ASSESSMENT OF CLIMATE CHANGE IMPACTS ON FOOD SECURITY AND ADAPTATION STRATEGIES AMONG SMALLHOLDER FARMERS IN SALIMA DISTRICT, MALAWI

BEN TWINOMUGISHA BUSIZORI

A THESIS SUBMITTED IN FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF ARTS IN GEOGRAPHY OF THE OPEN UNIVERSITY OF TANZANIA

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CERTIFICATION

The undersigned certifies that he has read and hereby recommends for acceptance by the Open University of Tanzania a thesis titled; Assessment of Climate Change Impacts on Food Security and Adaptation Strategies Among Smallholder Farmers in Salima District, Malawi in fulfillment of the requirements for the degree of Master of Arts in Geography M.A. (Geography) of the Open University of Tanzania.

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Date

DEDICATION

Dedicated to the Smallholder farmers in Sub-Saharan Africa who brave unpredictable seasonal changes

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ABSTRACT

Climate change is rated the greatest threat to smallholder farmers and their food security in the 21st century. This study assessed the impact of climate change on food security and adaptation strategies among smallholder farmers in Salima district, Malawi. The research design is descriptive and review in nature that deployed a case study survey with a mixed approach of both qualitative and quantitative research methods. Data collection method included Survey Questionnaire to 183 respondents, Key Informants Interviews, Focused Group Discussions as well as literature review. Meteorological data for 50 years was analysed to underpin farmers' perceptions on climate change. Findings reveal a felt slight increase in temperature. Rainfall seasonality changes (inter annual and intra variation) are suspected to lead to more frequent and intensified droughts and floods that affect four pillars of food security i.e. food availability, access, utilization and stability. Perceived climate change risks are based on smallholder farmers' experience and knowledge of their local farming system. Majority of smallholder farmers depend on subsistence farming that is rain fed and vulnerable to seasonality changes. It was found out that farmers are taking adaptation measures to ensure food security. Adaptation measures include indigenous knowledge based on past experiences and adoption of modern and climate smart agriculture technologies. However, there are some limiting factors and apparent constraints in incremental and transformational adaptation strategies due limited livelihoods-based capitals, knowledge and skills of climate smart agriculture. There is a need for reforming agriculture extension services provided by government. Integration of climate smart agriculture in policy linkages to smallholder farmers is required.

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LIST OF ABBREVIATIONS

AGW	Anthropological Global Warming
CCA	Climate Change Adaptation
CPCs	Civil Protection Committes
CDM	Clean Development Mechanism, Kyoto Protocol
CO2	Carbon dioxide, the most important greenhouse gas
CBA	Community Based Adaptation
COP	Conference of the Parties, annual summit of UNFCCC
DDRMP	District Disaster Risk Management Plans and or Contingency Plans
DFID	Department for International Development (UK)
ENSO	El Niño Southern Oscillation
EU	European Union
FAO	Food and Agriculture Organization (United Nations)
FGD	Focus Group Discussion
GCF	Global Climate Facility
GDP	Gross Domestic Product
GCM	General Circulation Model
GEF	Global Environment Facility
GHGs	Greenhouse Gases (mainly CO2, N2O, and methane)
GM	Gender Mainstreaming
GPS	Global Positioning System
GVH	Group Village Headman
HYVs	High Yield Varieties (crops), also hybrid seeds
IPCC	Intergovernmental Panel on Climate Change

KAP	Knowledge Attitude and Practice
KII	Key Informants' Interviews
LDCs	Least Developed Countries
LDF	Local Development Fund
MDRRP	Malawi Disaster Recovery and Resilience Project
MFERP	Malawi Floods Emergence Recovery Project
MGDS	Malawi Growth and Development Strategy
NAPA	National Adaptation Programme on Action
NCCIP	National Climate Change Investment Plan
NCCMP	National Climate Change Management Policy
NEAP	National Environmental Action Plan (2002)
NEP	National Environment Policy (2005)
NGO	Non-Government Organizations
OUT	Open University of Tanzania
SDGs	Sustainable Development Goals
SHFs	Small Holder Farmers
SLF	Sustainable Livelihoods Framework
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
USAID	United States Agency for International Development
VCPC	Village Civil Protection Committes
WB	World Bank

CHAPTER ONE

INTRODUCTION

1.1 Background to the Research Problem

Climate change is one of the greatest threats facing humanity in the 21st century. As worldwide patterns of temperature, precipitation and weather events change, the delicate balance of climate and life is disrupted, with serious impacts on food and agriculture (Kareem, 2016). According to the IPCC special report of 2018, the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways indicates that human activities are estimated to have caused approximately 1.0°C of global warming above pre-industrial levels, with a likely range of 0.8°C to 1.2°C.

The report further reveals that global warming is likely to reach 1.5°C between 2030 and 2052 if it continues to increase at the current rate. This reflects the long-term warming trend since pre-industrial times, observed Global Mean Surface Temperature (GMST) for the decade 2006–2015 was 0.87°C (likely between 0.75°C and 0.99°C) higher than the average over the 1850–1900 period (very high confidence). Estimated anthropogenic global warming matches the level of observed warming to within ±20% (likely range).

Estimated anthropogenic global warming is currently increasing at 0.2°C (likely between 0.1°C and 0.3°C) per decade due to past and ongoing emissions (high confidence). Warming greater than the global annual average is being experienced in many land regions and seasons, including two to three times higher in the Arctic. Warming is generally higher over land than over the ocean (high confidence). Trends

in intensity and frequency of some climate and weather extremes have been detected over time spans during which about 0.5°C of global warming occurred (medium confidence). This assessment is based on several lines of evidence, including attribution studies for changes in extremes since 1950 (IPCC, 2018).

There is continuous rise in average temperature, extreme weather occurrence, occurrence of drought and floods, intensity and frequency of storms, change in precipitation, and so many other identified and unidentified effects (IPCC, 2007). Understanding how climate is changing in space and time has been gained through improvements and extensions of numerous datasets and data analyses, broader geographical coverage, better understanding of uncertainties and a wider variety of measurements. The Intergovernmental Panel on Climate Change (IPCC) fifth assessment report of the 2013 presents clear and robust conclusions in a global assessment of climate change science. The report confirms that warming in the climate system is unequivocal, with many of the observed changes unprecedented over decades to millennia: warming of the atmosphere and the ocean, diminishing snow and ice, rising sea levels and increasing concentrations of greenhouse gases. Each of the last three decades has been successively warmer at the Earth's surface than any preceding decade since 1850 (IPCC, 2013).

The period from 1983 to 2012 was the warmest 30-year period of the last 1400 years in the Northern Hemisphere, where such assessment is possible (medium confidence). Over the period 1992 to 2011, the Greenland and Antarctic ice sheets have been losing mass (high confidence), likely at a larger rate over 2002 to 2011. Glaciers have continued to shrink almost worldwide (high confidence). The

frequency of heat waves has increased in large parts of Europe, Asia and Australia (IPCC, 2014). A reduction in precipitation is determined over Northern Africa and the southwestern parts of South Africa. Projected rainfall changes over sub-Saharan Africa in the mid- and late 21st century is uncertain. In regions of high or complex topography such as the Ethiopian Highlands, downscaled projections indicate likely increases in rainfall and extreme rainfall by the end of the 21st century. Near surface temperatures have increased by 0.5°C or more during the last 50 to 100 years over most parts of Africa, with minimum temperatures warming more rapidly than maximum temperatures (IPCC, 2014).

Malawi has a high risk of climatic and hydrological hazards such as droughts, storms, floods and associated landslides. Since the 1970s, the country has experienced significant variations in weather patterns, ranging from severe drought (1978-79, 1981-82, 1991/92, 2004/05) conditions to extreme flood events (1996/97, 2000/2001, 2002/2003) and strong winds. More than 40% of disasters in Malawi have been caused by severe floods, including those experienced in 1942, 1946, 1956 and 1991, with the latest disasters occurring in 1997, 2001/2 and 2003 (GoM, 2016). Increased temperatures of 0.9°C between 1960 and 2006 were observed, an average rate of 0.21°C per decade. Evaporation has increased in line with temperature increases. Longer term trends in precipitation are more difficult to discern given the nature of the underlying variability (Simelton *et al*. 2013).

Temperature in Malawi averaged 21.45 Celsius from 1850 until 2015, reaching an all-time high of 26.17 Celsius in November of 1957 and a record low of 15.83 Celsius in July of 1907 (Trading Economics, 2015). With temperature change, there

is observed drying trend in annual rainfall, particularly since the early 2000s. Between 1981 and 2016 there were areas of moderate drying in parts of northern and southern Malawi. In contrast, very small wetting trends occurred in the central part of Malawi. Very wet years occurred in 1989 and 1997 and dry years in 1992, 2005 (driest on record) and 2008. Precipitation in Malawi averaged 88.89 mm from 1901 until 2015, reaching an all-time high of 368.62 mm in February of 1952 and a record low of 0 mm in August of 1978.

Moreover, future projections show that temperature increase is projected throughout Malawi; there is 90% chance that mean annual maximum temperature will exceed 10C in the south of the country; and a 90% chance that the mean annual maximum temperature increase will be less than 2.4-2.60C. As with statistical downscaling, dynamical downscaling therefore also shows an increase in mean annual maximum temperature throughout Malawi (Katharine *et al*. 2014). For developing countries like Malawi, climate change complicates existing challenges of poverty eradication (Hassan, 2010) and the realization of Sustainable Development Goals (UN, 2017). Left unaddressed climate change contains the potential to reverse progress on development and to compromise the wellbeing of the current and future generations (World Bank2010b, p.37).

Smallholder farmers make significant contribution towards food in security Sub-Saharan Africa producing up to 85 per cent of the food (IFAD, 2013 and AGRA, 2014). In Malawi, for example, smallholder agriculture accounts for about 85 per cent of agricultural production and over 75 per cent of employment (Salami *et al*. 2010). Malawi is an agrarian-based economy and therefore largely dependent on its

environmental and natural resource for economic development and poverty reduction. Over 80% of the country's 16 million population are smallholder farmers and an estimated half of the population live in extreme poverty of less than $1.90 per day, with 60-80% of the population experiencing food insecurity in at least one month of the year (World Bank, 2016).

On the other hand, smallholder farmers and poor farmers lack assets, social networks, mobility, and political power, commonly cited as being critical for adaptation to climate change (Tanner *et al*. 2008). Despite the incidences of high risk of climatic hazards on food security in Malawi, there is no adequate or specific research on the small holder farmers (GoM, 2016). To be effective global and national efforts need to be aligned with local realities and focused on how policy can support the adaptative capacities and resilience of vulnerable smallholder farmers and communities' (Adger, 2003. p.193).

1.2 Statement of the Research Problem

Climate change is one of the greatest threats facing humanity in the 21st century. As worldwide patterns of temperature, precipitation and weather events change, the delicate balance of climate and life is disrupted, with serious impacts on food and agriculture (Kareem, 2016). The IPCC 2018 special report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways indicates that human activities are estimated to have caused approximately 1.0°C of global warming above pre-industrial levels (IPCC, 2018). Malawi is highly food insecure as a nation, for example 1.9 million people (9.5% of the population) were food insecure in 2013/2014 (WFP, 2014). Just under a quarter

of Malawi's population was considered 'undernourished' in 2010-2012. The Government of Malawi declared a state of disaster in April 2016. At least 6.5 million people (or 39 percent of the population) in Malawi were not be able to meet their food requirements during the 2016/17 consumption period due the drought and flooding, according to Malawi Vulnerability Assessment Committee Report on food security (GoM, 2016).

In Malawi scenario, it is observed that climate change adaptation has gained much power amongst government and development agencies. However, there is limited harmonization of understanding how affected communities especially smallholder farmers define their own experience. The major gap is that farmers are yet to substantively link with climate change adaptation policy interventions in food security system. Given the repeated and increasing climate change induced extreme drought and flood events that affect Malawi, it is essential to assess specific impact on the small holder farmers' food security systems and determine how they adapt and can connect to institutional structures and policy instruments. Improved knowledge of small holder farmers' food security situation amidst climate change impact is needed to contribute to the designing of appropriate adaptation strategies.

1.3 Research Objectives

The main objective of this study is to assess climate change impacts on food security and adaptation strategies among small holder farmers in Salima district, Malawi. Specific Objectives include:

i. To examine seasonality changes in rainfall and temperature trends overtime in the past 50 years as evidence of climate change in Salima District.

ii. To assess the impact of climate change on food security elements among smallholder farmers in Salima district.
iii. To assess adaptation practices by small holder farmers in response to the impacts of climate change on food security in Salima District;
iv. To examine barriers to small holder farmers' ability to adapt to climate change adverse impacts on food security in Salima district.

1.4 Research Questions

More specifically, the following research questions were considered:

i. What are the seasonality changes in rainfall and temperature trends overtime in past 50 years as evidence of climate change in Malawi, Salima District?
ii. What are the impacts of climate change on food production and accessibility among smallholder farmers in Salima district?
iii. What are the adaptation practices among small holder farmers in response to the impacts of climate change on food security in Salima District?
iv. What are the barriers to small holder farmers' ability to adapt to climate change adverse impacts on food security in Salima district?

1.5 Significance of the Study

This study's significance is articulated in its topicality and relevance. Climate change impacts on food security among small holder farmers are dynamic and interact in complex ways. Within the context of this study, understanding smallholder farmers' perceptions, vulnerability and adaptation is current and important since climate change poses significant challenge to already existing

problems of poverty and development (Adger *et al*. 2003). For as long as climate change is occurring, and more challenges are anticipated with significant vulnerability of agriculture or food security systems, gaining deeper understanding of the subject is timely and critical across communities, space, and disciplines.

For least developed countries such as Malawi, climate related research is crucial for practical and theoretical reasons. The resilience of smallholder farmers is more important than ever where there is a need to maintain the food security threatened seasonality change. In this era of climate change, the shocks that poor rural people face are multiplying. Smallholder farmers, particularly young people, may leave their communities and migrate to urban areas or abroad in search of elusive work opportunities, thus compromising food security (IFAD, 2017). It is therefore hoped that the result of this study will be valuable to the climate change adaptation and food security practitioners, researchers as well as academia, contributing to knowledge for developing better practices and policies that address challenges in climate change adaptation in food security system at household level.

Although this study is not generating a new theory on climate change, it generally works on contributing and improving what already exists. Theoretically, the study pays attention to Transformational Adaptation Theory which is initially applied in Global Climate Facility. Transformational adaptation occurs when fundamentally new and innovative responses are required—typically upon realizing that historic approaches are insufficient for current or anticipated climate risks. (IPCC, 2017). Transformational adaptation is recommended as a useful approach to understand and categorize the nature of response to climate change risks, or potential to provide

practical tools for more effective adaptation. Transformation Theory can be characterized and articulated in forms that can facilitate scientific dialogue, empirical testing and application of concepts and theories and, ultimately, theoretical development (Feola2014).

This study can contribute knowledge to key themes, with a focus on the small holder farmers practice implications, as a starting point for exploring what is required to move transformation from an attractive concept to something more tangible and policy-relevant. In principle, this study will make an important theoretical contribution by simply adding evidence or factors to the transformational adaptation theory as it indicates how climate change impacts on food security and the adaptation strategies among small holder farmers. The study contributes to the debate on the domestication of the Sustainable Development Goals (SDGs) 2 and 13. Goal 2 seeks sustainable solutions to end hunger in all its forms by 2030 and to achieve food security while Goal 13 calls for urgent action not only to combat climate change and its impacts, but also to build resilience of farmers in responding to climate-related hazards and natural disasters (UN, 2015).

As part of SDGs follow-up and review mechanisms, Malawi and other countries are required to conduct regular and inclusive reviews of progress at the national and sub-national levels, for which findings of this study can be significant. In terms of response measures to climate change, the scope of the study is confined to adaptation rather than mitigation of climate change. The reason to prioritise adaptation as important and urgent policy imperative and research agenda rests with the fact that mitigation efforts to reduce greenhouse gases will take time and are often fraught

with complicated and protracted international negotiations. The lack of progress on reducing emissions through policy has frustrated policy makers in developing countries (Schipper, 2004, p.11).

This study recommends appropriate measures for the improvement of food security among smallholder farmers amidst climate change challenge. Moreover, assessment of adaptation options is important for building resilience of small holder farmers' households as a unit of the socio-economic and geographical spatial system. The contributions of this study would be of interest to scholars in climate change as well as to practicing managers, particularly in the development and food security practice and policy development. Development practice and policy studies on climate change in the field of food security are few, to which this study would be significant. This study also contributes literature to the exiting one in the field of climate change.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter provides a review of some of the key literature on the impacts of climate change on food security and smallholder farmers' adaptation strategies. The literature review part also looked at different methodologies that researchers have employed in their various studies. The objective of this review was to unearth what has already been done around climate change implications for food security among smallholder farmers, and to identify gaps that this study addressed. The review also helped to identify key variables that have been documented to reduce vulnerability and enhance adaptation among smallholder farmers. Therefore, this study reviewed secondary data on climate change causes, impacts on agriculture and vulnerability of food security system among smallholder farming households.

In the first section of this chapter, conceptual definitions of key teams are underscored; the theory and climate variations are reviewed and cited. Other sections revisit the literature concerning climate change impact on agriculture and food security as a rising problem in terms of declining productivity levels. The next section reviews the literature on climate change and food security policy. The literature review presented is based on research related to the area selected for study. Review of secondary data has helped this study to collate the major issues and the state of evidence by its theme.

2.2 Defining and Conceptualizing Key Terms

2.2.1Climate Change

The word Climate Change in the Intergovernmental Panel on Climate Change (IPCC) usage refers to a change in the state of the climate that can be identified (e.g. using statistical tests) by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer. It refers to any change in climate over time, whether due to natural variability or because of human activity (IPCC, 2007).

The above definition usage differs from that in the United Nations Framework Convention on Climate Change (UNFCCC). The UNFCCC thus makes a distinction between climate change attributable to human activities altering the atmospheric composition, and climate variability attributable to natural causes. Article 1 of UNFCCC defines climate change as: 'a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods (UNFCCC, 1992).

Environment Protection Agency (EPA) of United States of America defines climate change as significant changes in the measures of climate lasting for an extended period, including temperature, precipitation, or wind patterns that occur over several decades or longer in each geographic area. EPA observes that the Earth's climate is changing. Temperatures are rising, snow and rainfall patterns are shifting, and more extreme climate events – like heavy rainstorms and record high temperatures – are already happening. Many of these observed changes are linked to the rising levels of

carbon dioxide and other greenhouse gases in our atmosphere, caused by human activities (EPA, 2014). This study adopted the definition provided in IPCC 2007 report since it rhymes with the theoretical framework of this study, the Anthropogenic Global Warming (AGW) theory that contends that emissions of greenhouse gases by human activities are causing a catastrophic rise in global temperatures.

