and application of fertilizer, casual labour and petty business (Table 3). Some of the adaptation strategies (variables) were found to have negative influence while others had positive influence to smallholder farmers' well-being. Adaptation strategies that showed positive influence to smallholder farmers' well-being were; planting early maturing maize varieties, change in planting dates, Irrigation, application of fertilizers, and involving in petty business. This implies that those adaptation strategies were effective to the impact of climate change. Adaptation strategies found to have negative influence to smallholder farmers' well-being means they were weakening smallholder farmers' well-being which implies that they were not effective adaptation strategies to the impact of climate change.

Planting drought resistant crops was one of adaptation strategies used against impact of climate change. Respondents in Ismani who claimed to plant drought resistant crop

(sorghum) accounted for 97.8% (Table 2). No respondent claimed to plant drought resistant crops in Pawaga. During focus group discussion and key informant interview in Pawaga it was revealed that due to unreliability of rainfall and prolonged drought condition, all smallholder farmers depended on irrigation, drawing water from the river Ruaha. Irrigation made them to involve in paddy production since conditions are favourable for paddy production and the paddy was marketable. Therefore, they abandoned sorghum and other drought resistant crops and concentrated on paddy production.

Drought resistant crops had positive coefficient (Table 3). This implies that those who did not plant drought resistant crops were likely to be in higher category of well-being than those who planted drought resistant crop. This is perhaps due the fact that, drought resistant crop (sorghum) had been performing poorly and the production was very low specifically in Ismani Division (Kihupi *et al.*, 2015a). In other words, sorghum cultivation made smallholder farmers use more resources in terms of production cost and yet harvest less. This means planting drought resistant crop such as sorghum is not an effective adaptation strategy and may lead to reduction in smallholder farmers' well-being hence, weakening their resilience to the impact of climate change. These findings are contrary to the findings reported in the study by Nelson and Stathers (2009) which showed that smallholder farmers in Dodoma cultivated drought tolerant crops to overcome food insecurity hence improving their well-being.

Change in planting dates was one of adaptation strategies undertaken against climate change. About 96% of the respondents in Ismani and 3.3% of the respondents in Pawaga changed crop planting dates (Table 2). During focus group discussions, it was revealed

that smallholder farmers used to sow seeds in the soil before rains start, and at the onset of rains those seeds germinate, but nowadays if you plant seeds before rains when rain comes it may not be enough to reach the sown seeds resulting into failure of those seeds to germinate. It was also revealed that the start of rains has shifted from November to mid-December and the end of rain season has shifted from May to April. Therefore, smallholder farmers wait until it starts raining that is when they plant. Change in planting dates was among the adaptation strategies that influenced smallholder farmers' well-being. The negative coefficient (Table 3) implies that the likelihood of those who did not change their planting dates to be in a higher well-being category was less than that of those who changed their planting dates. This is may be due to the fact that the distribution, the start and the end of rains are not reliable. As described above the rain used to start in November but it has shifted to mid-December (Kihupi *et al.*, 2015b). Therefore, for those who did not change their planting dates to match with the changes in onset and end of rain season were more likely to harvest less, hence, they were more likely to be in lower well-being categories. This means change of planting dates is an effective adaptation strategy, because those who changed their planting dates were likely to have good harvest hence improving their well-being and strengthening their resilience to climate change.

Table 2: Smallholder Farmers Adaptation Strategies in Ismani and Pawaga Division (n=240)

	Ismani		Pawaga	
Adaptation strategies	**n**	**%**	**n**	**%**
Drought resistant crop	176	97.8	-	-
Crop diversification	172	95.6	7	11.7
Change in planting dates	172	95.6	2	3.3
Early maturing maize varieties	165	92.7	-	-
Agriculture diversification	148	83.1	26	43.3
Application of fertilizer	99	55.0	2	3.3
Petty business	82	45.6	26	43.3
Casual labour	67	37.2	3	5.0
Making local brew	53	29.4	3	5.0
Irrigation	7	3.9	60	100

Agriculture irrigation was one of the strategies carried out by all respondents in Pawaga Division (100%) while only 3.9% of the respondents in Ismani Division were involved in agriculture irrigation (Table 2). During focus group discussions in Ismani Division it was revealed that there was limited access to water for irrigation while in Pawaga Division there is small Ruaha River. However, the findings revealed that irrigation contributes to smallholder farmers' well-being in semi-arid areas of Iringa District. The negative coefficient (Table 3) implies that the likelihood of smallholder farmers who did not practise irrigation farming to be in higher well-being category was less than that of those who practised irrigation farming. Irrigation can be used to supplement water requirements of a plant in case rains stop before crops maturity or during long drought spells. This made smallholder farmers who practised irrigation farming to be sure of harvest than those who did not. This means irrigation as an adaptation strategy against impact of climate change

is effective and can contribute to the improvement of smallholder farmers' well-being as well as strengthening their resilience to climate change. Tanzania water policy (URT, 2002) states that irrigation provides protection against drought, ensures availability of food reserve and improvement of income. The findings are similar to those of Gbetibouo (2009) in Limpopo Basin South Africa and Deressa *et al.* (2009) in the Nile Basin of Ethiopia which show that irrigation water increases smallholder farmers' resilience to climate change.

Use of fertilizer significantly influenced smallholder farmers' well-being. About 55% of the respondents in Isimani and 3.3% in Pawaga claimed to apply fertilizer in their fields (Table 2). The negative coefficient (Table 3) implies that the possibility of smallholder farmers who did not use fertilizers in their fields to be in a higher well-being category was less than that of those who used fertilizer in their fields. Majority of smallholder farmers in Ismani Division plant hybrid early maturing maize varieties (Kihupi *et al.*, 2015a), which need fertilizer for good harvest. Therefore, those who did not apply fertilizer in their fields were likely to have low maize harvest; hence they are placed in the lower category of wellbeing. This means application of fertilizer is an effective adaptation strategy against the impact of climate change. This is because application of fertilizer leads to good harvest; thus ensuring food security and improvement of household income, hence, improvement of smallholder farmers' well-being.

Casual labour was one of the adaptation strategies against the impact of climate change in the study area whereby 37.2% of the respondents in Ismani and 5% of the respondents in Pawaga were involved in casual labour (Table 2). Casual labour has positive coefficient (Table 3) implying that smallholder farmers who were not involved in casual labour were

more likely to be in a higher well-being category than those who were involved in casual labour. This may be due to the fact that most of casual labour activities in rural areas are available during rainy season. So most of smallholder farmers who were involved in casual labour spent more time in casual labour activities so that they can get money to buy food and other necessities and less time was spent in their fields; they thus consequently end up having low harvest leading to food insecurity status in their households (Kihupi *et al.*, 2015a). This implies that involvement in casual labour as an adaptation strategy against climate change is not effective. This is due the fact that, harvesting little leads to food insecurity, less income and eventually low well-being.

Petty business was another adaptation strategy against the impact of climate change reported by 45.6% and 43.3% of the respondents from Ismani and Pawaga respectively (Table 2). Involving in non-farm activities such as petty business helps in reducing the impact of climate change. In a prolonged drought situation, income obtained from petty business can be used to buy food and other necessities. Income obtained from petty business can also be used in improvement of agricultural production through different adaptation strategies against the impact of climate change. The findings show that petty business had a significant contribution to smallholder farmers' well-being. The negative coefficient (Table 3) implies that smallholder farmers who were not involved in petty business were less likely to be in a higher well-being category than those who were involved in petty business. Petty business helps smallholder farmers to buy agricultural inputs and food supplement in case of food crop failure due to climate change. This means involvement in petty business as an adaptation strategy against the impact of climate change is effective in improvement of smallholder farmers' well-being. These findings are similar to those of Simbarashe (2013) who reported that diversification of livelihood

activities such as petty trading activities widened the smallholder farmers' source of income and thus enhancing their well-being.