2.2.2 Climate Change Impacts

Climate change impacts are the consequences of climate change – both expected and realised for natural and human systems. Adverse impacts of climate change mean alteration in the physical environment or biota resulting from climate change which have significant deleterious effects on the composition, resilience or productivity of natural and managed ecosystems or on the operation of socio-economic systems or on human health and welfare (UN, 1992). The Third Assessment Report (TAR) of the IPCC identified a range of impacts associated with climate Change and variability, including decreases in grain yields; changes in runoff and water availability in the Mediterranean and southern countries of Africa; increased stresses resulting from increased droughts and floods; and significant plant and animal species extinctions and associated livelihood impacts. Such factors were shown, moreover, to be aggravated by low adaptive capacity (IPCC, 2001).

Climate change impacts exert a significant control on the day-to-day economic development of Africa, particularly for the agricultural and water-resources sectors, at regional, local and household scales. Since the TAR, observed temperatures have indicated a greater warming trend since the 1960s. Although these trends seem to be

consistent over the continent, the changes are not always uniform. For instance, decadal warming rates of 0.29°C in the African tropical forests and 0.1 to 0.3°C in South Africa have been observed (Kruger *et al*. 2004).

In South Africa and Ethiopia, minimum temperatures have increased slightly faster than maximum or mean temperatures (Conway *et al*. 2004). Between 1961 and 2000, there was an increase in the number of warm spells over southern and western Africa, and a decrease in the number of extremely cold days (New *et al*. 2006). For precipitation, the situation is more complicated. Rainfall exhibits notable spatial and temporal variability (Hulme *et al*. 2005). Warming of the climate system is unequivocal, as outlined in the IPCC 4th Assessment Report and that without significant changes in policy, the trend in global emissions of greenhouse gases and associated climate change impacts will continue (IPCC, 2007).

2.2.3 Climate Change Vulnerability

Climate Change Vulnerability is defined as the extent to which a natural or social system is susceptible to sustaining damage from climate change. Vulnerability is a function of the sensitivity of a system to changes in climate and the ability to adapt to system to changes in climate. Under this framework, a highly vulnerable system would be one that is highly sensitive to modest changes in climate (IPCC, 1997) The ordinary use of the word ‘vulnerability’ refers to the capacity to be wounded, that is the degree to which a system is likely to experience harm due to exposure to a hazard (We Adapt, 2011). The scientific use of ‘vulnerability’ has its roots in geography and natural hazards research, but this term is now a central concept in a

variety of research contexts such as natural hazards and disaster management, ecology, public health, poverty and development, secure livelihoods and famine, sustainability science, land change, and climate impacts and adaptation (IPCC, 2007).

2.2.4 Food Security

The concept of food security has many definitions. At the time of the global food crises of the 1970s, the concept of food security originated primarily focusing on supply side particularly food availability and this was only at international and national level. In the first food summit, the World Food Conference that took place in Rome in 1974, food security was defined as availability always of adequate world food supplies of basic food stuffs to sustain the steady expansion of food consumption and to offset fluctuations in production and prices (UN, 1975). The definition of food security was later revised as it become apparent that the success of the green revolution did not necessarily see improvement in food security for all.

The World Food Summit of 1996 considered a definition that involved food security not only at national level but at household and individual level, it was defined as: when all people at all times have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life (FAO, 1996). This definition put the emphasis not only on supply side but also on demand side, consumption and on the access both physically and economically. The UN food and agriculture organization (FAO) redefined the concept further to include social access to food in their State of food insecurity 2001 document. Four dimensions of food security have been deduced from the definition

above, these are availability, access, the utilization of food and stability of both availability and access to food. Availability of food: For food security to be attained food must be available in sufficient quantities and be of appropriate quality. According to the Unites States Development Agency USDA (2006) such food can be supplied through household production, other domestic output, commercial imports, or food assistance. Food availability refers to the existence of sufficient quantities of food with appropriate quality and supplied through domestic production or import. Food availability is probably most frequently used as a measure of food security and it has a channel with climate change which directly affects food security (Thompson *et al*. 2010).

2.2.5 Climate Change Adaptation

The Intergovernmental Panel on Climate Change Working Group II defined; Adaptation as adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. Various types of adaptation were distinguished, including anticipatory, autonomous and planned adaptation: Anticipatory adaptation takes place before impacts of climate change are observed. Also, referred to as proactive adaptation. Autonomous adaptation – Adaptation that does not constitute a conscious response to climatic stimuli but is triggered by ecological changes in natural systems and by market or welfare changes in human systems. Also, referred to as spontaneous adaptation.

Planned adaptation – Adaptation that is the result of a deliberate policy decision, based on an awareness that conditions have changed or are about to change and that

action is required to return to, maintain, or achieve a desired state. (IPCC, 2007). Adaptive capacity (in relation to climate change impacts) is the ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences. Both autonomous and planned adaptation may require additional outside support in terms of financing, knowledge and technology, including guidance on how to assess who and what needs to adapt and how-to do it. For this reason, there are a raft of adaptation policies, plans and projects, which are supposed to facilitate the move towards adaptation at all levels — from local to national. Adaptation planning involves the full spectrum of activities from identifying and assessing to implementing adaptation measures and is informed by the assessment of impacts and vulnerability (Schipper, 2010)

The most consistent observation among smallholder farmers is that Africa is experiencing increased temperature and decreased rainfall across all its agro-ecological zones. In response to their perceived climatic risks, smallholder farmers are using both short-term and long-term strategies, with the former mainly consisting of coping mechanisms against climate chocks. In addition, the adaptation strategies implemented by the farmers are influenced by agro-ecological conditions, which shape their farming systems and institutional settings including proximity to a major city and markets (Sika *et al*. 2017).

This study notes that although many researchers have identified different types of adaptation and presented several concepts and frameworks to describe them, most of the literature on adaptation largely focuses on providing policy guidance. Yet

adaptation needs to be a multidisciplinary approach to both policy, practice and action to the vulnerable communities. Thus, meanings of the term may differ by policy and in practice. Therefore, adaptation to climate change must not only consider response to climate change through policy but also consider the adaptation action in practice.

2.2.6 Farmers

There is no single definition of small farms and smallholder farmers. However, there are common characteristic that define smallholder farmers. Smallholder farmers are highly subsistent and characterized by low levels of input and low output levels (Kondwani *et al*. 2013*)*. According to (Rebecca *et al*. 2008), small holder famers are sometimes marginal farmers who are 'farming yet hungry' and characterised smallholder farmers as people for whom farming is a major livelihood activity yet have insufficient assets to produce a surplus from their agricultural activities and; whose non-farm activities are insufficiently reliable or remunerative for them to rely on market purchases for adequate food intake. Concluded by asserting that smallholder farmers are vastly a group that is distant from centres of power and influence and has long suffered neglect by policy makers.

In fact, Nagayets (2005, p.1) cited in Chamberlin (2008, p.1) pointed out that the sole consensus on small farms may be the lack of a sole definition. The simplest and conventional meaning of a smallholder is the case when the land available for a farmer is very limited (Chamberlin, 2008, p.3 and Hazell *et al*. 2007, p.1). However, the meaning goes far beyond this conventional definition and consists of some general characteristics that the so-called small farms or smallholders generally

exhibit. Chamberlin has identified four themes based on which smallholders can be differentiated from others. These themes include landholding size, wealth, market orientation, and level of vulnerability to risk (Chamberlin, 2008). Despite smallholder farmers being considered subsistent, they are the backbone of agricultural production in developing countries. Four-fifths of the developing world's food is a product of small-sized farms. Small, family-run farms are also home to most people living in absolute poverty, and half of the world's undernourished people (Fan *et al*. 2013).

In this study's findings, smallholder farmers comprise of families with small farms that rely mainly on family labor. According to this study's findings smallholder farmers' land tenure was mainly (79%) customary with indicators of limited land accessibility and availability. Other observed indicators of a farmer in the category of smallholder included owning small plots of land on which they grow subsistence crops especially maize that is stable food and cash crop and one or two cash crops relying largely on family labour. In conclusion, the smallholder farmer may or may not exhibit all the proportions of being smallholders simultaneously. In different countries, they are variously described as family farmers, subsistence farmers, poor farmers and peasant farmers. Smallholder farming is characterised by small farm size, low technology and low capitalization.

2.3 Theoretical Literature Review

2.3.1 Introduction

This part of literature review chapter intends to give a theoretical framework for this study. The word "theory" is defined as: an idea or set of ideas that is intended to

explain something about life or the world, especially an idea that has not been proved to be true; general principles and ideas about a subject; an idea or opinion that someone thinks is true but for which they have no proof (Summers, 2003).

Theory is a model or framework for observation and understanding, which shapes both what we see and how we see it. What is expected from a theory is a model capable of predicting future occurrences or observations, being tested through experiment or otherwise verified through empirical observation (Kawulich, 2009). Therefore, application of theory is to allow this research to make links between the abstract and the concrete; the theoretical and the empirical; thought statements and observational statements.

In this research climate change is a generalized statement that asserts a connection between smallholder famers and food security phenomena. Therefore, this study discusses different theories of climate change and how they relate to the topic that is; “assessment of climate change impacts on food security and adaptation strategies among small holder farmers in Malawi”. The discussion of climate change theories is based on the reviewed studies that have tried to classify the effect of climate change and their implication on food security among smallholder farmers and the struggle to adapt as changes in temperatures and precipitation have a potential to affect the food production given that agriculture in Malawi vastly depends on the mercy of nature. It is noted that agricultural loses can result from climate variability and the increased frequency of extreme events such as droughts and floods or changes in precipitation and temperature (IPCC, 2014).

2.3.2 Anthropogenic Global Warming Theory

The Anthropogenic Global Warming (AGW) is the first and widely accepted theory of climate change that this research will dwell on. AGW theory contends that emissions of greenhouse gases, principally carbon dioxide (CO2), methane, and nitrous oxide, are causing a catastrophic rise in global temperatures. The mechanism whereby this happens is called the enhanced greenhouse effect (NASA, 2012). According to the AGW theory, the history of scientific discovery of climate change began in the early 19th century when ice ages and other natural changes in paleoclimate were first suspected and the natural greenhouse effect first identified. In the late 19th century, scientists first argued that human made emissions of greenhouse gases could change the climate. Many other theories of climate change were advanced, involving forces from volcanism to solar variation. In the 1960s, the warming effect of human made carbon dioxide gas became increasingly convincing (Neumann, 1985).

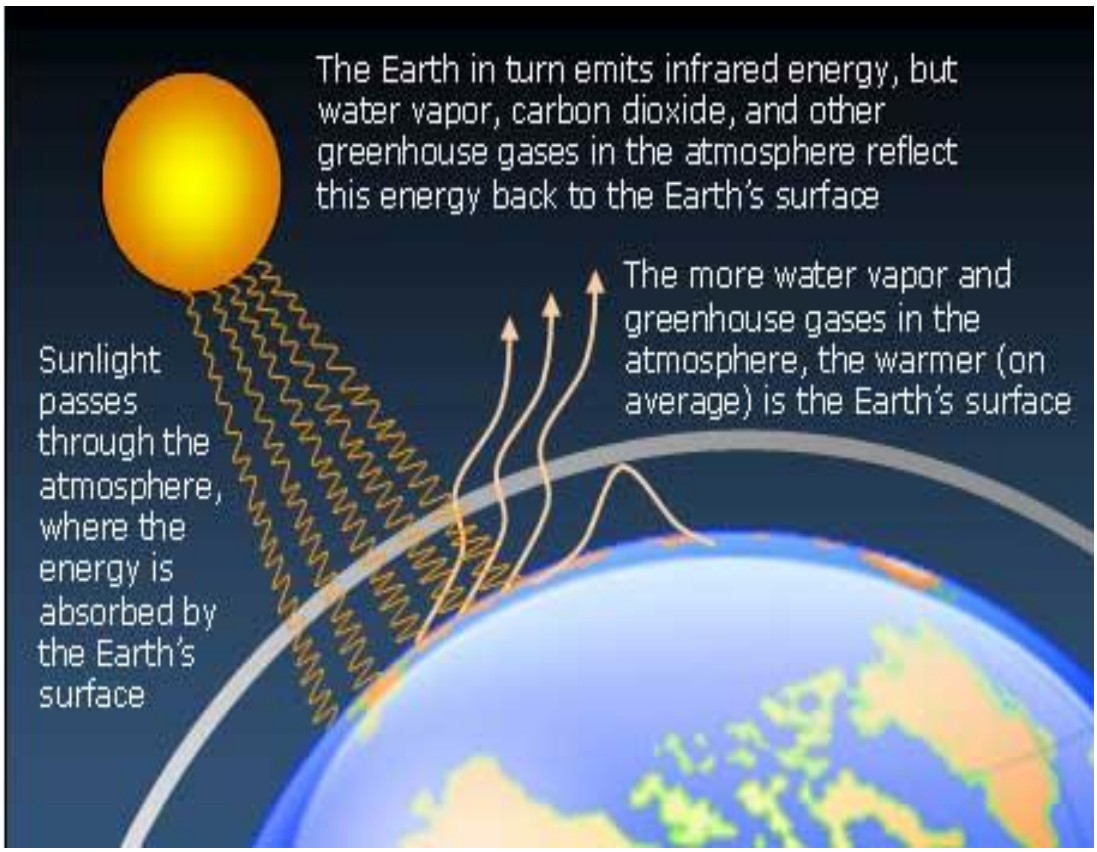


Figure 2.1: The Greenhouse Effect

Source: NASA 2012

AGW theory of climate change as the most familiar among scientist holds that man-made greenhouse gases are the predominant cause of the global warming that occurred during the past 50 years (Green, 2007). In its Fifth Assessment Report, the IPCC concluded that there's a more than 95 percent probability that human activities over the past 50 years have warmed our planet. The industrial activities that our modern civilization depends upon have raised atmospheric carbon dioxide levels from 280 parts per million to 400 parts per million in the last 150 years. The IPCC also concluded that human-produced greenhouse gases such as carbon dioxide, methane and nitrous oxide have caused much of the observed increase in Earth's temperatures over the past 50 years (IPCC, 2014).

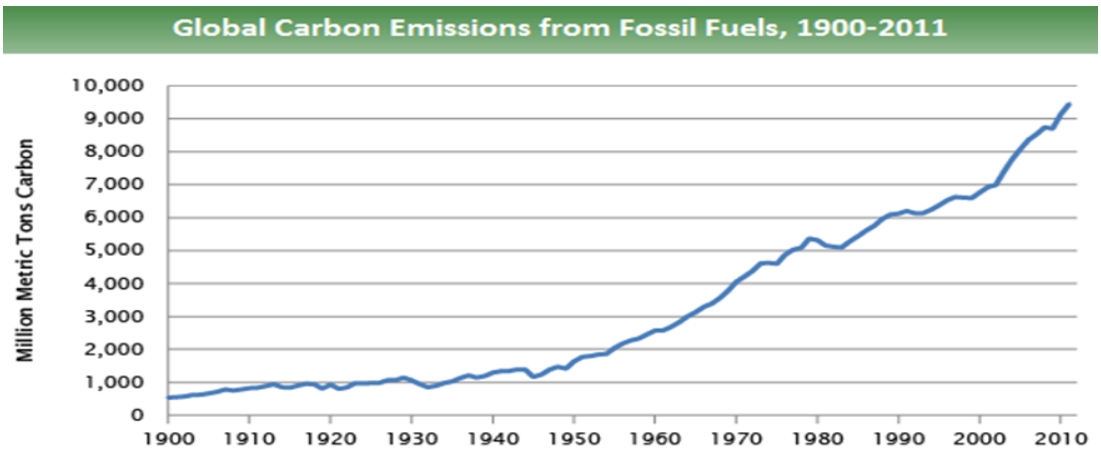


Figure 2.2: Global Carbon Emissions from Fossil Fuels

Source: Boden *et al*. (2015).

Global carbon emissions from fossil fuels have significantly increased since 1900. Since 1970, CO2 emissions have increased by about 90%, with emissions from fossil fuel combustion and industrial processes contributing about 78% of the total greenhouse gas emissions increase from 1970 to 2011. Agriculture, deforestation, and other land-use changes have been the second-largest contributors. Emissions of non-CO2 greenhouse gases have also increased significantly since 1900 (EPA, 2012).

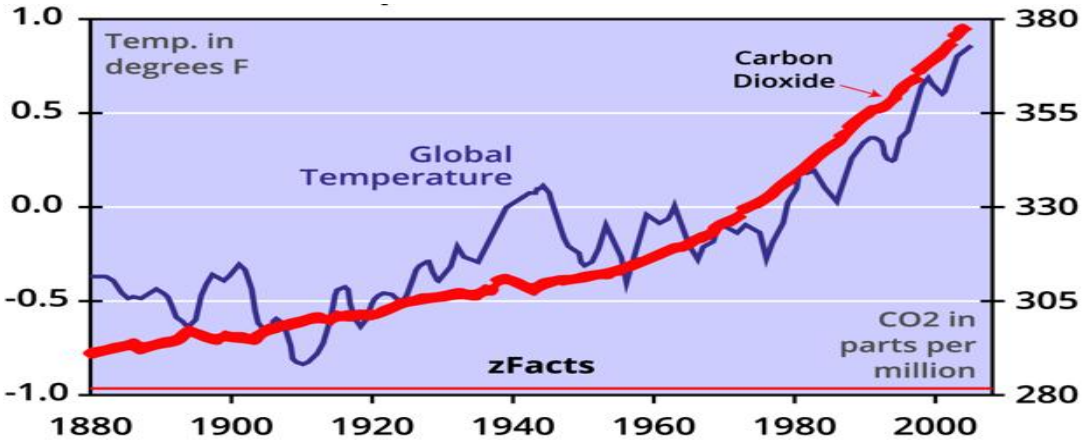


Figure 2.3: Global Temperature and Carbon Dioxide

Source*:* USA National Centers for Environmental Information (2017).

Despite vital consensus on the AGW theory, disagreement exists on the two major causes of climate change: anthropogenic and natural factors. Proponents of the former, on one hand, believe that increasing human activities such as uses of fossil fuels, unsustainable agriculture, deforestation and forest fires have added millions of tons of greenhouse gases such as carbon dioxide, methane, and nitrous oxide, that are responsible for the global warming (Antilla, 2005; Watson *et al*.2006; Mwandosya, 2006; IPCC2007; UNFCCC2008). Opponents, on the other hand, believe that the global warning has nothing to do with human activities; rather it is a result of natural changes that have occurred on earth over a long period (Kaser *et al*. 2004; CSPP, 2005; Schmundt2006). On these debates, Mooney (2005) showed that analysis of more than 900 recent scientific articles listed with the keywords "global climate change," has failed to find a single study that explicitly disagreed that humans are contributing to climate change.

The AGW theory is put into action through the 2015 UNFCCC Paris Agreement which is contained in the Paris Decision, the formal decision of the United Nations Convention on Climate Change Conference of parties adopting the Paris Agreement and mapping out a process towards the climate change agreement's formal entry into force. The Paris Agreement formalizes consensus on climate change phenomena because of man-made greenhouse gases and sets an ambitious goal to hold global warming to "well below 2°C" and to pursue efforts to limit the temperature increase to 1.5°C above preindustrial levels (UNFCCC, 2015).