Table 3: Ordinal Logistic Regression results on influence of demographic characteristics and adaptation strategies on smallholder farmers' well-being

	Variable	Estimate	Std. Error	Wald	Df	Sig.
Threshold	[WBINDEX = 1]					
	[WBINDEX = 2]	3.289	2.615	1.582	1	.209
Location	AGEHH	.031	.014	5.090	1	.024
	[SEXHH=0]	1.663	.708	5.523	1	.019
	[SEXHH=1]	0[a]	.	.	0	.
	[EMVAR=0]	-1.274	.743	2.942	1	.086
	[EMVAR=1]	0[a]	.	.	0	.
	[DRCROP=0]	4.120	1.078	14.621	1	.000
	[DRCROP=1]	0[a]	.	.	0	.
	[CROPDIV=0]	.412	1.799	.052	1	.819
	[CROPDIV=1]	0[a]			0	
	[AGRDIV=0]	-.257	.377	.466	1	.495
	[AGRDIV=1]	0[a]	.	.	0	.
	[CHPLANT=0]	-1.809	.737	6.028	1	.014
	[CHPLANT=1]	0[a]	.	.	0	.
	[IRRIGATE=0]	-1.424	.839	2.878	1	.090
	[IRRIGATE=1]	0[a]	.	.	0	.
	[FERTIL=0]	-1.186	.379	9.782	1	.002
	[FERTIL=1]	0[a]	.	.	0	.
	[LABOUR=0]	.716	.375	3.649	1	.056
	[LABOUR=1]	0[a]	.	.	0	.
	[PBUSINES=0]	-1.350	.347	15.165	1	.000
	[PBUSINES=1]	0[a]	.	.	0	.
	[LBREW=0]	-.107	.394	.074	1	.785
	[LBREW=1]	0[a]	.	.	0	.
	[EDUHH=0]	-.617	2.035	.092	1	.762
	[EDUHH=1]	.434	2.201	.039	1	.844
	[EDUHH=2]	-1.065	1.965	.294	1	.588
	[EDUHH=3]	.400	2.274	.031	1	.860
	[EDUHH=4]	0[a]	.	.	0	.
	[MARITAL=0]	-2.661	.695	14.640	1	.000
	[MARITAL=1]	0[a]	.	.	0	.

P<0.001; Goodness-of-Fit 0.997 for Pearson and 000 for Deviance; Cox and Snell R^2 was 1. 0.524

Nagelkerke R^2 was 0.610.

The findings show that 92% of the respondents in Ismani (Table 2) plant early maturing maize varieties and abandoned the use of tradition maize varieties which take long to mature so as to cope with shortened growing season while in Pawaga no respondent claimed to plant early maturing maize varieties. During focus group discussion and key informant interview in Pawaga Division, it was revealed that smallholder farmers used to plant maize in the highlands and paddy in the lowlands. Due to prolonged dry spells and improved irrigation scheme, most of smallholder farmers in Pawaga abandoned maize production and concentrated in paddy production. The negative coefficient implies that possibility of smallholder farmers who did not plant early maturing maize varieties in their fields being in a higher well-being category was less than that of those who planted early maturing maize varieties in their fields. This means planting early maturing maize varieties is an effective adaptation strategy against impact of climate change. However, the findings show that planting early maturing maize variety was slightly significant. This may be due to the barriers that affect effective implementation of early maturing maize varieties and this barrier was high cost of agricultural inputs. This was revealed during focus group discussions in Nyang'oro Village, Ismani Division whereby one participant made the following comment (which was confirmed by most participants):

> "*High cost of farm inputs such as fertilize made us unable to buy fertilizer for our fields, this situation contributes to poor harvest because the land is exhausted*".

Agriculture diversification (involvement both in cultivation of crops and keeping livestock) also was reported as one of adaptation strategies which were practised by 83% of the respondents in Ismani and 43.3% in Pawaga (Table 2). However agriculture diversification was statistically not significant in contributing to smallholder farmers' well-being. This is contrary to this study's hypothesis that smallholder farmers who both cultivate crops and keep livestock would be in a good position in overcoming impact of

climate change. It was hypothesized that such smallholder farmers would have been in a higher category of well-being than those who cultivate crops only. This is due to the fact that keeping livestock helped smallholders in case of total crop failure; livestock were sold so that food and other necessities could be bought. Livestock such as cows are also farm assets which can be used in ploughing land using oxen-driven plough thus ensuring maximum utilization of shortened rain season. Also oxen-driven plough can be used to plough other people's fields hence increasing household income.

Crop diversification (planting more than one crop) was among adaptation strategies undertaken by smallholder farmers in Ismani as well as Pawaga Divisions against the impact of climate change. About 96% of the respondents in Ismani and 11.7% in Pawaga (Table 2) adapted crop diversification. The findings show that crop diversification was not statistically significant in the contributing to smallholder farmers' well-being. Therefore, crop diversification is not an effective adaptation strategy against impact of climate change. This study had hypothesized that crop diversification could contribute to smallholder farmers' well-being due to the fact that growing more than one crop is an insurance against total crop failure because different crops have different maturing times and drought tolerance degrees hence reducing risk of complete failure since different crops are affected differently by climate event. But these findings are contrary to the hypothesis; this may be due to prolonged drought condition which made the crop harvested to have insignificant contribution to improvement of smallholder farmers' well-being. As Kihupi *et al.* (2015a) argue, crop diversification adaptation strategy can become less effective when droughts are more widespread and severe.

Making local brew was done by 29.4% of the respondents in Ismani Division and 5% in Pawaga Division (Table 2). During focus group discussions and key informant interview, it was revealed that local brew making increased household income which used to buy

food, pay for children's school fees and other household necessities. However, the findings show that there was no statistically significant contribution of local brew making to smallholder farmers' well-being. This may be due to the fact that local brew making uses maize, so in case of low harvest local brew making may lead to food insecurity and hence this adaptation strategy was found to be ineffective against impact of climate change.

3.2 Demographic factors influencing wellbeing of smallholder farmers in semi-arid areas of Iringa District

Some demographic characteristics, such as age, marital status, sex and education were added to independent variables because they have an indirect influence on household well-being. The demographic variables found to have significant influence were: age of head of household, sex of head of house hold, and marital status of the household head (Table 3).

The positive coefficient in age means that through increase in age by one year, an individual's possibility of being in higher well-being category increases. This means the older an individual becomes the more likely he/she will be in higher category of well-being. This may be due to the fact that the older one becomes the more experienced and knowledgeable he/she becomes on climate change as he/she works in farm. This makes him/her more likely adapt to different adaptation strategies against the impact of climate change. Hence the improvement in yield for food security and household income as well as the well-being of a household. The findings are similar to those of Hassan and Nhemachana (2008) who asserts that experienced farmers usually have better knowledge and information on climate change that they can use to adapt to climate change.

The positive coefficient of sex of head of household (Table 3) means that the possibility of female headed household being in a higher well-being category was greater than that of

the male headed household. This implies that female headed households in semi-arid areas of Iringa District were more likely to be in a better category of well-being than male headed households. This may be due to the fact that women in the study area are responsible for much of agricultural work. The findings are contrary to those of Deressa *et al.* (2009) which indicated that male headed household adapted more readily to climate change, hence their well-being were likely to be in a higher category. On other hand, the findings from this study were similar to the findings reported in the study by Nhemachena and Hassan (2007) in Southern Africa (South Africa, Zambia and Zimbabwe), which indicated that women were more likely to adapt because they were responsible for much of the agricultural work. Women also had greater experience and access to information on various management and farming practices (Nhemachena and Hassan, 2007).

Marital status of the respondents had negative coefficient, this means that the possibility of single headed household (not married, separated, divorced, widow/widower) to be in a higher well-being category was less than that of married headed household. This may be due to the fact that married people may create a synergy which means more knowledge on adaptation strategies as well as more resources and capability of adapting to climate change through different adaptation strategies. This synergy may make them produce more than their peer in single headed households. This phenomenon may make married people be placed in a higher well-being category than single headed households.

Contribution of ~~the study~~ this paper to body of knowledge

Mitchell and Harris (2012) define resilience as the "ability to resist, recover from, or adapt to the effects of a shock or a change". Resilience in social ecological system is important to their ability to adapt to climate change (Tompkins and Adger, 2004). Adaptation on the

other hand strengthens resilience of the community to the impact of climate change (Nelson *et al.*, 2007). However, adaptation strategies do not contribute uniformly towards strengthening the resilience in response to the impact of climate change; this means that adaptation strategies should be disaggregated and ranked basing on their effectiveness. Though some studies have been done (Molua, 2002; Shemdoe, 2011; Gatiso, 2015) on the effectiveness of smallholder farmers' adaptation strategies, such studies have had a narrow focus on food security alone. This study has broadened the scope by encompassing the well-being perspective (a multiple of indicator).

4.0 Conclusion and Recommendation

The study has revealed various adaptation strategies carried by smallholder farmers against the impact of climate change in Ismani and Pawaga divisions. Those adaptation strategies were planting early maturing maize varieties, drought resistant crop such as sorghum, changing planting dates, irrigation and application of fertilizer. Other strategies include petty business, casual labour and local brew making.