This research agrees with the proponents of the AGW theory who believe that man-made CO2 is responsible for floods, droughts, severe weather, crop failures, spread

of diseases, famines, and literally hundreds of other catastrophes. All these disasters will become more frequent and more severe as temperatures continue to rise as AGW proponents agree. Nothing less than large and rapid reductions in human emissions and adaptation to existing climate change adverse impact will save the smallholder farming households and entire planet from these catastrophic events (Al Gore, 2006).

2.3.3 Adaptation Theory

The theory of adaptation to climate change implies change from the current to an adapted situation. This change can occur in different ways: gradual and incremental, through a transition or in the form of a transformation. Rainfall variability and uncertainty surrounding its annual reliability have prompted farming communities to adapt to dynamic climatic, environmental and weather conditions throughout history. The future of smallholder farming household is about adaptation since weather is expected to exacerbate current climate variability, leading to more intense cycles of floods, droughts and unpredictable rains. Moreover, the speed of current climate change is feared to exceed the limits of adaptation in many parts of the world (Adger and Vincent, 2005; IPCC, 2007b).

The theory of adaptation is becoming increasingly important in climate negotiations and implementation. Integral to IPCC (2014) are two theoretical core concepts of; Incremental and Transformational adaptation referred to as a “paradigm shift” in the Green Climate Fund Governing Instrument (GCF, 2013). Incremental Adaptation concept refers to actions where the central aim is to maintain the essence and integrity of the existing technological, institutional, governance, and value systems,

such as through adjustments to cropping systems via new varieties, changing planting times, or using more efficient irrigation. While transformational adaptation seeks to change the fundamental attributes of systems in response to actual or expected climate and its effects, often at a scale and ambition greater than incremental activities.

Transformational theory includes changes in activities, such as changing livelihoods and changes in perceptions and paradigms about the nature of climate change, adaptation, and their relationship to other natural and human systems (IPCC, 2014 Sections 3.3, 8.6.2.3, 20.5; Climate Fund, 2013b). The climate change AGW and adaption theoretical tools form the basis of this study. Although they have been elaborated upon, it is important to relate them under the subject of study which is about assessment of climate change impact on food security and adaptation strategies among smallholder farmers. Transformational theory of adaptation is more relevant to this study since it means a paradigm shift away from practices that are incompatible with the present challenges of climate change to smallholder farmers.

The study by (Pauw *et al*. 2010) suggested that smallholder farmers in Malawi are the most affected by climate change shocks. For example, Jury and Mwafulirwa (2002) reported that failure of the rains for over one month in the 1992 drought reduced maize output by 50 percent and this resulted in food insecurity. Considering the scale of the climate change challenge to food security and the growing influence of adaptation theory, interests mean that transformation is both especially likely and desired. Transformational adaptation in and of agriculture was recently recognized as a priority by IPCC (2014) and is an emerging field of research (Walker *et al*. 2009;

Park *et al*. 2012).

Smallholder farmers who are usually using indigenous knowledge and rudimentary tools need to transform to catch up with the speed and intensity of climate change. There is an urgent need for governments, donors and practitioners to ramp up efforts to help smallholder farmers cope with existing climate impacts and build resilience to future changes. Transformational adaptation will be more important to highlight the importance of tailoring climate adaptation policies and programs to the diverse socioeconomic conditions, biophysical contexts, and climatic stresses that smallholder farmers face. Transformational adaptation is key on how different types of smallholder farmers vary in their perceptions and responses to climate change, and how to tailor adaptation programs in this context. There is need to understand farmer's perceptions about climate change and the impacts they are experiencing, how they are transforming their agricultural systems in response to climate change, and their adaptation needs.

2.3.4 Analytical Framework for this Study

The study largely deploys sustainable livelihoods framework (SLF) as analytical tool. SLF is complimented by transformational adaptation framework to address gaps and failings of SLF tool. Climate change transformational adaptation is widely accepted as a necessity and opportunity as an adaptive response by smallholder farmers.

Sustainable Livelihoods Framework (SLF): In 1992 Robert Chambers and Gordon Conway proposed the following composite definition of a sustainable rural

livelihood: “A livelihood comprises the capabilities, assets (stores, resources, claims and access) and activities required for a means of living: a livelihood is sustainable which can cope with and recover from stress and shocks, maintain or enhance its capabilities and assets, and provide sustainable livelihood opportunities for the next generation; and which contributes net benefits to other livelihoods at the local and global levels and in the short and long term’’ (Chambers *et al*. 1992). The need to analyse and prepare for smallholder farmers’ vulnerability to climate change hazards is rooted in the Sustainable Livelihoods Framework (SLF), which aims to reduce the elements of vulnerability. The SLF incorporates climate shocks as a highly significant component of the ‘vulnerability context’.

This study deploys SLF as analytical tool since it is rich in presenting the main factors that affect people’s livelihoods and relationships between vulnerability context, livelihood assets, structures and processes, strategies and outcomes (Cannon *et al*. 2003). A modified SLF, as illustrated starts by elucidating stressors and vulnerability context arising from external environment having impact on livelihoods. For smallholder farmers, the vulnerability context is associated with shocks, seasonality and trends and changes over which they have limited or no control (Ellis, 2000b).

The arrows in the framework do not imply direct causality save a certain level of influence. Shocks emanate from environmental, social and economic factors. They include floods, droughts, earthquakes, illness of deaths in the family, harm to livestock or crop health, ceremonial expenses, litigation, social crises, local or regional conflicts and violence, food shortage and inflation. Smallholder farmers are

also vulnerable to seasonality. The problem is more pronounced where livelihoods depend on the amount and timing of rainfall. Similarly, livelihood outcomes for smallholder farmers are inextricably linked to seasonal based production, prices and employment opportunities. Changed seasonal patterns introduce uncertainty, which in turn impacts on livelihood strategy and outcomes.

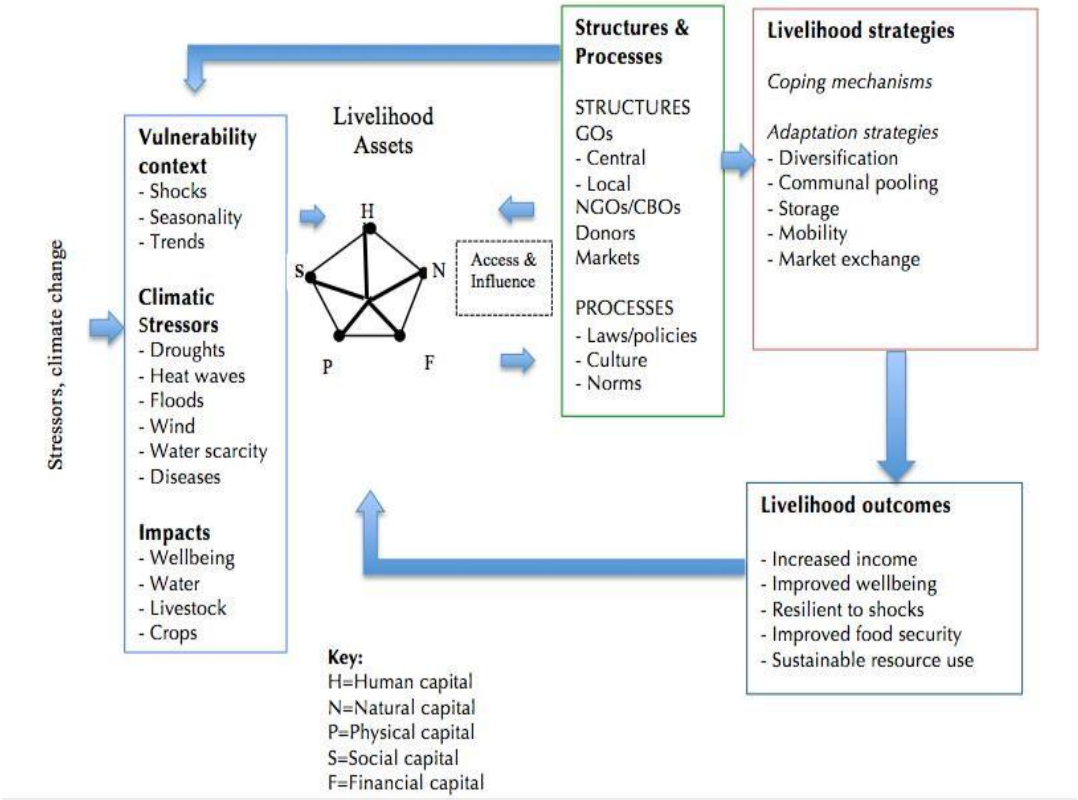


Figure 2.4: Sustainable Livelihood Framework

Source: (DFID, 1999; Scoones, 1998; Carney *et al*. 1999)

Livelihood Assets; The Sustainable Livelihoods Framework (SLF) places considerable importance to livelihood assets represented in asset pentagon in the figure 7. They are also referred as capitals or livelihood building blocks that determine how people respond to the impacts of climate change. According to IISD (2003) the ways in which livelihoods work and how people respond to climate

change depend on livelihood assets that form the basis of adaptation strategies. The stronger and more varied the asset base, the greater is the peoples' adaptive capacity and the level of food security and sustainability of livelihoods (Cooper *et al*.2008).

The SL literature categorises livelihood assets into five capitals, namely, human, social, natural, physical and financial capital. Human capital takes the form of training, skills, and knowledge that translate into ability to labour and good health, food security/nutrition, education, as well as capacity to work and adapt (DFID, 1999). Together they enable people to pursue different strategies and achieve their objectives. Human capital is particularly vital in perceiving climate change and taking adaptation actions. For instance, smallholder farmers with better education and skills are better placed to adopt new ideas and tools.

Social capital denotes important category of assets consisting of networks and norms that enable people to act collectively (Woolcock and Narayan, 2000; Adger *et al*. 2003b). Through networks, people share knowledge, spread risk and claims for reciprocity in times of crisis. In the context of climate change, the web of relationships, trust, reciprocity and exchange and the evolution of common rules play important role in determining adaptive capacity (Adger *et al*. 2003b, Jaja and Dawson, 2014). This is particularly the case for rural communities where relationships and institutional access, rights and claims derived from farmer group membership and village organisations play a vital role.

Natural capital is another component of livelihood asset. It refers to the natural resource base from which smallholder farmers engage in agricultural pursuits and

resource collection for both sustenance and income generation (Ellis, 2000b). Examples include land, forest, air, water, fish, livestock, pasture, wild products and biodiversity. Depending on local contexts, some of these natural assets such as agricultural land, pasture land, forest and water are communally held. Irrespective of communal or private proprietorship of natural capital, access to these assets is critical to farmers who directly depend on natural resources for cultivation and livestock (Kebede and Adane, 2010).

Physical Capital or Built Capital refers to infrastructure resources and technology (e.g. tools and equipment for production, seed, fertilizer, pesticides, traditional technology, livestock used in animal traction). The components of infrastructure essential for sustainable livelihoods include affordable transport, secure shelter and buildings, adequate water supply and sanitation, clean, affordable energy and access to information or communications (DFID, 1999).

Finance capital, expressed in the form of money or liquid assets (e.g. savings, credit/debt from formal, informal and NGO sources and remittances), plays an important role to build resilience against shocks. In developing countries, microfinance institutions (MFIs) provide access to financial credit for smallholder farmers as commercial banks hardly invest in small scale agriculture (Jessop *et al*. 2012, p.16).

The nature and combination of the livelihood assets, to which smallholder farmers and communities have access, determines adaptation choices (Agrawal, 2010). However, the combination of livelihoods assets should not be construed as static;

quite the contrary, it is dynamic in that some assets shrink or expand over time changing the shape of the 'asset pentagon'. Livelihood assets are not the only determinants of the ability of smallholder farmers. The SLF approach is not without limitations, it is evident that some aspects of the research, for example, perceptions of climate change hardly fit the original framework although the modified version includes them as part of human capital (as education, skills and knowledge).

Scoones (2009) highlighted the failures of sustainable livelihoods approaches including: a) the lack of engagement with processes of economic globalization; b) the lack of attention to power and politics and the failure to link livelihoods and governance debates in development; c) the lack of rigorous attempts to deal with long-term change in environmental conditions, and e) the lack of debates about long- term shifts in rural economies and wider questions about agrarian change. Despite the limitations, SLF as a method is a useful analytical tool to help understand smallholder farmers' vulnerability and adaptation to climate change. It enables the deployment of different data sources to capture the complexity related to vulnerability and adaptation to climate change.

Transformational Adaptation Analytical Framework: SLF failings are summarized to questions of knowledge, politics, scale and dynamics. In terms of knowledge, SLF's focus on the local context is at the expense of dealing with big shifts in the state of global markets and politics (Scoones, 2009). In the age of globalization, exclusive focus on the local misses the influences of global forces; therefore, this research categorically complemented SLF with Transformational Adaptation analytical framework.

Climate change transformational adaptation is widely accepted as a necessity and opportunity but remains an ambiguous topic and task. An emerging focus is on 'transformational' change as an adaptive response (Howden *et al*., 2007; O'Brien, 2011; Pelling, 2011). In agriculture, the scale of the climate change challenge and the growing influence of outside interests mean that transformation is both especially likely and desired. Transformational adaptation in and of agriculture was recently recognized as a priority and an emerging field of research (Walker *et al*. 2009, Park *et al*. 2012). Noting that livelihood assets are not the only determinants of the ability of smallholder farmers, transforming adaptation theory is also considered for transforming structures or institutions that create and enforce legislation provide the necessary requirements to acquire assets, manage natural resources, and provide other services crucial for gaining access to assets, exchanging them, and benefiting from their use.

Transforming structures work at different scales starting at local (household, village/community, and culture), private sector (markets), community-based associations, and NGOs. They extend to government (central and local governments) and international structures. All of these have the capacity to 'structure' the risks and sensitivity to climate hazards, facilitate or impede individual and collective responses, and shape the outcomes of such responses (Agrawal, 2010). Viable and functioning institutions are required to coordinate activities of smallholder farmers for pooling or collective action. Important too are processes in the form of policies, legislation, rule of law, and power relations that determine the interactions between the structures and individuals (Kollmair and Gamper, 2002).

The effectiveness of adaptation practices by smallholder farmers depends on the social and institutional contexts in which they are pursued. For example, land tenure or the system of rights and institutions that govern access and use of land are important for farmers to invest on land and take or spread risks. Thus, inappropriate policies and weak institutions may result in smallholder farmers adopting practices that are unsustainable or that actively degrade the environment. It is also the case that policy and institutional failures exacerbate market failures, locking smallholder farmers into a low-level equilibrium that perpetuates poverty and land degradation. This study uses transformational framework while it mainly explores the SLF (local context) in which structures and processes determine access to assets and support or hinder smallholder farmers' adaptation strategies and livelihood outcome.

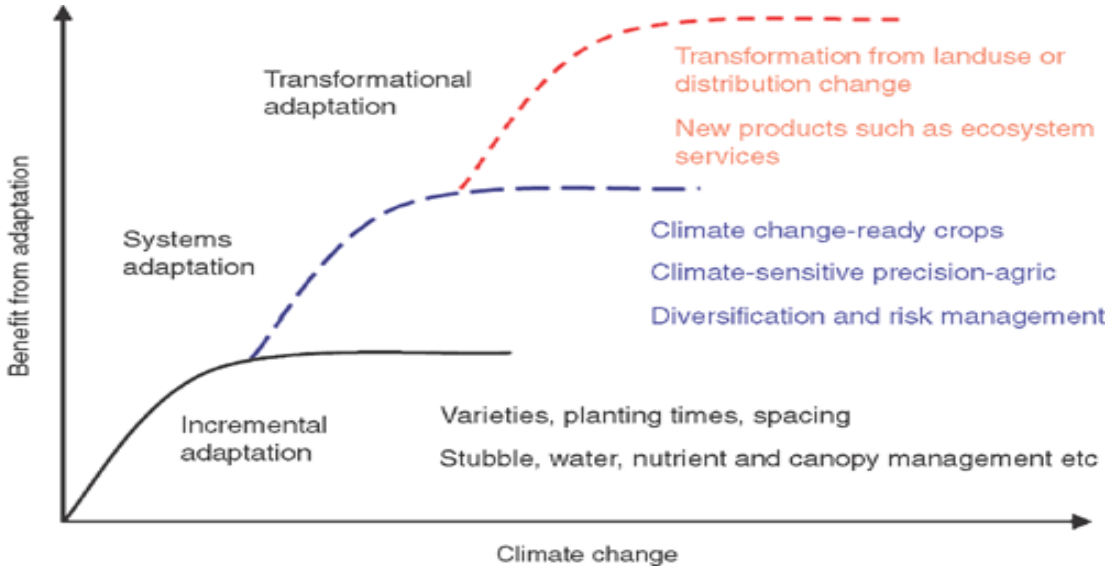


Figure 2.5: Transformational Adaptation

Source: Howden *et al*. 2010)

Figure 2.5 shows the levels of adaptation in relation to benefits from adaptation actions and degree of climate change, with illustrative examples. Transformational adaptation will be more important to highlight the importance of tailoring climate

adaptation policies and programs to the diverse socio-economic conditions, biophysical contexts, and climatic stresses that smallholder farmers face. Transformational adaptation is key on how different types of smallholder farmers vary in their perceptions and responses to climate change, and how to tailor adaptation programs in this context. There is need to understand smallholder farmers' perceptions about climate change and the impacts they are experiencing, how they are transforming or desire to transform their agricultural systems in response to climate change, and their adaptation needs.

2.4 Empirical Literature Review

2.4.1 Introduction

Evidence of climate change and variability has been presented both from empirical data and perception of various sectoral stakeholders. Poor rainfall distribution coupled with drought periods, particularly inter-seasonal dry spells have amplified the problem of moisture stress (Paavola 2003; Tillya and Mhita,2006) and put at risk between 20% and 30% of human population living in semi-arid areas (DFID, 2001). This clearly indicates that climate change and variability has increased the burden on food security and income among many farming families in Malawi. For example, analysis by (Hatibu *et al*. 2000) revealed that more than 33% of disasters in over 100 years' period were related to drought, which is a major pre-cursor of agro-hydrological problems in the semi-arid regions.

The African continent has been highlighted as particularly vulnerable in the future, primarily due to its low adaptive capacity and its sensitivity to many of the projected changes (IPCC, 2007b; Callaway, 2004). Additionally, climatic changes are taking

place in the context of other developmental stresses, notably poverty, fluctuating oil prices, and food insecurity (FAO, 2006), as well as in combination with environmental change, drought and land degradation. (Thomas *et al*. 2008). Empirical analysis shows that Malawi is highly exposed to natural disasters, such as floods and droughts. Available records indicate that in the last 100 years, the country has experienced about 20 droughts.

In the last 36 years alone, the country has experienced eight major droughts, affecting over 24 million people in total. The impact, frequency and spread of drought in Malawi have intensified in the past four decades and are likely to worsen with climate change. Droughts and dry spells in Malawi cause, on average, a 1% loss of Gross Domestic Product (GDP) annually. Most drought episodes have occurred in El Niño years, during which the country experiences rainfall deficits. For example, the 2015/2016 agricultural season was greatly affected by strong El Nino conditions and resulted in erratic rains and prolonged dry spells across most parts of the country that led the Government of Malawi to declare a state of disaster in April 2016 (PDNA, 2016).

2.4.2 Climate Changes Impact on Rainfall and Temperature in last 50 Years

IPCC Special Report in 2018 on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways indicates that human activities are estimated to have caused approximately 1.0°C of global warming above pre-industrial levels, with a likely range of 0.8°C to 1.2°C. Global warming is likely to reach 1.5°C between 2030 and 2052 if it continues to increase at the current rate. Risks from droughts and precipitation deficits are projected to be

higher at 2°C compared to 1.5°C of global warming in some regions. Risks from heavy precipitation events are projected to be higher at 2°C compared to 1.5°C of global warming in several northern hemisphere high-latitude and/or high-elevation regions. This assessment is based on several lines of evidence, including attribution studies for changes in extremes since 1950 (IPCC, 2018)

Globally, the planet's average surface temperature has risen about 1.62 degrees Fahrenheit (0.9 degrees Celsius) since the late 19th century, a change driven largely by increased carbon dioxide and other human-made emissions into the atmosphere. The oceans have absorbed much of this increased heat, with the top of ocean showing warming of 0.302 degrees Fahrenheit since 1969. The Greenland and Antarctic ice sheets have decreased in mass. Glaciers are retreating almost everywhere around the world — including in the Alps, Himalayas, Andes, Rockies, Alaska and Africa/disappearing snowcap of Mount Kilimanjaro (Anthony, 2013).

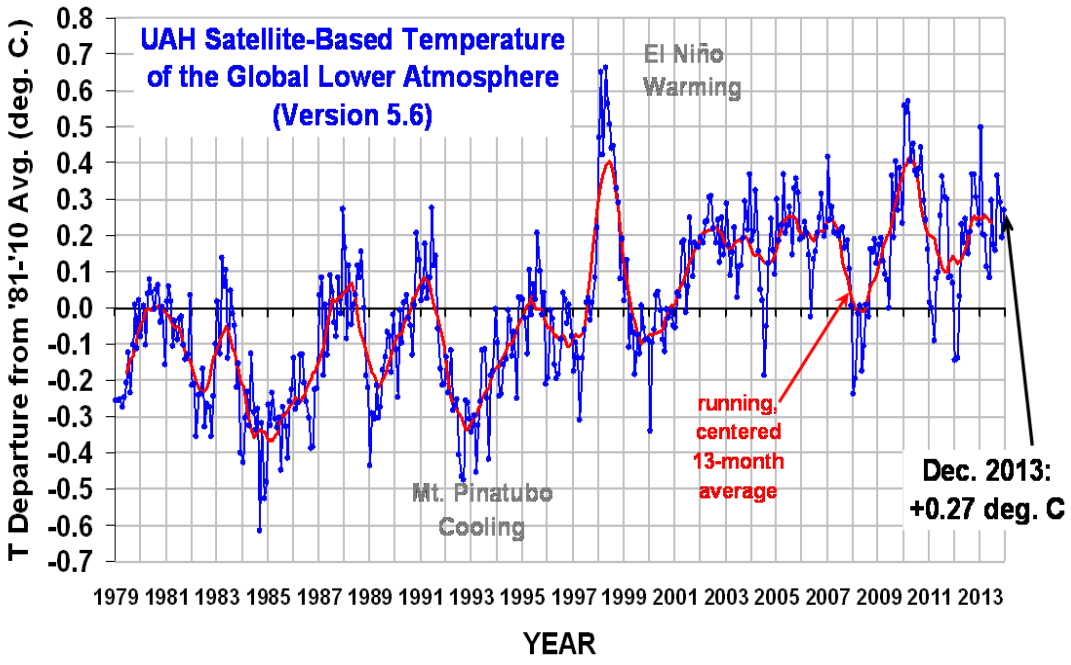


Figure 2.6: Global Temperature Anomalies on a 30-year average (1981-2010).

Source: Global Temperature Report 2014, University of Alabama, Hunstville

The above figure shows that global climate trend since 1979 has temperature raise of +0.14 C per decade December temperatures (preliminary) with global composite temperature being +0.27 C (about 0.49 degrees Fahrenheit) above 30-year average for December. There is also widespread acceptance that the climate of southern Africa region will be hotter and drier in the future than it is today. By 2050, average annual temperature is expected to increase by 1.5-2.5° C in the south and by 2.5-3.0° C in the north compared to the 1961-1990 average. Temperature rises will be greater in the summer than in winter, exacerbating stress on crops. Model outputs obtained by scientists from the US-based National Centre for Atmospheric Research (NCAR) and the National Oceanic and Atmospheric Administration (NOAA) revealed very clear and dramatic warming of the Indian Ocean into the future, which means more and more drought for southern Africa (NCAR 2005). This study showed that monsoons across southern Africa could be 10 to 20 percent drier than the 1950-1999 average. Annual regional precipitation is expected to reduce by 10 percent, with greater reductions in the north than in the south (Ragab *et al*. 2002).

Current and future climate-related risks to Malawi and key areas of vulnerability have been analyzed showing that agriculture is more vulnerability resulting severe food insecurity scenarios according Malawi's First and Second National Communication to the United Nations Framework Convention on Climate Change (GoM2011). In terms of temperature related extremes, the frequency of hot days and hot nights has increased in all seasons. The average number of hot days increased by 30.5 days per year between 1960 and 2003, particularly in summer. The average

number of hot nights increased by an additional 41 days over the same period. Analysis of trends in monthly rainfall across Malawi indicates that most regions have experienced decreasing but non-significant rainfall trends over the period 1960-2006. Decreases in annual runoff and increases in evaporation losses have also been found over the period 1971-2017 indicating that decreasing rainfall has practical significance in that Malawi has become more water limited in recent decades (World Bank, 2015).

The most up-to-date climate change and vulnerability assessment in Malawi was conducted by a USAID in 2013. The findings of this assessment on climate modelling show that climate change will increase mean annual temperatures and shift the timing of, and amounts of rainfall from the current patterns, and increase the frequency and intensity of existing climate hazards particularly droughts and floods. The climate modelling determined a range of 1997–2011 temperatures to be as follows: Observed annual minimum daily temperatures nationwide range from 13–21°C; Observed annual maximum daily temperatures nationwide range from 23–33 °C; and Observed annual extreme daily maximum temperatures range from 27–39.5 °C (USAID, 2013). These findings portray a clear increase over the annual temperature averages often reported by the Malawi Meteorological stations. All the stations assessed showed a relatively sharp increase in temperature, both maximum and minimum, over the years of available data. (USAID, 2013)

The above findings are in line with the country's climate projections based on Global Circulation Models (GCM) used by the Inter-Governmental Panel on Climate Change, which projected that the mean temperature in Malawi is projected to

increase by 1.1 to 3.0°C by the 2060's, and by 1.5 to 5.0°C by the 2090 (IPCC, 2007). They are also in line with those reported by other models. According to UNDP Climate Change Profile for Malawi, the mean annual temperature has increased by 0.9°C between 1960 and 2006, at an average rate of 0.21°C per decade.

Likewise, the average number of 'hot' days per year in Malawi has increased by 30.5 between 1960 and 2003, and the average number of 'hot' nights per year has increased by 41 (an additional 11.1% of nights) between 1960 and 2003 (UNDP, 2014). People's felt experience on seasonality change tells that there are changes in temperature. Reviewed studies indicate that Malawi is facing increasing trends in temperatures (0.9°C observed 1960-2006); dry days, hotter summers, drought and flood frequency, and inter-annual variability in rainfall is some of the observed changes that negatively affecting agriculture and food security (Leo, 2016).

2.4.3 Climate Change Impact on Food Security

Climate change and food security are inextricably linked. The Food and Agriculture Organization (FAO) warns that an increase in average global temperatures of just two to four degrees Celsius above pre-industrial levels could reduce crop yields by 15-35 percent in Africa and western Asia, and by 25-35 percent in the Middle East. An increase of two degrees alone could potentially cause the extinction of millions of species (Sarah, 2008). This means that countries already struggling with food security are likely to find they struggle still harder in the future. The IPCC projects that yields from rain-fed farming in some African countries could be reduced by up to 50 percent by 2020 (IPCC, 2013).

The problem of food security will increase in the future due to climate change with population growth which are contributing the great share of the problem in addition to the pre-existing traditional determinants. Climate change will reduce crop yields and in turn will increase the price of food that force people to change production and consumption patterns and directly will reduce calorie intake (Howard *et al*., 2008). So, climate change is undermining current efforts to address food security and malnutrition problems, one of the world's most serious but least addressed socioeconomic and health problem (United Nations System Standing Committee on Nutrition UNSSCCN (2010).

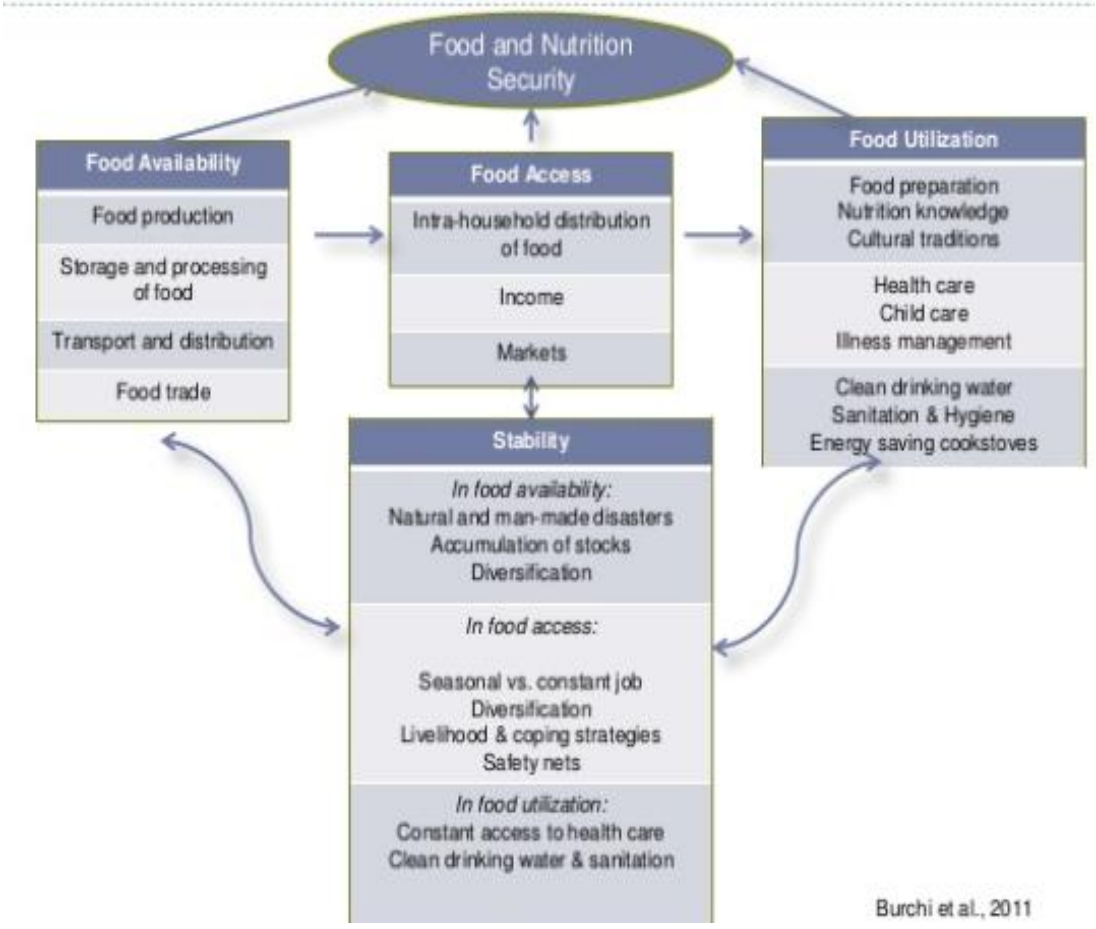


Figure 2.7: Climate Change Impact on Food Security Pillars
Source: Burchi *et al*. 2011

The the World Summit on Food Security of 2009 recognised that climate change will affect all four dimensions of food security: food availability, food accessibility, food utilization and food systems stability. It will have an impact on human health, livelihood assets, food production and distribution channels, as well as changing purchasing power and market flows. Its impacts will be both short term resulting from more frequent and more intense extreme weather events, and long term, caused by changing temperatures and precipitation patterns (FAO, 2009).

2.4.3.1 Climate Change Impact on Food Availability

The major direct impact of climate change is expected to have on food security is through food availability component due to changes in agricultural productivity. Food availability in Sub Saharan Africa is directly affected by many aspects of climate change like temperature increase, change in rainfall amount and patterns, rising atmospheric concentrations of CO2, change in climatic variability and extreme events and sea water rise (Wlokas *et al*. 2008). Except for mid- to high-latitude regions of Africa, where crop productivity may increase because of climate change, it is projected that mean crop productivity will decrease across Sub-Saharan Africa.

Higher temperatures, for example, are expected to have an overall negative impact on crop productivity through decreased crop growth and duration. The implications of climate change for food availability in Sub-Saharan Africa are generally expected to be severe. This is primarily due to the vulnerability of subsistence farmers, who are believed to have a low capacity to cope with environmental stressors (Christensen *et al*., 2007)

Literature reviews indicate consensus in argument that there are significant impacts of climate change on food security based on evidences from sub Saharan Africa. Climate change has a potential to shift land suitability which leads to increases in suitable cropland in higher latitudes and declines of potential cropland in lower latitudes. Moderate increase in temperature (1°C-3°C mean temperature) is expected to benefit crop yields in temperate regions but have a negative impact in tropical and seasonally dry regions particularly for cereal crops. However, warming of the climate more than 3°C is expected to have a negative effect in all regions (Badolo *et al*., 2012).

2.4.3.2 Climate Change Impact on Access to Food

Access to food refers to the ability of individuals, communities and countries to purchase food in sufficient quantities and quality (ibid, p.22). In Sub Saharan countries, households fail to access food for many reasons like high food price, access to markets, the level of poverty, employment condition, educational status and property rights. This will affect Sub Saharan Africa population that relies primarily upon subsistence agriculture, markets have long been important as a secondary source of food.

In general, there has often been a hungry seasonal from June to August, when crop yields do not meet demands, and food must largely be bought from markets. Falling real prices for food and rising real incomes over the last 30 years have led to substantial improvements in access to food in many developing countries. Possible food price increases and declining rates of income growth resulting from climate change may reverse this trend (Ludi, 2009).Access is based on the ability to procure

food. This may be impeded on both sides of the consumption process, with high food prices or lack of financial capital to acquire goods. While a large proportion of the African population relies primarily upon subsistence agriculture, markets have long been important as a secondary source of food.

In general, there has often been a ―hungry season from June to August, when crop yields do not meet demands, and food must largely be bought from markets (Brown *et al*. 2009). Those who derive their livelihood from natural resources will additionally suffer increased food insecurity, based on smaller crop yields limiting availability of food for both personal consumption and as a source of capital. Lack of capital is identified as a major constraint in the ability of poor farmers to adapt, thus making them much more sensitive to climate change. With rain-fed agriculture and pastoralism being the primary livelihood options in Sub-Saharan Africa, there are a great many people who are vulnerable, and who could see their financial capital seriously limited. Limited financial means, combined with expectations of high food prices, will thus seriously affect accessibility, and serve as an additional source for potential food insecurity in the face of climate change (Cooper *et al*. 2008).

2.4.3.3 Climate Change Impact on Food Utilization

Food utilization depends on how food is used, whether food has enough nutrients and whether diet can be maintained. Food utilization refers to the individual or household capacity to consume and benefit from the food (FAO, 2011). The most significant component of food security in a changing climate, but least studied, is food utilization. Even when the availability and accessibility are not infringed upon, if food sources are not able to contribute to a balanced, nutritious diet, then the

implications for health and productivity of the population could be significant. The utilization component of food security is generally related to nutritional aspects of food consumption. Most poor households receive what micronutrients they do get through the consumption of plants. There are the main ways by which climate change could directly affect micronutrient consumption by changing the yields of important crop sources of micronutrients, by altering the nutritional content of a specific crop, or by influencing decisions to grow crops of different nutritional value (Badolo, 2012).

Climate change affects food utilization capacity through different mechanisms. Climate change affects the production rate and pattern of different food items and this can affect the nutritional requirements of the population. Climate change can affect the income and capacity of the household to purchase a diversity of food items to get a balanced diet. A study in Sub Saharan Africa indicates the price of food has increased since 2006 and almost by 50% from June 2010 to February 2011. For this, climate change (extreme weather events) is one of the root causes of the recent high and volatile food prices. Most of the Sub Saharan Africa countries are negatively affected by the rise of price where they are net food importers and more vulnerable to climate change than developed countries. Due to this high food price, households may be forced to reduce both quality and/or quantity of food they consume, consume less preferred food and allocate food only to certain household members (Oviga *et al*. 2011).

2.4.3.4 Climate Change Impact on Food Stability

Food stability refers to the ability to obtain food over time. Food insecurity can be

transitory, seasonal, or chronic (FAO, 1997). In transitory food insecurity, food may be unavailable during certain periods of time. At the food production level, climate change disasters such as floods and drought result in crop failure and decreased food availability. This can cause instability in markets resulting in food-price spikes which can cause transitory food insecurity. Seasonal food insecurity can also result from the regular pattern of growing seasons in food production (Breisinger *et al*. 2012). Climate change can also cause chronic (or permanent) food insecurity which is defined as the long-term, persistent lack of adequate food. In this case, households are constantly at risk of being unable to acquire food to meet the needs of all members.

Climate change is likely to cause both chronic and transitory food insecurity, since repeated climate disasters can lead to the reoccurrence of transitory food security which makes households more vulnerable to chronic food insecurity (ibid) This study's literature review identified limited research related to climate change impacts on food security pillars such as food utilization, accessibility and stability. The most covered pillar is food availability since most studies on climate change and food security are concerned with agriculture production.

2.4.4 Smallholder Farmers Vulnerability to Climate Change

Smallholder farmers represent 75% of the world's farms, they comprise 60% of the agricultural workforce worldwide and provide over 80% of the food consumed in the developing world. Even though there are no widely-accepted definition of smallholder farmers, most of them depend on their production for both food security and income, cultivate small areas (less than 10 ha) and often use family labour

(Nagayets, 2005). Despite the importance of smallholder farmers to the agricultural sector, they often have limited resources to maintain or increase agricultural productivity, live in environmentally fragile and remote locations, and are often marginalized from social and development assistance programmes (Harvey *et al*. 2014). Many smallholder farmers are also affected by ongoing stressors such as the fragmentation of landholdings, the unpredictability in the prices of many agricultural commodities and the existence of regionalized and globalized markets, which brings smallholder farmers into direct competition with industrial-scale farming (Morton, 2007)

Climate change is a threat that further exacerbates the already precarious life conditions of many smallholder farmers. They are considered one of the most vulnerable groups to climate change due to: (i) their high reliance on ecosystem goods and services that are under increasing pressure as a result of climate change, (ii) their low capacity to adapt to changes their dependence on rainfed crops their location in marginal landscapes (such as hillsides, deserts and floodplains), where their farms are exposed to a variety of climatic hazards (ibid). Smallholder farmers are also considered vulnerable to climate change due to the direct and negative impacts of climate change on the suitability and productivity of crops they rely on for both subsistence and income. One of the regions where smallholder farmers are expected to be highly impacted by climate change is Sub Sahara Africa and Central America and Mexico (Hannah *et al*. 2013).