Some demographic variables were found to have significant influence on smallholder farmers' well-being. Those demographic characteristics of household head were; age, sex and marital status, and adaptation strategies carried out by smallholder farmers. Similarly some adaptation strategies were found to be statistically significant and to have positive influence on smallholder farmers' well-being. Those adaptation strategies were; planting early maturing maize varieties, change in planting dates, use of irrigation, use of fertilizer, and getting involved into petty business. This means that adaptation strategies which had positive influence on smallholder farmers' well-being are the ones which are effective against the impact of climate change. The most effective adaptation strategies against

impact of climate change were; change in planting dates followed by irrigation and getting involved into petty business.

However, adaptation strategies carried out by majority in Ismani Division such as crop diversification, and agriculture diversification were found to be insignificant contributors to smallholder farmers' well-being. Planting drought resistant crops although practiced by majority of respondents in Ismani division, it had negative influence on smallholder farmers' well-being. This implies that adaptation strategies carried out by majority in Ismani division were not effective. This situation can lower smallholder farmers' well-being in Ismani, hence, their resilience to climate change. Pawaga Division, in contrast to Ismani, had only one major adaptation strategy (agriculture irrigation) carried out by all respondents and it had significant contribution to smallholder farmers' well-being.

The government of Tanzania and other stakeholders should help smallholder farmers by supporting them in those adaptation strategies which seem to have positive influence on smallholder farmers' well-being. Specifically, the Ministry of Water and Irrigation together with the Ministry of Agriculture, Livestock and Fisheries should establish irrigation schemes in Ismani and other semi-arid areas through construction of water reservoirs for collection of rain water for irrigation. The ministries also should look for possibilities of exploring underground water for irrigation agriculture. This will enable smallholder farmers in Ismani and other semi-arid/arid areas to improve their food security as well as income through selling agricultural products obtained through irrigation as indicated in the case of Pawaga Division. Supporting smallholder farmers through adaptation strategies which proved to be effective to the impact of climate change will

improve their well-being and strengthen their ability to adapt to a changing climate, hence, building their resilience to the current and future climate change impacts.

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CHAPTER THREE

3.0 SUMMARY OF MAJOR FINDINGS, CONCLUSION AND RECOMMENDATIONS

3.1 Summary of the major findings and Conclusion

3.1.1 Smallholder farmers' perceptions towards climate change

The first objective of this study assessed smallholder farmers' perceptions towards climate change. The study has established that smallholder farmers perceived that the climate is changing and it is getting worse over time. There is a concern that the temperature is increasing and rainfall is unreliable and unpredictable; the onset and end of rain have changed leading to significant shortening of the crop growing season. Dry spells have also increased resulting into poor germination and drying of crops before reaching a maturity stage. This sometimes led to re-planting crops thus increasing cost of production to smallholder farmers. Smallholder farmers' perceptions on climate change are likely to be influenced by other factors such as availability of water for irrigation, soil fertility, and information from media on climate change. In agreement with smallholder farmers, the meteorological data trends (from Nduli station in Iringa District) for temperature, rainfall, onset and cessation of rain, growing seasons, number of wet days and probability of occurrence of dry spells provide evidence that climate of semi-arid areas in Iringa District is changing. Change in rainfall pattern and temperature pattern have significant impacts on smallholder farmers whose livelihood depends on rain fed farming. Therefore smallholder farmers need to adapt to the changing climate so as to sustain and improve their livelihood.

Division were responding to impact of climate change using various adaptation strategies such as crop diversification, use of early maturing maize varieties, planting drought resistant crops, changing planting dates, and diversification of agriculture. Other strategies are involvement in petty business, casual labour and making local brew. Smallholder farmers in Pawaga Division respond to impact of climate change through mainly three adaptation strategies, those were; irrigation, diversification of agriculture, and petty business. Among those adaptation strategies, irrigation seemed to the major because it was practised by the entire population in Pawaga Division.

In spite of those adaptation strategies carried in Ismani Division, smallholder farmers in Ismani were the ones who mostly received government food aid due to crop failure as a result of drought. This implies that either those adaptation strategies were not effective and/or there were barriers that impede effective implementation of adaptation strategies.