Droughts and floods are exposing the crisis in livelihoods of smallholder farmers in Malawi. Smallholder farmers' experiences with disaster are often traced back to the

1991/92 southern Africa drought that caused suffering to over 6.1 million people. Disasters have continued to escalate, with the 2002 drought and flood causing a landmark food crisis that will never be forgotten in Malawian history. Since then, the small holder farmers have been undergoing food crises caused by erratic rains and regular floods. Smallholder farmers believe that climate change has resulted in the limited income opportunities in the face of increased floods and droughts. They say droughts have forced women to engage in unsafe sex practices, exposing them to greater risk of HIV. They say that girls as young as 13 are being forced into early marriage due to hunger, thus aggravating the impact of HIV and AIDS (Sithabiso *et al*. 2006).

2.4.5 Adaptation to Climate Change

The significant role of adaptation as a policy response by government has been recognized internationally. Article 4.1b of the United Nations Framework Convention on Climate Change (UNFCCC (1992) states that parties are 'committed to formulate and implement national and, where appropriate, regional programs containing measures to mitigate climate change and measures to facilitate adequate adaptation to climate change.' The Kyoto Protocol (Article 10) further commits parties to develop adaptation measures (UNFCCC, 1992).

It is essential to develop and implement effective adaptation measures so that climate-related risks and opportunities might support development objectives within local and policy decision-making processes (Adger *et al*. 2006; IPCC, 2007b). Adaptation is a process of deliberate change, often in response to multiple pressures and changes that affect people's lives. Identifying the precise drivers of these

changes, whether environmentally, climatically, or economically driven, is extremely difficult (Adger *et al*. 2005). Government of Malawi has developed the National Climate Change Management Policy to address the adverse impacts of climate change (GoM, 2016). Climate change is also highlighted in the Malawi Growth and Development Strategy I and II (2011-2016), focusing on the need to mainstream mitigation and adaptation into all sectors to increase resilience and promote sustainable development.

In addition, the National Environmental Policy (2006) highlights the need to reduce the impacts of climate change. Malawi has produced a National Adaptation Programme of Action (NAPA), and two National Communications on Climate Change to the UNFCCC (GoM, 2011).Research has expanded understanding of causal relations, links with historic data and ability to model climate change numerically. Research during this period has been summarized in the Assessment Reports by the Intergovernmental Panel on Climate Change with empirical evidence that climate change is a reality in Malawi.

2.5 Conceptual Framework

In this study, the conceptual framework proposed by (FAO, 2016) addressing the linkages between climate change and vulnerability to food insecurity was reviewed in comparison with the one proposed by (Sarah *et al*. 2015). Analysis of the two conceptual frameworks helped the researcher to draw various ways in which climate change impacts on the food security and adaptation strategies among smallholder farmers.

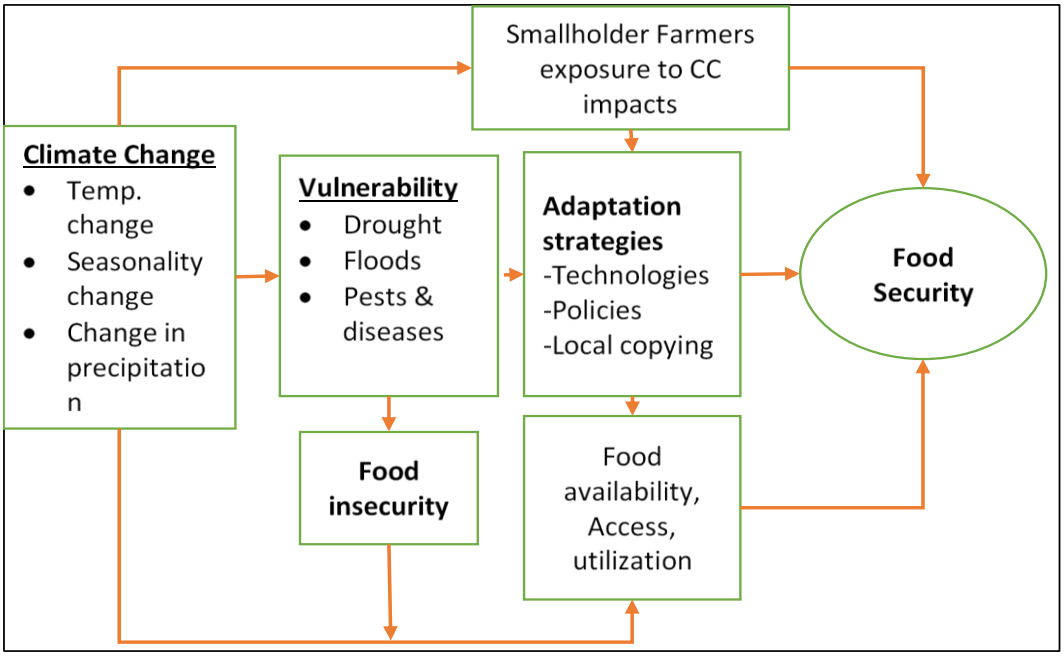


Figure 2.8: Conceptual Framework
Source: (FAO, 2016; Sarah *et al*. 2015)

Figure: 2.6 is the conceptual framework for this study that illustrates how climate change impacts heighten smallholder farmers' vulnerability. It further demonstrates the fact that climate change increases the frequency and intensity of some disasters such as droughts, floods and crop pests and diseases. This has an adverse impact on livelihoods and food security especially to smallholder farmers living in disaster prone areas with high incidences of poverty and inequality. Under these conditions, smallholder farmers' vulnerability to climate change intensifies as they are likely to use most of their income on food and deploy weak adaptation strategies. The dependable variables assessed are; occurrences of climate change impacts especially, droughts and floods and their impact on food security. The study likewise assessed food security dependable elements such as food availability, accessibility, utilization and stability. Independent variables include demographics which are articulated in this study's survey findings in chapter 4.

2.6 Research Gap

Most studies reviewed in literature part of this study clearly and strongly highlighted the link between climate change and food security. Though there was less research exploring vulnerability by poor smallholder farming in typical Malawi households. Climate change causes and governments policy formulation are by far the best researched, with ample evidence on how temperature and rain variability impacts crop productivity (food availability). Academic research is also limited in linking climate change to food security and adaptation challenge in the lenses of individual smallholder farmer and household level.

There is a large body of literature on the vulnerability of many people in Sub-Saharan Africa, but little research has been done to examine whether food security will be disproportionately affected by climate change, or whether individual farmers have autonomously responded or planned to meet the challenge of a likely future more widespread with climate change problem. Climate change may be another challenge in the way of Sub-Saharan Africa reaching its potential, but it could also provide the impetus to push for the adaptation strategies that will not only mitigate further food insecurity but could also diminish that which has already set in.

The review of the scenario studies demonstrated that researchers restricted their focus to dimensions of climate change in agriculture production (food availability) while food security pillars of utilization, accessibility and stability were hardly covered. The reason for this should do with the way the models have been built– they are well developed to simulate climate change adverse impacts on agriculture

performance but have limited scope to analyse the small farmer as a unit of household and individual aspect of food security.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This chapter explains the methodology and procedures which were used to collect and analyze data. The chapter firstly describes the study area and briefly presents the reasons for the choice research design, underscoring the meaning of qualitative, quantitative and data analysis methods and their relevance in the context of this study. Subsequently, procedures for sampling the informants, techniques of data collection and analysis are presented. The likely constraints and solutions are also highlighted especially those inherent in the qualitative research approach. Furthermore, the reliability and validity of data and research ethics issues are mentioned.

3.2 Description of the Study Area

This study was conducted in Salima district, Chipoka Extension Service Area (EPA), Ndindi Traditional Authority. Salima is a district in the Central Region of Malawi with location coordinates 3.6810° **S**, 34.4198° **E**. It has a total land area of 2,196 square kilometers, which represents 2.3% of Malawi's total land area. Salima district lies within the Great African Rift Valley system with Lake Malawi on the east side. Salima is bordered by Nkhotakota district to the north, Ntchisi district to the north-west, Dowa to the West, Lilongwe to the South West, Dedza to the south and south and Lake Malawi to the east (GoM, 2006). Chewa and Yao are the major tribes in the district. However, there are four other minor tribes namely Tonga, Tumbuka, Nyanja, and Ngoni. The Yao and the Tonga live mostly along the lake while the rest

of the tribes live further inland.

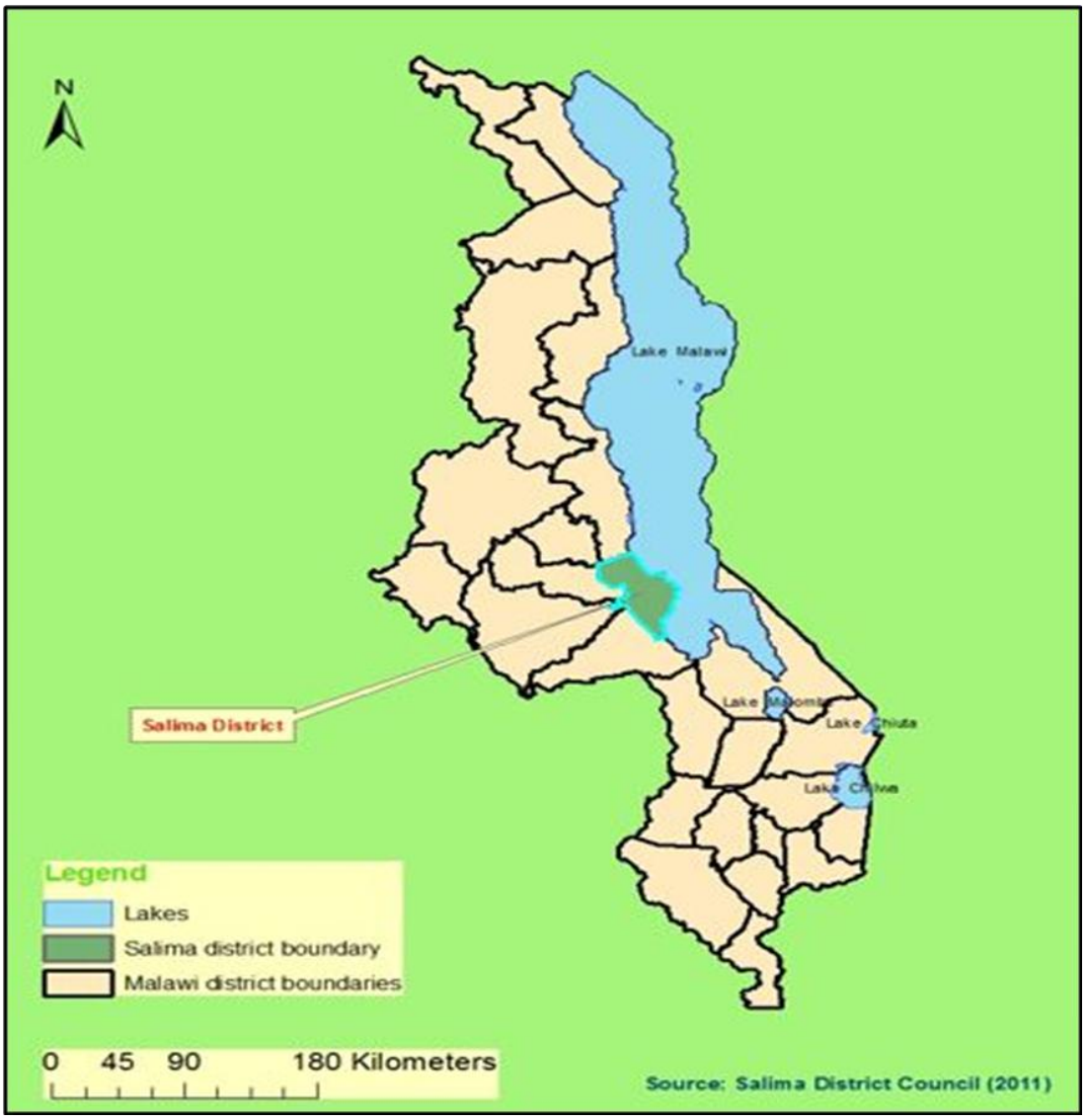


Figure 3.1: Map of Malawi Showing Salima District

Source: Salima District Council 2011

Salima's climate is subtropical with the rainy season extending from November to April, and the dry season from May to October. The study area, Ndindi, has a hot tropical climate with mean annual temperature of 22^0C. The highest temperatures are experienced in October reaching as high as 33^0C while the lowest temperatures are experienced between May and July reaching 12^0 C. The area has three seasons

throughout the year: Hot dry season (August- October), Hot wet season (November-April), and Cool dry season (May- July).

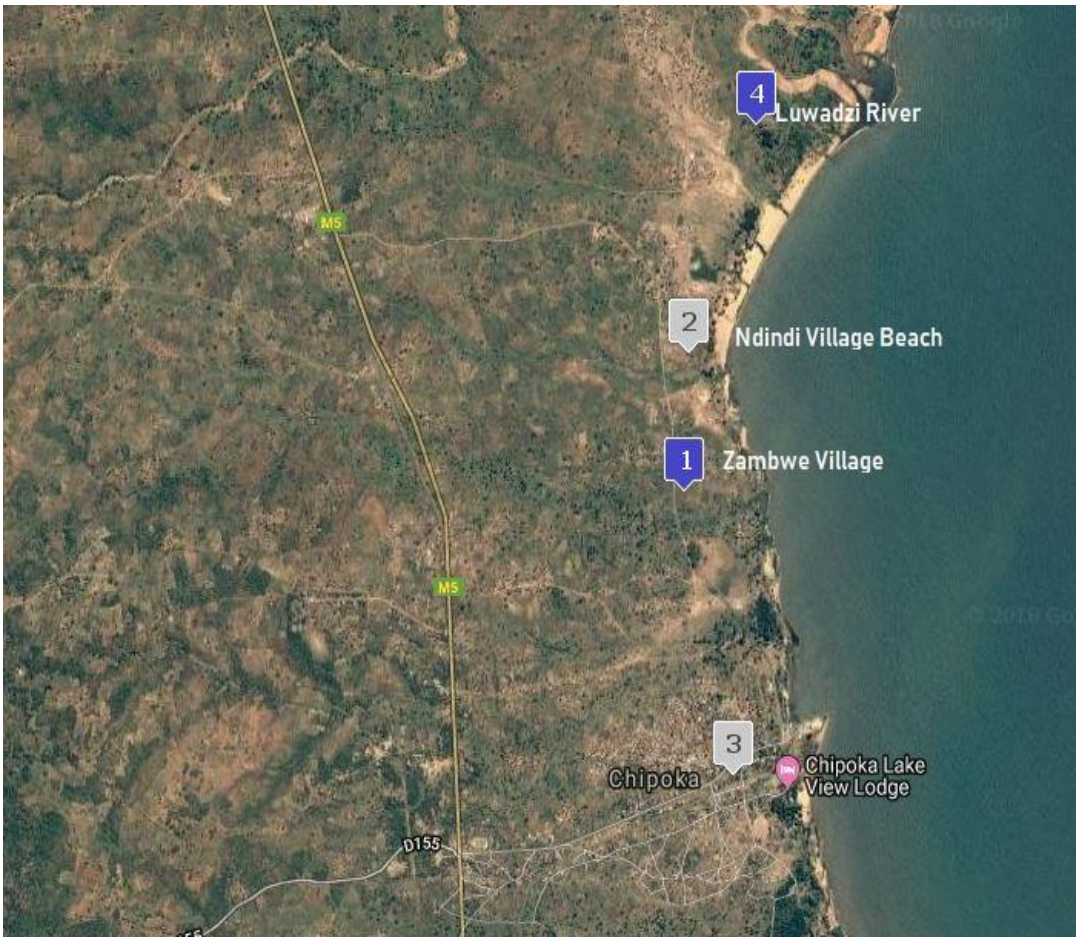


Figure 3.2: Location of Study Area/Satellite Imagery of Ndindi

Source: Map Data @Google 2018

Vegetation in the area is composed of savannah woodlands characterized by grasslands with scattered trees. There are no evergreen forests in the area due to dryness of the land during the hot and cool dry seasons. The district has alluvial soils in the rift valley floor due to seasonal deposition of the upland soils during river flooding. These soils are very suitable for arable farming especially for crops like maize, cotton, and rice. Red loamy soils are also available mainly in the upland areas and are suitable for tobacco farming as well as other arable crops such as beans and

groundnuts.

The study concentrated in Ndindi Traditional Authority to assess the impact of climate change on food security and adaptation strategies among smallholder farmers. Salima was selected for this study due to its vulnerability and location at shores of Lake Malawi which is a hotspot for repeated floods and drought. Salima is one of the 15 districts declared under a state of climate disaster since January 2015. It is one of the most vulnerable to climate change and this has affected food security of the households in the district. Every year an estimated 3,000 families are affected by floods alone which increase incidences of food insecurity and need of relief items. Large areas of maize and rice plantations get washed away (GoM, 2016).

3.3 Research Design

The research design here refers to the overall strategy that was chosen to integrate the different components of the study in a coherent and logical way, thereby, ensuring that the research problem is effectively addressed (Gorard, 2013). According to Burns and Grove (2003) research design is defined as "a blueprint for conducting a study with maximum control over factors that may interfere with the validity of the findings". Burns and Grove highlighted different types of research designs.

The main types of research design are: Descriptive (e.g., case-study, naturalistic observation, survey), Correlational (e.g., case-control study, observational study); Semi-experimental (e.g., field experiment, quasi-experiment), Experimental (experiment with random assignment) and Review (e.g., literature review) and Meta-

analytic (Burns and Grove, 2003, p.195). This study adopted descriptive research design while combining literature review, case-study and survey design sub-types of research to obtain a picture of smallholder farmers' opinions about climate change impact on their food security and the adaptation strategies.

According to Burns and Grove (2003), descriptive research design "is designed to provide a picture of a situation as it naturally happens". It may be used to justify current practice and make judgment and to develop theories. The descriptive research design is highly considered more flexible (Burns and Grove 2003, p. 201). Bell (1999) states "a case study approach is particularly appropriate for individual researchers because it gives an opportunity for one aspect of a problem to be studied in some depth within a limited time scale" The resulting body of 'case study research' has long had a prominent place in many disciplines and professions, ranging from psychology, anthropology, sociology, and political science to education, clinical science, social work, and administrative science. A descriptive case-study research design survey was conducted in Salima district Chipoka Extension Planning Area, Ndindi Traditional Authority as highlighted in research approach (section 3.4) and data collection methods (section 3.6).

3.4 Research Approach

This study employed a qualitative approach, yet it also utilized quantitative data analysis and interpretation. This study applies both quantitative and qualitative approaches to strengthen the reliability of data, validity of the findings and recommendations, and to broaden and deepen the understanding of the processes through which research findings have been achieved. The survey questionnaire

required quantitative approach while key informant interviews and FGDs applied needed qualitative approach. Quoting Trow's paper where he suggested that researchers in social sciences, should: ‘'get on with the business of attacking problems with the widest array of conceptual and methodological tools that we possess, and they demand' (Trow, 1957). As early as 1957 authors published several papers where they advocated for the use of multi trait-multi method matrixes and triangulation of measurement for validation, proposed 'transition experiments' and quasi-experimental designs (Campbell, 1957; Campbell and Fiske, 1959, Campbell and Stanley 1963, Webb *et al*. 1966). These early works attempt to advocate for the use of multiple methods as well as the opportunity to mix some aspects of quantitative and qualitative methodologies. Drawing on these ideas (Denzin, 1978) developed the concept of triangulation - the term that is probably most widely used to denote any attempt to combine different methods in a research study.

According to Katrin (2000), quantitative and qualitative approaches can be combined in the social research. He evaluates the idea to use multiple methods in the framework of one study as was proposed already in the middle of the past century by influential methodologists like Campbell, Stanley and others. According to Michael (2012), mixed methods seek to integrate social science disciplines with quantitative and qualitative approaches to theory, data collection, data analysis and interpretation. Although many evaluators now routinely use a variety of methods,

“What distinguishes mixed-method is the intentional or planned use of diverse methods for mixed-method purposes using mixed-method designs” (Greene, 2005, p. 255). Most commonly, methods of data collection are combined to make an

evaluation mixed method, but it is also possible to combine conceptual frameworks, hypothesis development, data analysis, or frameworks for the interpretation of the evaluation findings (Bamberger, 2012). This study used mixed methods (qualitative and quantitative) as complementary tools to provide different perspectives and help answer the research questions. To achieve the study's objectives, three data collection instruments were deployed:

Focus Group Discussion (FGD), Semi-Structured Interviews and a Survey. The first two methods aimed to generate qualitative data while the survey intended to produce quantitative data. The qualitative method took the form of FGD and semi-structured interviews with closed and open-ended questions that were intended to 'evoke responses that are meaningful and culturally salient to the participant unanticipated by the researcher as well as rich and explanatory in nature' (Mack *et al*. 2005). Fieldwork followed OUT's ethics clearance. Like other plans of field research, this phase involved site selection, sampling and data collection. The researcher was aware that research on human subjects requires informed consent of the participants in the research. Researchers "do not involve a human being as a subject in research without the informed consent of the subject or the subject's legally authorized representative" (Bailey, 2007).

3.5 Sample Population and Sampling Technique

Overall Salima has a total population of 340,327. The study specifically targeted Ndindi Traditional Authority (TA) which has a total population of 35,987, of whom 16,306 are 18+ years of age according to the most recent census (Malawi Population and Housing Census, 2008). This study targeted individual farmers who are likely to

be above 18+ years of age and ensured that the sample represents 50% of target age bracket since the study was to find significant relationships from the data, as statistical tests it required a larger sample size to ensure a representative distribution of the population and to be considered representative of groups of people (smallholder farmers) to whom findings were generalized. Therefore, total population of 18+ is 16,306 people. The study drew a sample from 50% which is 8,153 people.The study is applying the following formula to determine required sample size with accepted confidence level of 90%.

Formula:

$$\textbf{Sample Size} = \frac{\frac{z^2 \times p(1-p)}{e^2}}{1+\left(\frac{z^2 \times p(1-p)}{e^2 N}\right)}$$

Source: Adopted from Monkey Survey®, Sample Size Calculator

Note:

(Population Size = N) =8,153 | (Margin of error = e) =0.06 | (z=1.4), with *Confidence Level of =90%*. Therefore, the acceptable Sample Size for this study is equal to183respondents.

All the target smallholder farmers were sampled using Simple Random Sampling (SRS) ensuring that the subset of a statistical population (8,153) has a total of 183 individuals chosen around the targeted areas in Ndindi Traditional Authority, Chipoka Extension Planning Area. Fieldwork took place between June and July 2018 involving a survey with 183 smallholder farmers' respondents representing a response rate of 100 percent. There were four (4) Key Informant Interviews

consultations with 2 government officers and 2 NGO development workers. At community level, 2 Focused Group Discussions (FGDs) were held with a total of 17 members of the community. The first FGD was held with 8 members at Kuntupa village while a second one was conducted with 9 members at Karonga II village. During FGDs, the impacts of climate change on food security and smallholder farmers' adaptation strategies was defined through a process of identifying, classifying, and recommending solutions. A sample of 183 respondents was optimal bearing in mind that the study was conducted in Ndindi Traditional Authority and that the sample was proportional to the total number of smallholder farming families in the area with confidence level of 90%.

Table 3.1: Distribution of 183 Respondents of Survey Sample

Traditional Authority	Section	Village	Sample
Ndindi	Chimoga	Karonga II	33
Ndindi	Chimoga	Chimoga	36
Ndindi	Mchoka	Kandeu	38
Ndindi	Mchoka	Kuntupa	37
Ndindi	Mchoka	Mzwenene	39

Source: Research Field Survey 2018

3.6 Data Collection Methods

Data collection approaches used both secondary and primary data sources. Secondary data is referring to data that was collected by others which was reviewed for this study. Common sources of secondary data for this research include, information collected by government departments/district, organizational records and data that was originally collected for other research purposes. Primary sources are original materials on which research is based. The main thrust of the study

focused on quantitative data that was collected on smallholder farmers in Salima district. Primary data was collected mainly using semi-structured questionnaires administered to 183 smallholder farmers. There was first hand testimony or direct evidence concerning a topic under consideration; the impact of climate change on food security and adaptation options among smallholder farmers. The primary sources of this study are presenting information in its original form, neither interpreted nor condensed nor evaluated by other writers. Primary data was collected from the study area during fieldwork. The data collection methods included the following;

3.6.1 Literature Review

This was review of books, scholarly articles, and any other sources relevant to the topic in this research. Literature review helped researcher to get a description, summary, and critical evaluation of existing information in relation to the research problem of climate change impacts on food security and adaptation strategies among smallholder farmers. There was also review of existing information in Malawi and Salima district in relation with this study. There was review of meteorological information for Malawi and Salima district. This included statistical analysis of series of observations and recorded climate data to detect changes and trends in temperature and rainfall for over a period of 30-50 years.

3.6.2 Structured Questionnaire

The study asked a standard set of questions to research informants. Quantitative data involved 183 smallholder farmers for survey. This included face-to-face interviews with a distinct advantage of enabling to establish rapport with potential interviewees

and therefore gain their cooperation. These interviews yielded highest response rates. They allowed the study to clarify ambiguous answers and when appropriate, sought follow-up information. This study designed and applied a survey with closed and open-ended questionnaire (see annex I). Choosing both closed and open-ended questionnaire is based on Worley's central arguments that practitioners should be aiming for both open-ended and close ended are "grammatically closed, but conceptually open" "gives the best of both worlds.

3.6.3 In-Depth Interview with Key Informant

The study chose key informants that were knowledgeable about the topic of the study. There were three (3) Key Informant Interviews consultations held with government official at district level, 1 member of NGO in Chipoka and one Meteorological Officer in the Department of Climate Change and Meteorological Services (DCCMS). The KIIs helped the researcher to be familiar with the research area and concept. The 3 key informants were more knowledgeable about climate change impact on food and adaptation strategies among smallholder farmers in the area.

3.6.4 Focused Group Discussions

These were interviews in which a group of people was organized and asked about their perceptions, opinions, beliefs, and attitudes towards a climate change impact on food security and adaptation strategies among smallholder farmers. At community level, 2 Focused Group Discussions (FGDs) were held targeting 17 members of community, 8 and 9 members for first and second FGDs respectively. Members of the two FGDs were randomly selected however the researcher ensured that group

members represented gender, social class and age groups structures in Chipoka EPA, Ndindi TA. Questions were asked in an interactive group setting where participants were free to talk with other group members. During this process, the researcher took notes of the vital points from the group's discussion.

3.7 Data Analysis

Quantitative data analysis was done using statistical package for the social sciences (SPSS) software package (IBM® SPSS Statistics 2014). After the data was captured, it was edited, cleaned and summarized. Charts were generated using Microsoft Excel, a spreadsheet developed by Microsoft for Windows10®. Content Analysis was used to analyse qualitative data based on emerging themes within the context of the research to quantify qualitative information by systematically sorting and comparing items of information to summarize them. This process entailed turning raw data into useable evidence through data reduction methods problem framework. These themes were constituting the sub topics under which detailed reporting has been made in the findings section (chapter 4).

3.8 Validity and Reliability

3.8.1 Validity

Validity refers "to the truth and correctness of the statement" (Kvale, 1996, p.236). A valid argument according to Kvale is the one which is sound, well grounded, justifiable, strong and convincing. In the case of research interview for example, validity pertains to the trustworthiness of the subject's reports and the quality of interviewing itself which include careful questioning as to the meaning of what is said (ibid). To ensure that matters of validity are observed, this study considered the

following checks; Applying a mix of qualitative and quantitative methodology. According to Bamberger (2012), mixed methods seek to integrate social science disciplines with quantitative and qualitative approaches to theory, data collection, data analysis and interpretation. The purpose is to strengthen validity of the findings and recommendations, and to broaden and deepen our understanding of the processes through which research findings are achieved.

Applying the idea of internal and external validity; internal validity refers to the believability and trustworthiness of the findings. This depended more on the richness of the data gathered (Altheide *et al*. 1994). Therefore, the study used triangulation as method for verifying accuracy that involves cross-checking information from multiple perspectives. Triangulation was factored in the methodology since the study involved consulting more than one source of information and using multiple techniques of data collection. Various respondents, notably the community members, local leaders, government officials at district level, NGO's officials were interviewed. As indicated in the data collection tools, numerous techniques of data collection were employed, including document review and analysis, KIIs, semi-structured interviews as well as Focus Group Discussions (FGDs).

To ensure external validity, this study refers to the degree that the findings can be transferred to other contexts by the readers. This means that the findings are generalizable and can be applied to other similar settings, populations, situations and so forth. There was an endeavor to thoroughly describe the context of the research to assist the external readers to generalize the findings and apply them appropriately. Information obtained from secondary sources was compared to the primary data

collected from the field to see if they correlate. In this regard, other studies related to this research reviewed thoroughly as shown across all chapters.

3.8.2 Reliability

Reliability refers to the consistency of the research findings in interviewing, transcribing and analysis (Creswell, 2005). Reliability means that the scores of an instrument are stable and should remain the same when the instrument is administered repeatedly at different times, and it should remain consistent (ibid). Reliability in this study was ensured in terms of information collected from the field survey as well as its consistency in transcribing and analysing it. Reliability in this case therefore relied on three main interviewed aspects such as Government and Non-Government Officials as well as 183 survey respondents and other informants. In this regard, the most related answers from the survey and interviews were compared and analysed in SPSS. The opinions about the topic of study from every aspect are clearly quoted, described and analyzed in the findings of this study.

3.9 Ethical Issues

Research ethics are concerned with the extent to which the researcher is ethically and morally responsible to her/his participants, the research sponsors, the public and his or her own belief (Kitchin and Tate, 2000). This research involved human participants/respondents and there were minimal ethical issues since this is purely academic research without economic or political motivation. Nonetheless, the research put in place mitigation measures that included;

i. During the research process, ethical issues were considered in several ways. The first relates to the recognition that the position of the researcher (and of

participants) has influence on social inquiry (Scheyvens and Storey, 2003; Sultana, 2007). As a researcher in the field and as a person with lived experience of the Salima district, I shared my experience and knowledge on the challenges of farming and climate change with participants. I also explained my professional background and motivation to undertake the study. For readers of this thesis, I also stated my research positionality at the beginning.

ii. Seeking informed consent; respondent's right to autonomy was protected. Research respondents were informed about the purpose of the study in order make informed decisions to participate in research voluntarily. The study sought free and informed consent of participants. Respondents were communicated to both verbally and written in introductory letter, and informed consent was written on top of questionnaires.

iii. The issue of confidentiality and anonymity. The study ensured to address confidentiality through the management of private information to protect the subject's identity in case respondents would want to be anonymous. Confidentiality meant that respondents were free to give and withhold as much information as they wished. The researcher ensured his responsibility to "maintain confidentiality that goes beyond ordinary loyalty''.

Generally, the study did not meet ethical issues that would have critical risks on its execution. The researcher was aware of the limits of personal competence in research of this field. Moreover, the researcher worked with three experienced research assistants who are university graduates and, both of whom were fluent in Chichewa (the local language) and English. The researcher also coached Research Assistants in research methods and ethics and they were familiarized with the

research tools.

3.11 Chapter Summary

The research deployed case study research design and survey sub design to assess impact of climate change on food security and adaptation strategies among smallholder farmers in Salima district, Ndindi Traditional Authority. Primary data was collected through FGD, semi-structured interviews and a household survey. Data was analyzed using Statistical Package for the Social Sciences (SPSS) software package used in statistical analysis of data (IBM SPSS Statistics, 2014). The process of data collection and fieldwork involved ethical issues and practical challenges. The following chapters four (4) and Five (5) present the findings , discussion and recommendations/conclusion of the findings.

CHAPTER FOUR

FINDINGS AND DISCUSSIONS

4.1 Introduction

This chapter presents and discusses the findings of socioeconomic characteristics of the survey respondents in the study area (Ndindi Traditional Authority). Most of the findings discussed in this chapter are derived from field quantitative survey and qualitative (structures and processes derived from Focus Group Discussions (FGDs) and Key Informants Interviews (KIIs) data. The topics under consideration include; Section one (1) describes demographic characteristics (age, gender, education, occupation, land ownership households' size among others); Section two (2) presents climate change scenarios for a period of 30 or 50 years. Section three (3) is concerned with climate change impact on food security among small holder farmers' in Salima district and section four (4) is concerned with adaptation options as well as policy structures and processes.

In terms of analytical framework Sustainable Livelihood Framework and Transformational Adaptation are espoused in this study as shown in Figure 4.3 and Figure 4.4 respectively explaining characteristics that form part of the socio-economic capacity and vulnerability context of the smallholder farmers' food security. Survey findings are analysed using different tools such as descriptive statistics applying Statistical Package for the Social Sciences (SPSS) frequency tables and Excel charts that include pie charts, bars and graphs. The study also applied naturalistic observational method (field observation) where climate change impact, food security, small farmers' adaptation characteristics were closely observed, and pictures were captured to visualize the findings.

4.2 Socio-economic Characteristic of Respondents and Climate Change Vulnerability Context

4.2.1 Salima District General Population

Salima District Council has a population of 337,895 people according to the 2008 National Population Census (the most recent census) with a projected population of 342,236 people for 2011. The figure 4.1 gives details of the population status.

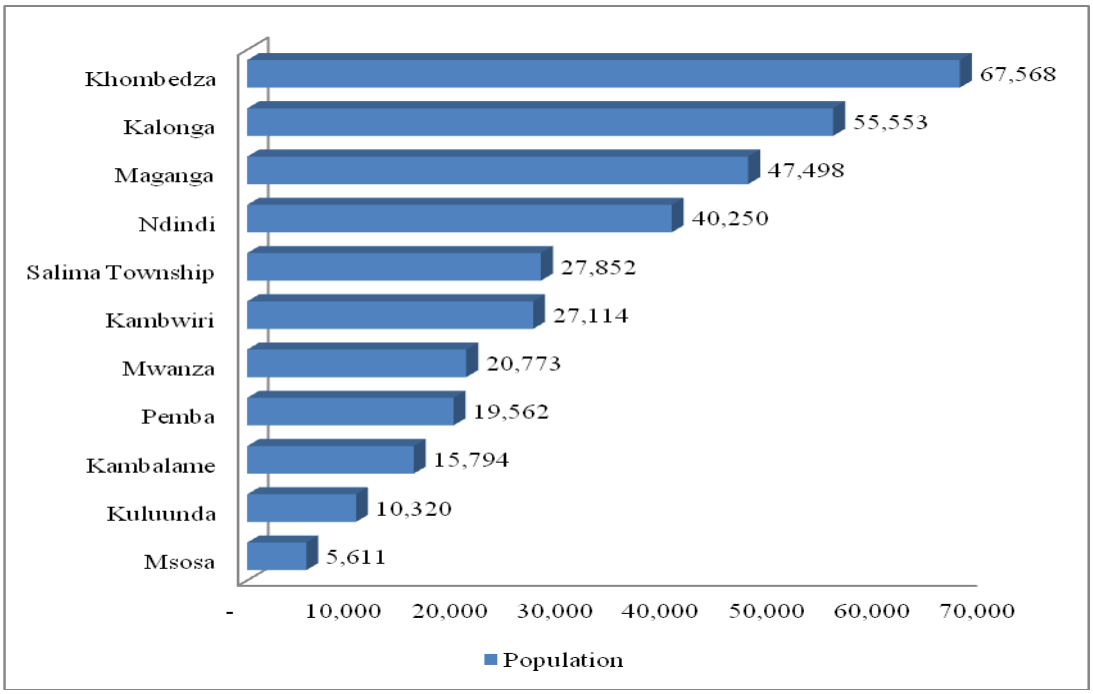


Figure 4.1: Population of T/As and Townships in Salima
Source: Malawi National Population and Household Census 2008

In addition, according to the national Mortality Analytical Report (2010) the average life expectancy for Salima males is 47.5 years and 50.5 for females, which is slightly under the countrywide life expectancy rates for rural Malawians of 47.5 years for males and 50.9 years for females. The following (Figure 4.1) gives details of the population status in Salima showing that that the study area, Ndindi Traditional Authority ranks fourth (4^{th}) most populated out of eleven (11) TAs. Ndindi has a total population of 40,250 people.

According to the 2015-2016 Demographic and Health Survey the Total Fertility Rate (TFR) for Salima is 5.6 which is slightly higher than Malawi's rate of 4.6. The high TFR reflects cultural, social, economic, and demographic factors in the district that favour large family sizes. In addition, the TFR reflects differences in educational attainment levels. Usually, those parents who have never attended education prefer having large family sizes than those who have gone to school. Smallholder farmers are associated with low levels of literacy which make them tend to have many children, so that they can have more assistance with farm labour.

4.2.2 Age and Sex of Respondents

The survey was mainly conducted considering simple random sampling technique among selected age groups and all gender (Male and Female) in target villages of Ndindi Traditional Authority. In terms of target population, it was decided that the survey should omit young people below 18 years of age, sick people in hospitals and people in prison as well as people who are visiting from other districts (non-residents). The survey's findings on age and sex distribution of the population are shown in Table 4.1 and figure 10 respectively.