3.1.3 Barriers to smallholder farmers' adaptation strategies

The third specific objective of this study explored barriers to smallholder farmers' adaptation strategies. Though smallholder farmers in semi-arid areas of Iringa District apply various adaptation strategies to overcome the impact of climate change and variability, the study has revealed various barriers that hinder those adaptation strategies from being effective. Those barriers were unreliability of weather forecast information, lack of agricultural extension services and limited access of water for irrigation. Other barriers are lack of capital, inaccess to affordable credit institutions, lack of farm assets (plough and tractors), and cost of agricultural inputs. Existence of these barriers has impact on effective implementation of adaptation strategies against the impact of climate change.

3.1.4 Effectiveness of adaptation strategies as reflected in smallholder farmers' well-being

The fourth specific objective of this study examined the effectiveness of adaptation strategies as reflected in smallholder farmers' well-being. Despite the fact that the study revealed several adaptation strategies carried out by smallholder farmers against the impact of climate change in Ismani and Pawaga divisions; only a few of them were found to have significant influence on smallholder farmers' well-being. Those adaptation strategies were planting of drought resistant crops, change in planting dates, planting early maturing maize varieties, irrigation practices, use of fertilizer, involvement in casual labour activities, and petty business. Some of these adaptation strategies seem to have positive influence on smallholder farmers' well-being, which means they were effective adaptation strategies to the impact of climate change.

The study concluded that only adaptation strategies that had positive influence on smallholder farmers' well-being were the ones which were effective to the impact of climate change in the study area. Those adaptation strategies which proved to be effective to impact of climate change were; planting early maturing maize varieties, change in planting dates, use of irrigation, use of fertilizer, and getting involved into petty business.

3.2 Recommendations

In the view of the above conclusions, it is recommended that there is a need for development of appropriate adaptation strategies to climate change as perceived by smallholder farmers in the semi-arid areas of Iringa District. This can be achieved by encouraging and supporting smallholder farmers to use their indigenous knowledge in combination with scientific/expert-based innovations to enhance adaptation to the impact

of climate change. Joint action among researchers, extension officers, smallholder farmers and policy makers will enable development of adaptations strategies which are more efficient and effective in addressing the impact of climate change.

Smallholder farmers should join together to form their own credit institutions such SACCOS and "vikoba". This will help smallholder farmers to have access to affordable credit institutions. Because access to water for irrigation increases farmers' resilience to climate variability and change, then greater investment in irrigation as one of adaptation strategies is needed to overcome impact of climate change. Iringa District council should invest in irrigation schemes as an adaptation strategy to impact of climate change. This will help smallholder farmers to build resilience to impact of climate change. Extension services need to be expanded with highly qualified personnel so as smallholder farmers should have reliable knowledge on adaptation strategies against adverse impact of climate change.

Furthermore, Tanzania Meteorological Agency (TMA) should ensure that smallholder farmers receive reliable and up-to-date information about rainfall patterns in succeeding seasons. This will enable smallholder farmers to make well-informed decision on their planting dates. Though the Government of Tanzania subsidizes its smallholder farmers, still the input cost seems unaffordable to many smallholder farmers in the semi-arid areas of Iringa District. Therefore the Government should provide subsidies basing on smallholder farmers' financial situation.

Lastly, the Government of Tanzania and other stakeholders should help smallholder farmers by supporting them in those adaptation strategies which are found to be effective

against the impact of climate change. Specifically, the Ministry of Water and Irrigation together with the Ministry of Agriculture, Livestock and Fisheries should establish irrigation schemes in Ismani and other semi-arid areas through construction of water reservoirs for collection of water runoff from rains and/or drilling underground water. This will enable smallholder farmers in Ismani Division improve their food security status as well as income through selling agricultural products obtained through irrigation as is the case for Pawaga Division. Supporting smallholder farmers through effective adaptation strategies will improve their well-being and strengthen their ability to adapt to changing climate, hence, building their resilience to the current and future impacts of climate change.

3.3 Recommended Areas for Further Studies

The study recommends the following areas for further studies:

i. It was revealed by this study that agriculture diversification (involving in both crop cultivation and livestock keeping) was not a statistically significant effective adaptation strategy to the impact of climate change. Further studies on effectiveness of adaptation strategies against impact of climate change should find out why this adaptation strategy is not significant which contrary to other studies done on adaptation strategies.

ii. The study also focused on effectiveness of smallholder farmers' adaptation strategies. This is not enough because adaptation strategies may be effective but not efficient. Adaptation strategies are efficient only if the implementation cost is less than the resulting benefits. Therefore, this study recommends further studies on efficiency of those adaptation strategies carried by smallholder farmers.