Table 4.1: Respondents Age Range

Age		**Frequency**	**Percent**	**Valid Percent**	**Cumulative Percent**
Valid	under25	20	10.9	10.9	10.9
	25-34	61	33.3	33.3	44.3
	35-44	62	33.9	33.9	78.1
	45-54	19	10.4	10.4	88.5
	55-64	14	7.7	7.7	96.2
	65-74	6	3.3	3.3	99.5
	75above	1	.5	.5	100.0
	Total	**183**	**100.0**	**100.0**	

Source: Study Field Survey 2018

Clear majority of the survey respondents (78%) were below 45 years of age. Older respondents above 45 years of age accounted for the remaining 22%. This may mean that Ndindi has more young people. This result is in conformity with Malawi demographics profile 2018 projections on age structures that is; 0-14 years: 46.34% (male 4,427,403/female 4,468,120), 15-24 years: 20.55% (male 1,956,360/female 1,988,123), 25-54 years: 27.41% (male 2,612,840/female 2,648,997) 55-64 years: 3.01% (male 275,998/female 302,286) 65 years and over: 2.69% (male 227,582/female 288,537) (2017 est.)[1].

The age structures also show the high dependency ratios among the youths. Dependency ratios measure the age structure of a population and relate the number of individuals that are likely to be economically "dependent" on the support of others. Dependency ratios contrast the ratio of youths (ages 0-14) and the elderly (ages 65+) to the number of those in the working-age group (ages 15-64) (Hardly *et al*., 2011).

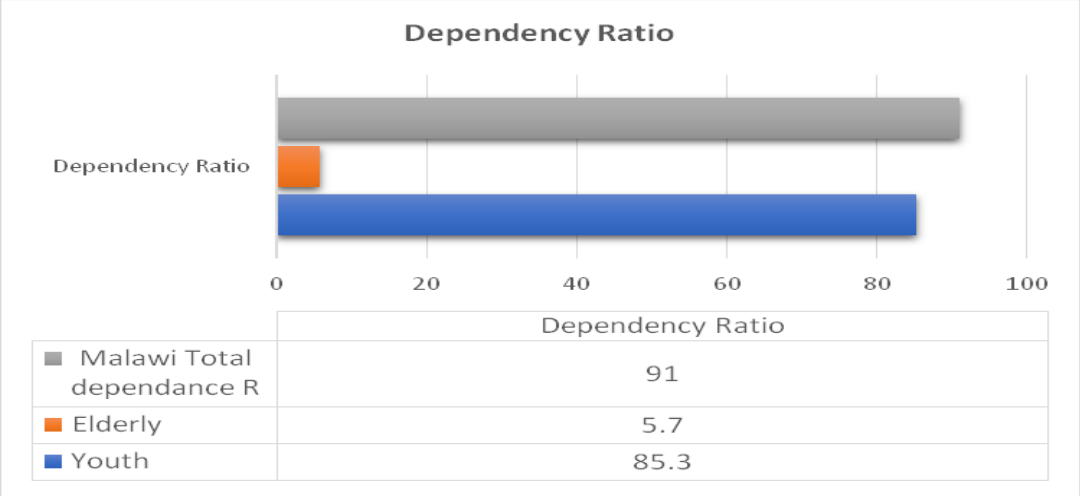


Figure 4.2: Dependency Ratio
Source: CIA World Fact book, Malawi Demographics Profile 2018

[11]CIA World Factbook, Malawi Demographics Profile 2018

The above findings show higher dependency ratio (91) value for Malawi which means that employed people support more non-working people, either young or old. A high total dependency ratio indicates increased smallholder farmers' vulnerability to impacts of climate change and food insecurity. High dependency ratios within smallholder farmers' households mean that labor is in high demand as there are a few who work to produce and meet the food security needs of many. High dependency ratios in the study area indicate family strain. FGDs participant testified that;

> "*Families are strained both in terms of income and labor and are less efficient at producing enough food amidst climate change disasters especially the wide-ranging Southern Africa drought phenomena*".

4.2.3 Sex Distribution

The selection process randomly captured more female (60%) compared to male respondents (40%).

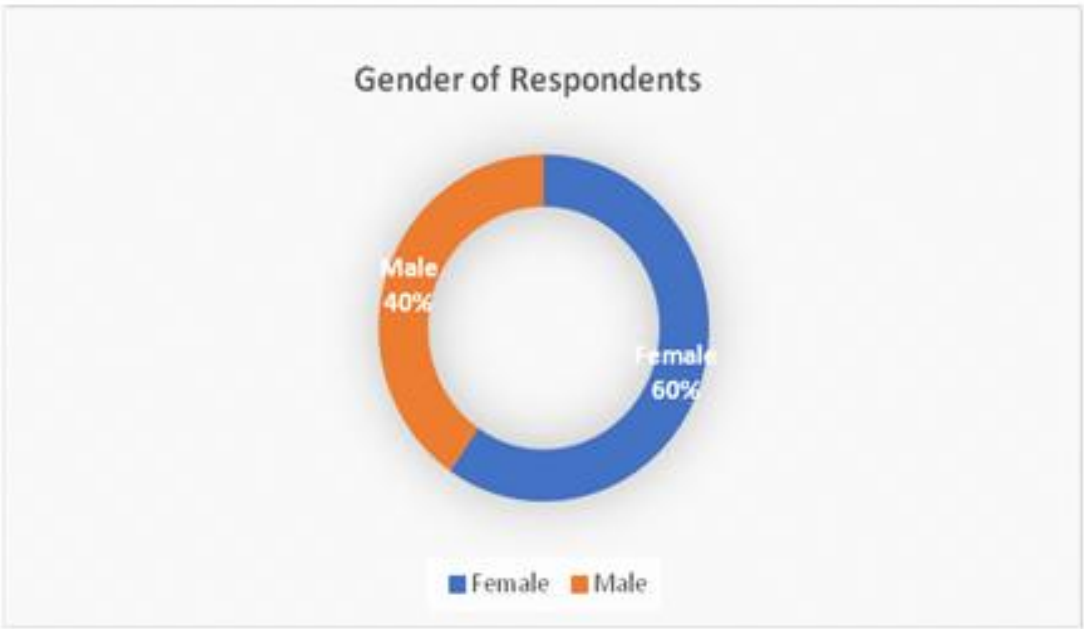


Figure 4.3: Gender of the Respondents
Source: Study Field Survey 2018

The researcher during the FGDs probed why there were more female participants than male since the survey was unbiased practice that applied a simple random sampling technique where each individual respondent was chosen randomly and entirely by chance (Each male or female respondent had the same probability of being chosen at any stage during the sampling process). It was reported during the FGDs that males are leaving farming due to declining yields in cash crops a problem largely blamed on frequent droughts. It was stated that many smallholder farmers in subsistence agriculture are female. It was also reported that droughts and floods that have repeatedly affected crops and livestock could have forced thousands of male farmers in Ndindi out of farming.

> ‘’*Many of these male farmers out of frustration chose to migrate to urban centers in search of employment’’* asserted FGD participant at Karonga II village.

This confirms the view espoused by Agrawal (2010, p.185) that the poor are more likely to migrate in response to crop failure.

4.2.4 Households Size

The majority (57%) of surveyed smallholder farmers’ households in Ndindi were composed of 1-5 members. This was followed by families that had 6-9 members that accounted for 38% while larger families of 10-14 members accounted for roughly 5%. There were hardly families with more than 15 members. This finding is in line with the national household size average of 4.5 persons according to the 2015-2016 Demographic and Health Survey findings.

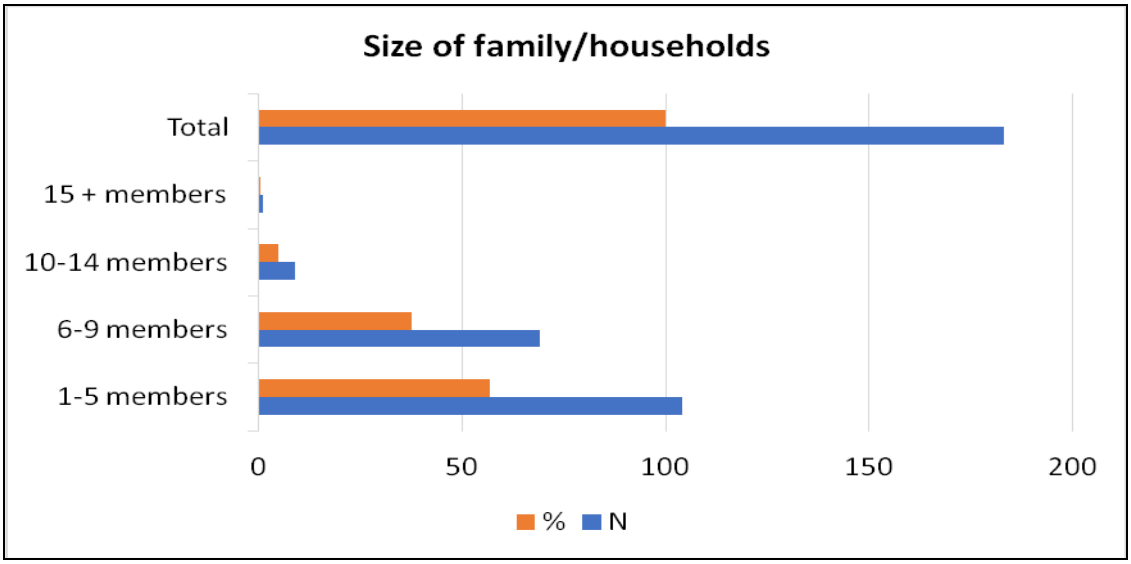


Figure 4.4: Size of Households
Source: Study Field Survey 2018

Size of a smallholder farmer's family is a significant characteristic of resilience or vulnerability to climate related disasters. In the application of Sustainable Livelihood Framework (SLF), the size of a family can affects the household human capital or labour capacity to cope with climate change hardships. A household that has more adult members that are working on the farm is more likely to have more farm labour than a smaller household. Tesso *et al*. (2012) study in Ethiopia recognized that the number of persons in a household is one of the factors that determine resilience. However big families come with a cost of requiring more food for the members of a large household as compared to a smaller household.

4.2.5 Marital Status

Most of the survey members were reported being married (60%). This may partly explain the dominant social expectations and survival challenges. According to United Nations Children's Fund UNICEF (2016) report on the state of the world's children, Malawi has one of the highest rates of child marriage in the world, with

approximately 1 in 2 girls married by the age of 18.

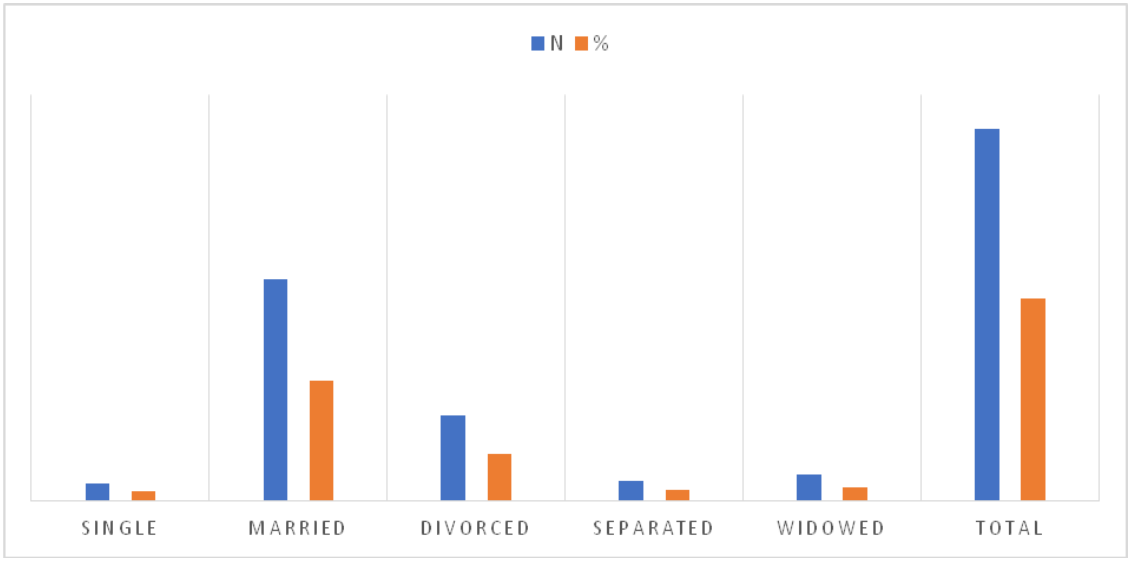


Figure 4.5: Marital Status of Respondents
Source: Field Study Survey 2018

During the FGDs it was reported that girls often drop out of school early to provide farm labor in family's agriculture and retail trade, such as selling vegetables in a market. It was also reported that dropping out of school leads to early marriages which are closely linked to food insecurity, and poverty, as often girls will be married off very young to secure new homes for survival. It was reported that one important strategy for being food secure and drought resilient is to have a working and income earning spouse. The report by (FAO, 2014) to a large extent agrees with this finding that food insecurity contributes to child marriage. However, FAO's report adds another angle that early marriage worsens the cycle of food insecurity and malnutrition. Further, FAO study states that Girls who are married young experience higher rates of anaemia and malnutrition than those who marry later in life. Children born to adolescent mothers are more likely to have low birth weight, suffer from poor nutritional status, and experience stunting.

4.2.6 Education Level

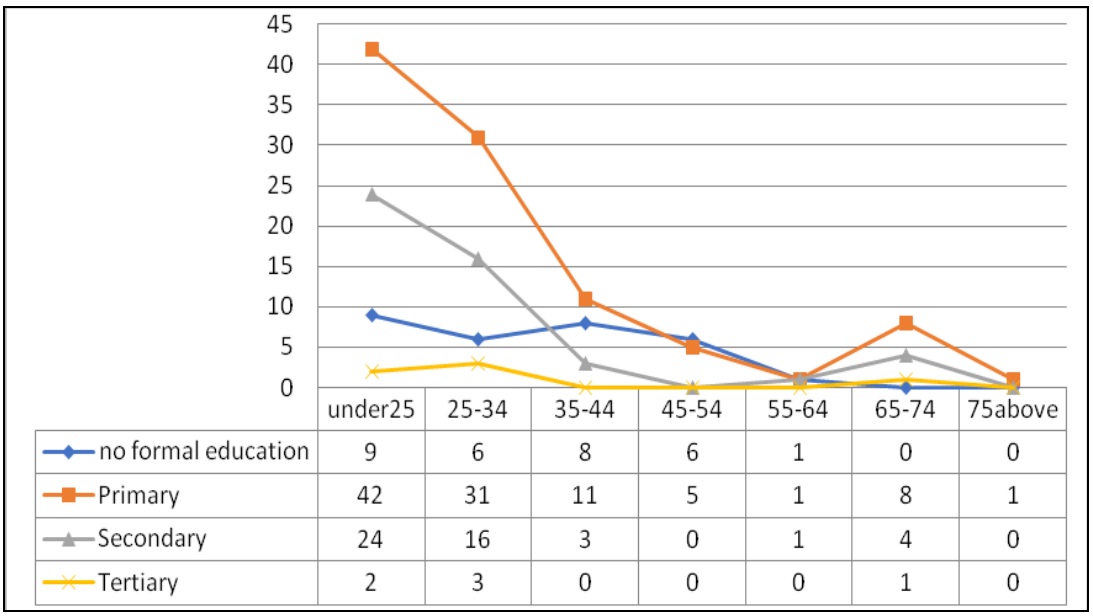
In general, the survey considered getting balanced views though the educational level of the respondents varied. The findings show in table 5 that; 16% of the respondents had not had any formal education, 54% had at least attended primary school, and 26% gone beyond primary level to secondary/technical/vocational institutions, while 3% had attended tertiary institutions and acquired diploma and degree certificates.

Table 4.2: Education Level

Education Level	**Frequency**	**Percent**	**Valid Percent**	**Cumulative Percent**
No formal education	30	16.4	16.4	16.4
Primary school level	99	54.1	54.1	70.5
secondary/technical/vocational	48	26.2	26.2	96.7
Tertiary/Diploma/Degree/certificate	6	3.3	3.3	100.0
Total	**183**	**100.0**	**100.0**	

Source: Field Study Survey 2018

Most smallholder farmers had obtained at least primary education. The percentage of smallholder farmers having no formal education at all (16%) is mainly the elderly or women. The rates of people having finished secondary or high school are highest for the age groups 18+ under 25, 25-34 and 35-44 years. The rates get smaller as the age group increases, showing that the younger group is at more chances to get a higher education. This can be explained by the increased investment of government, donors and the smallholder farmers' households on children's education.



	under25	25-34	35-44	45-54	55-64	65-74	75above
no formal education	9	6	8	6	1	0	0
Primary	42	31	11	5	1	8	1
Secondary	24	16	3	0	1	4	0
Tertiary	2	3	0	0	0	1	0

Figure 4.6: Education Level Versus Age Groups

Source: Study Field Survey 2018

Education is an essential element of smallholder farmers' response to climate change disasters. It helps people understand and address the impacts, encourages changes in their attitudes and behaviour and helps them adapt. FGDs participants indicated that families with educated people have more access to information. Most respondents 70% (16% no formal education and 54% primary education) are said to be lacking scientific understanding of climate change which limits their ability to adopt climate smart agriculture technologies. The minority literate people have a basic understanding of the seasonality changes, market dynamics and can easily access early warning information.

Weber (2010) found out that people's perception of climate change and response is shaped by learning and by making use of statistical information. The most educated have some ability to assess the validity of scientific arguments about climate and to

use that information to support their farming decisions. By far, education is crucial to unlock the fundamental relationship between climate and human life and the many ways in which climate has always played a role in food security. According to (Indrani *et al*. 2010), awareness to the climate change phenomenon leads to significant behavioral change, alleviating the potential and existing threats of climate change phenomenon.

4.2.7 Occupation

Most of the respondents (48%) were smallholder farmers in subsistence agriculture. This is in line with other findings that in Malawi smallholder agriculture accounts for about 85 per cent of agricultural production and over 75 per cent of employment (Salami *et al*. 2010). 16% of survey respondents were unemployed while another 16% stated that they were in fishing industry. This momentous number of responds in fishing livelihood is attributed to location of Ndindi at the Lake Malawi shores. Only 8 % of the respondents were in formal employment especially as teachers, NGO community workers and health practitioners among others.