3.4 Contributions to Knowledge

3.4.1 Policy implication

The study revealed that, cultivation of sorghum is being enforced by local government through by-laws that required every individual household in Ismani Division to plant two acres of sorghum. Failure to do so a household is supposed to pay 50000 Tanzanian shillings as a fine. However, the crop has been performing badly and the harvest very low. Among other factors, smallholder farmers in Ismani division have not been putting more effort in production of sorghum compared to maize. Most of smallholder farmers in Ismani Division normally cultivate sorghum after cultivation of maize when the planting season is almost over. Policies to promote adaptation to the impact of climate change and risks should rely on the cooperation of the intended beneficiaries at their own will. If these beneficiaries disagree with policy makers about the need for that adaptation strategy, and force is being applied to undertake a certain adaptation strategy, then implementation of such policies are likely to fail. That is the case with sorghum in Ismani Division. This could be avoided if the Government would give farmers various options through discussing with them.

The study has established several adaptation strategies carried by smallholder farmers in the study area. Most of these adaptation strategies are autonomous adaptations, however, only a few of them proved to be effective against the impact of climate change. Therefore, policy makers when planning for adaptation strategies should put more emphasis on those adaptation strategies which have empirically proved to be effective against impacts of climate change.

3.4.2 Theoretical implications

The resilience theory recognizes the role played by the adaptation strategies in building resilience (well-being) of the social system (smallholder farmers in this case). However

the theory is inadequate in addressing the power the adaptation strategies have in contributing to the resilience of the social system. The study added to the resilience theory by disaggregating the adaptation strategies and categorizing them basing on their effectiveness in building the resilience (well-being) of the social system (smallholder farmers). This is due to the fact that the resilience of a system is a function of positive influence from multiple adaptation strategies whose effectiveness, nonetheless, are inequitable. Therefore by disaggregating them basing on their effectiveness, it is possible in the light of scarce and competitive resources to rank them on their importance and hence enable the efficient use of resources.

APPENDICES

Appendix 1: Questionnaire for Household Survey

Introduction

This study is carried out to assess the effectiveness of smallholder farmers' adaptation strategies against the impact of climate change carried out in semi-arid areas of Iringa District in improvement of their wellbeing. The findings will be used for academic purposes only at the Sokoine University of Agriculture. Your household has been selected to represent other households in this village. The information you will provide will only be used for the above purpose, and will remain confidential. Your cooperation is highly appreciated.

1. Household identification:

   Village..... Ward..... Division.....

2. Household Biodata

Respondent	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Sex (HH)								
Age								
Education level								
Marital status								
Main Occupation								
Work on farm								
Other								

Sex of household head: 0= female, 1 = male

Age:

Education level: 1 = none, 2 = primary, 3 = secondary, 4 = post secondary, 5 = adult education

Marital status: 1 = single, 2 = married, 3 = separated, 4 = divorced, 5 = widow/widower

Main occupation: 1 = Farmer, 2 = civil servant, 3 = self employed, 4 = housework, 5 = sick/old, 6 = other.

Work on farm: 1 = fulltime, 2 = part time, 3 = none

3. Perception of climate change

Variables	Strongly disagree 5	Disagree 4	Undecided 3	Agree 4	Strongly agree 5
There is increase in temperature					
There is extremely high temperature during summer					
There is extreme cold temperature during winter					
Precipitation has decreased					
There is change in timings of rains					
Frequencies of drought have increased					
It rains in patches within the same village					
It rains much in short time periods leaving other months dry					
There is increase in malaria					
There is increase in pests and crop diseases					

4. Put a tick (v)on adaptations to impact of climate change you are applying

Adaptation strategies	
Early maturing maize varieties	
Drought resistance crops	
Crop diversifications	
Agriculture diversifications	
Change in planting dates	
Moving to a different site	
Change from farming to non farming activities	
Increased use of irrigation	
Changed use of chemicals and fertilizers	
Increased use of soil and water conservation techniques	
Shading and sheltering/ tree planting	
Casual labour	
Involving in non agriculture activities	
Other	
No adaptation	

5. Rank the status of household wellbeing (indicators) after application of adaptation strategies you pointed in question 4 above

Indicator	**Rank**
Income (write exactly amount)	
Food availability	
Number of meals per day	
Clean water	
Housing	
Education	
Health	

Income per month	Food availability	Status of food security based on number of meals taken per day.	Housing condition based on construction materials
1 = low (below 100,000)	1 = 1-3 months	1 = not sure	1 = mud walls + thatched roofing
2 = relatively high (100, 000 – 199,000)	2 = 3- 6 months	2 = one meal	2 = brick walls + thatched roofing
3 = high (200,000-299,000)	3 = 6-9 months	3 = two meals	3 = brick/mud walls + iron sheet roofing
4 = very high (300,000 +)	4 = year round	4 = three meals	4 = brick/mud walls + iron sheet roofing + cement floor.

Distance to reach Clean water (minutes taken)	Education in terms of children level of education	Health in terms of affordability of services
1 = very long	1 = none	1 = cannot afford
2 = long	2 = primary school	2 = cannot easily afford
3 = not so long	3 = secondary school	3 = can afford
4 = short distance	4 = post secondary	4 = can easily afford

6. How many acres did you cultivate crops this year?
7. How many bags of maize/ paddy did you harvest per acre?
8. How many bags of sorghum did you harvest per acre?
9. How many bags of sunflower did you harvest per acre?
10. How many cows/goats/chickens/pigs/ducks/donkeys do you have?

Barriers to adaptation strategies

11. Do you get weather forecast information? 1=YES 2=NO
12. If yes in question 11 above, are the weather information obtained reliable? 1=YES 2=NO
13. If no in question 11 above, does the unreliability have any impact on crop cultivation 1=YES 2=NO
14. If yes in question 13 above, how?
15. If yes in question 11 above where do you get this weather forecast information?
16. Do you have access to agricultural extension services? 1=YES 2=NO
17. If no in question 13 above why?

18. Do you have access to water for irrigation? 1=YES 2=NO
19. If no in question 15 above why?
20. Do you think lack of capital/financial resources can hinder implementation of adaptation strategies? 1=YES 2=NO
21. If yes in question 17 above why?
22. Do you have any credit institution in your area? 1=YES 2=NO
23. If yes in question 19 above mention them 1..... 2..... 3.....
24. If yes in question 19 above, do have access in those credit institution above? 1=YES 2=NO
25. If no in question 21 above give reason(s)
26. Do you think cost of agricultural inputs can hinder adaptation strategies? 1=YES 2=NO
27. If yes in question 23 above explain how?
28. Do think lack of farm assets such as tractors and oxen-driven plough can hinder adaptation strategies to the impact of climate change? 1=YES 2=NO
29. If yes in question 25 above how?
30. Do you have any suggestion in relation to impact of climate change?

Appendix 2: Guide questions for Focus Group Discussion and Key Informant Interview

1. Name of Division
2. Name of Ward
3. Name of Village
4. Do you get weather forecast information?
5. Do you experience any changes in climate?
6. Are those changes having impacts on smallholder farmers' in your area?
7. What are measures taken to overcome those impacts?
8. Are those measures taken to overcome impacts of climate change effective?
9. Are there any barriers in implementation of measures to overcome impacts of climate change?
10. What are indicators for well-being in your area?

Appendix 3: Kivukoni Journal notification on having received paper for publication

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Date: 30 April 2016

In reply please quote: KJ/04/2015/9

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Dar es Salaam

Ref: **Your Paper on The Barriers in implementation of Climate Change Adoptation Strategies Among Smallholder Famers in Semi-Arid Areas of Iringa District in Tanzania.**

The heading above is concerned

The chief editor of Kivukoni Journal is hereby notifying you to have been received your paper titled: "**Barriers in implementation of Climate Change Adaptation Strategies Among Smallholder Famers in Semi-Arid Areas of Iringa District in Tanzania**" to be considered for publication in our third (3rd) volume, issue number one (1).

Your paper will undergo peer review by the Kivukoni Journal (KJ) Editorial Board. After the peer review you will immediately be informed of the Editorial Board decision.

Thank you.

Secretariat (KJ)