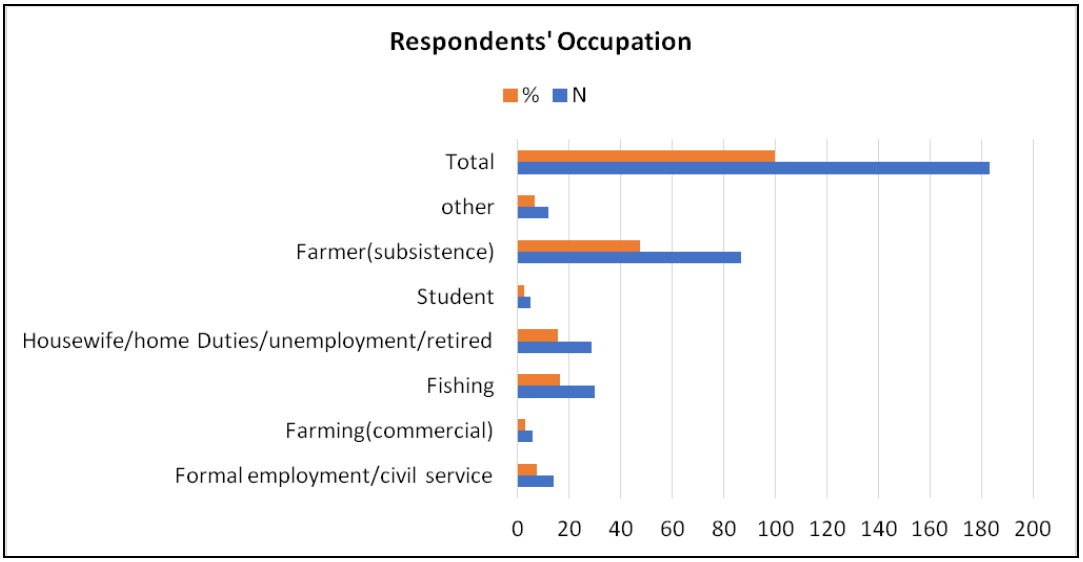


Figure 4.7: Occupation and Income of Respondents
Source: Study Field Survey 2018

Majority of the respondents in Ndindi being in "subsistence agriculture" means that the farming practices are associated with activities which together form a livelihood strategy where the main output is consumed directly (Barnett *et al*. 1997). Following the FGDs at Kalonga II confirmed that smallholder farmers in Ndindi had small farm sizes, low technology and low capitalization among others which leads to low food production and increases vulnerability. Moreover, most of these farmers are concentrating on crop production (mainly maize) that is more vulnerable to droughts and floods. This study agrees with other findings that smallholder farmers are highly subsistent and characterized by low levels of input and low output levels (Kondwani *et al*.2013).

4.2.8 Smallholder Farmers' Income Levels, Vulnerability to Climate Change and Food Insecurity

On the element of income, majority who comprised 30% of respondents stated that they were not earning and that if they got money, it ranged from 0-10,000 Malawi

Kwacha per quarter. This is followed by 27% and 12% who earned between 11,000 Mk-19,000 Mk and 20,000-29,000Mk respectively. Even this category was still earning less than $50 per a quarter. Most of the respondents who earned between 0-10,000MK were in fact earning a maximum of $15 according to 2018 average exchange rate. Only 19% of all survey respondents earned above $50 per quarter and majority of these were said to be in formal employment and fishing sectors. Crop farmers had the lowest quarterly incomes.

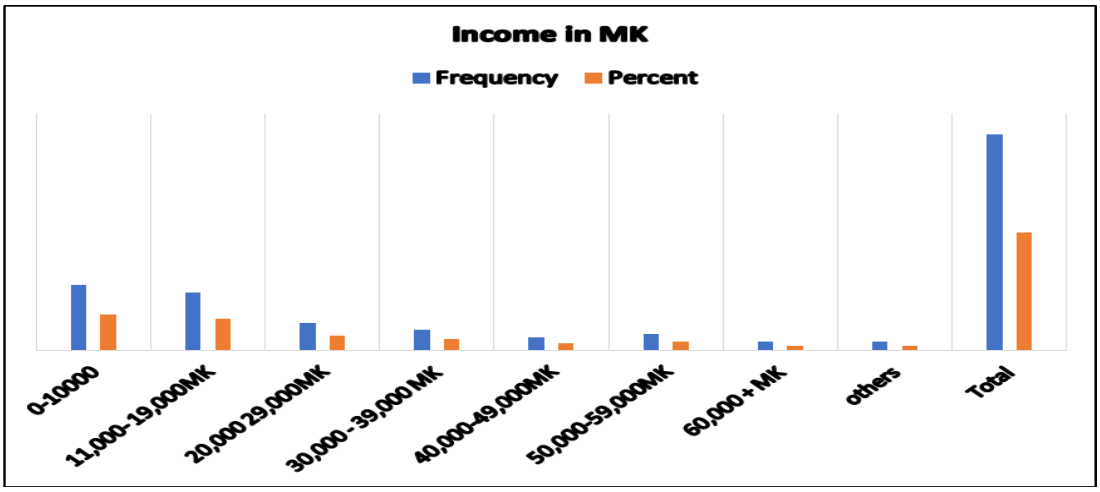


Figure 4.8: Income level of Respondents
Source: Study Field Survey 2018

According to the key informant interview with NGO worker, income is a major element of vulnerability and resilience to climate change. Low income and unemployment rates are related to smallholder farmers families' experiences of food insecurity and less adaptive capacity. It was understood that smallholder farmers produce much of the Malawi's food, yet they are much poorer than the rest of the population in the study area. Farmers were producing for subsistence requirements and if they got surplus it would be for sale (income).This is in line with a previous finding by (Rebecca *et al*. 2008) that subsistence farmers are people for whom farming is a major income and livelihood activity.

It was stated during FGDs that due to repeated drought and army worm attacks, the crop farmers were less food secure than even those people who were not farming but depended on informal jobs in urban centers. This finding agrees with the previous research that crop farmers are more vulnerable (Harvey *et al*. 2014). According to Apata *et al*. (2009), climate change great risk is more felt by crop farming that is more sensitive to rain and drought seasonal changes. This highlights the urgent need for the application of Transformational Adaptation theory that calls for the urgent need for income and employment-based policy interventions to help farmers build resilience and adapt to climate change (Agrawal, 2010).

The FGD participants asserted that families with good income and employment have ability to produce more food for home. According to the sustainable livelihood framework, poor income can cripple access to other livelihood assets that are necessary for smallholder farmers to adapt to climate change and ensure food security. Access to physical capital for example means that farmers need income to procure agricultural implements/tool, transport, energy and household consumable goods among others (DFID, 1999). The poverty situation in Salima is generally not different from the national level status due to an apparent lack of off-farm employment opportunities, among other things. However, in 2008, poverty in Malawi decreased from 50% in 2005 to 40% in 2007 and 2008. The proportion of ultra-poor people also decreased from 22% in 2005 to 15% in 2007 and remained the same in 2008[2].

[2]2008 NSO Welfare Monitoring Survey

4.2.9 Land Tenure as a Livelihood Asset for Smallholder Farmers' Climate Resilience

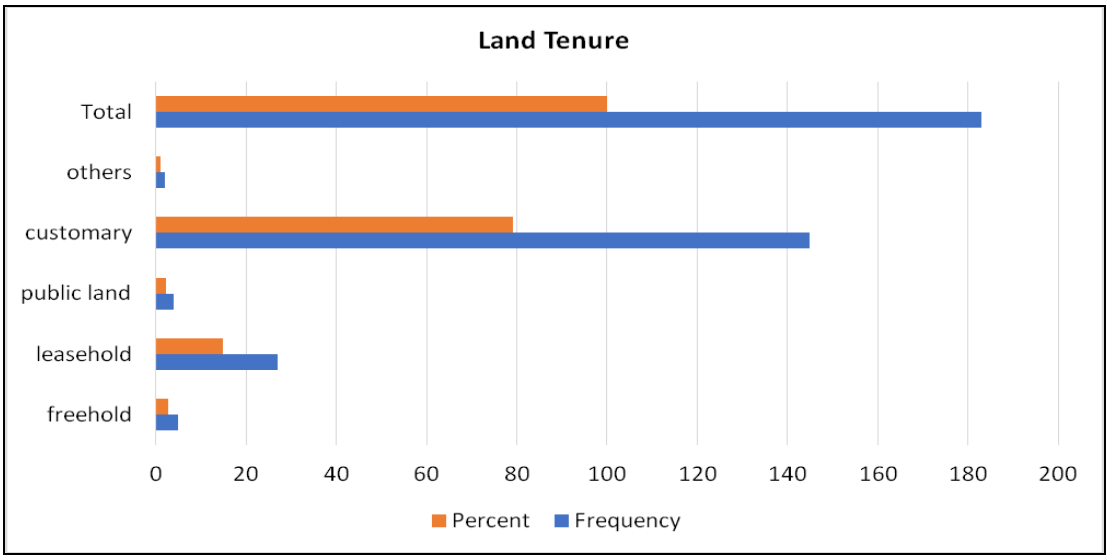


Figure 4.9: Land Ownership / Tenure System

Source: Study Field Survey 2018

Land is critical asset to farmers who directly depend on land resources for cultivation and livestock. In the study area and generally Malawi, three major categories for controlling land can be distinguished: customary land, public land, and private land (Land Act, 1965). The majority 79% of the survey respondents in Ndindi area are under the customary form of land tenure and are referred to as smallholders with small and fragmented holdings. Majority of the respondents having owned customary land in comparison to only 15 % with leasehold (private land), the researcher was prompted to probe further if land tenure system had specific barriers to smallholder farmers' efforts to be climate resilience and food secure.

During the key informants' interviews and FGDs it was clarified that the customary system of land tenure has the traditional concept of considering land in a village as

belonging to the community, but an individual farmer has the right to use the land as though he is the owner. The only identified barrier to meaningful access to and use of land was that customary system of land tenure that is not easily used by an individual farmer as collateral or security for a bank loan since it is the village headmen and chiefs that are key decision makers in customary land matters. The previous finding by (Feder and Noronha, 1987) likewise states that customary land tenure affects land security. Finding from a study done in Thailand by (Routray and Sahoo, 1995) indicates that land titled in an individual farmer's name and can be transferred is accepted as collateral for bank loans. Financial institutions in Malawi require registered fixed assets such as land or buildings as collateral for loans (Diagne and Zeller, 2001).

The study observed fragmentation of smallholders' land holdings and it is on the rise owing to increasing population density in Ndindi TA. It was observed that smallholder agriculture on fragmented pieces of land is associated with low productivity. This finding is in line with (Rahman and Rahman, 2009) study findings in Bangladesh that revealed that land fragmentation has a significant detrimental effect on productivity and efficiency. In their findings, elasticity estimates of land fragmentation revealed that a 1% increase in land fragmentation reduced rice output by 0.05% and efficiency by 0.03%.

In this study's Sustainable Livelihoods Framework, land is a key factor of agriculture production and a component of natural capital as a livelihood asset for smallholder farmers. It is a key natural resource base from which smallholder farmers engage in agricultural pursuits and resource collection for both sustenance

and income generation (Ellis, 2000b). Depending on local contexts, land is a natural asset that smallholder farmers need to increase food production and adaptation to climate change.

4.3 Climate Change Trends for 50 years in Salima District

4.3.1 Introduction

Despite scientists agreeing that the world is getting warmer, it is important that this study assesses whether climate change is a reality that is known and experienced by smallholder farmers in Salima district of Malawi. As part of the research approach, the study was to foremost determine farmers' Knowledge, Attitudes and Perceptions (KAPs) towards climate change in comparison with available meteorological data for 50 years. The researcher ensured to get respondents' knowledge (facts and reality of climate change derived from their experiences), attitude (their way of thinking or feeling about climate change) and perceptions (their thoughts and ideas about climate change). KAPs assessment was to establish if climate change was a reality known to smallholder farmers in Salima district. The researcher assessed meteorological data set for 50 years (*1961 -2015)* for Salima district to compare with smallholder farmers' knowledge, attitude and perceptions of climate change specifically on two aspects of rainfall and temperature patterns.

4.3.2 Smallholder Farmers' Knowledge of Climate Change

Respondents were asked if they have ever heard about climate change before this study's interviews. Interviewers simplified and explained the meaning of climate change as: "long-term changes in the weather/climate especially a change due to an increase in the average atmospheric temperature: leading to unpredicted rainfall and

drought seasons. 'Before this interview, have you heard about climate change?'; Respondents were required to answer; 'Yes', No' or 'Unsure' to the question. Figure 4.10 shows the distribution of responses to the question:

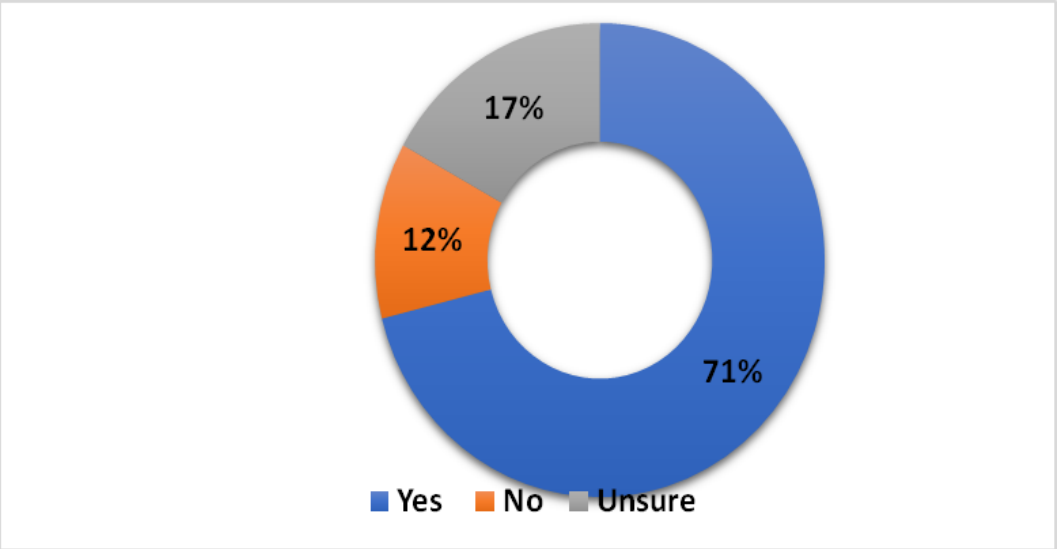


Figure 4.10: Respondents' Awareness of Climate Change

Source: Study Field Survey, 2018

Although most respondents (71%) asserted that they have heard about climate change, 17% were not sure whether they have heard about climate change and 12% denied having heard about climate change. When the researcher interviewed the district environmental officer about increased knowledge of climate change among community members, he attributed this to the repeated occurrence and intensity of drought and floods disasters where the Government, NGOs and other development partners have responded with climate change awareness campaigns.

The district environmental officer also mentioned that the FM radios and mobile phones have strengthened sharing of information on climate change and disaster early warning messages to the rural communities. This finding agrees with (Irfan *et al*. 2006) that the extension agencies are disseminating new technologies through

different means including mass media especially radio as source of agricultural information. During the FGDs the participants asserted that although they have heard about climate change over the radio, they don't understand what causes it.

4.3.3 Farmers' Knowledge and Perception of Climate Change Indicators

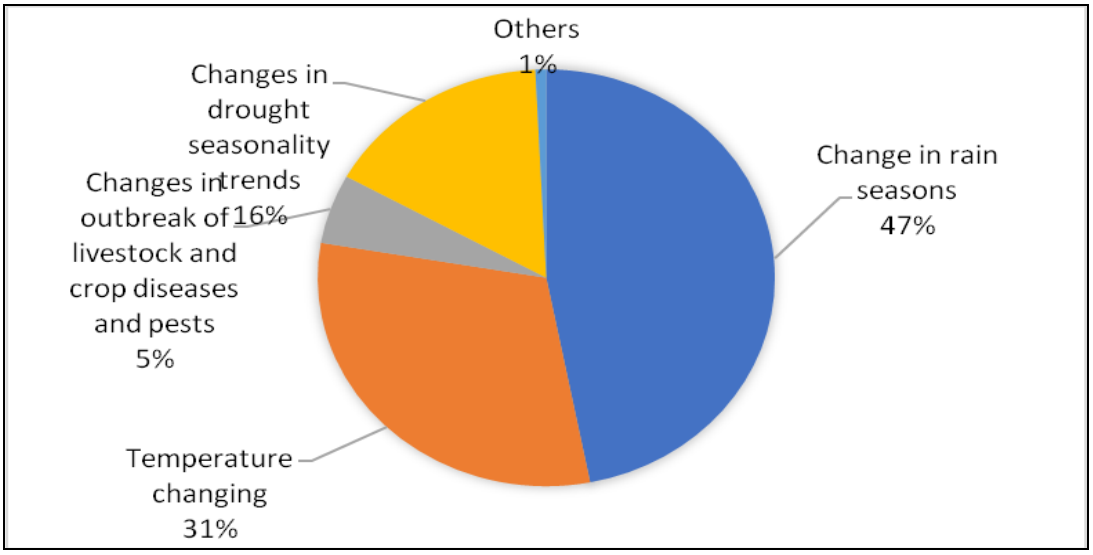


Figure 4.11: Perceived Indicators of Climate change in Local Environment

The researcher further assessed farmers' knowledge and perception of things that indicate the state or level of climate change.To the majority 71% (Figure 4.10) who said 'yes', that they had some knowledge of climate change, they were further asked to point out their observed or felt indicators of climate change. Figure 4.11 shows the distribution of responses. Majority of the respondents (47%) observed and felt that changes in rainy seasons was a key indicator of climate change in Ndindi. However, 31% of the respondents perceived that temperatures were changing. This claim was further explained by FGDs participants who felt that days and nights were becoming warmer than before. 16% and 5% perceived changes in drought seasons and changes in disease outbreaks respectively.

Older FGDs participants testified that they have observed changes in rain and drought seasons for more than the past 50 years. The older people (in their 60s and above) were probed further on what the climate was like when they were young and what has changed. They unanimously testified that the rain seasonality has changed, and they termed this as ‘*’KusinthakwaNyengo*’’ a term in Chichewa (native language) that means changes in the weather and overall climate. During FGDs it was explained that there is a shift in when the rainy season starts.

> “*In the 1960s, 1970s and 1980s rain would phenomenally start in October but these days it comes towards end of December. Moreover, when this rain comes a bit earlier in late November, it is interspersed with dry spells. Most crops grown by us, like maize dry up during unpredictable dry spells that occur in between rain season’’*.70 years old FGD participant at Kuntupa village.

The findings of this study on respondents’ perceptions that reveal presence of climate change indicators in Ndindi TA is confirmed by several previous studies in Malawi. Malawi’s First and Second National Communication reports to the UNFCCC indicate that temperature related extremes; the frequency of hot days and hot nights has increased in all seasons (GoM, 2011). Decreases in annual runoff and increases in evaporation losses have also been found over the period 1971-2017 indicating that decreasing rainfall has practical significance in that Malawi has become more water limited in recent decades (World Bank2015).

Malawi vulnerability assessment by USAID (2013) also revealed a shift in the timing of and amounts of rainfall and increase the frequency and intensity of existing climate hazards particularly droughts and floods. In conclusion reviewed studies confirm respondents’ feelings that Malawi is facing increasing trends in

temperatures (0.9℃ observed 1960-2006); dry days, hotter summers, drought and flood frequency, and inter-annual variability in rainfall is some of the observed changes that negatively affecting agriculture and food security (Zulu 2016).

4.3.4 Salima Meteorological Data for 50 Years

The researcher looked for meteorological data set for 50 years (*1961 -2015)* for Salima district to compare with smallholder farmers' knowledge, attitude and perceptions of climate change especially on two main aspects of climate change that is; rainfall and temperature patterns. The researcher complimented this meteorological data with literature on Salima seasonal changes that generate continuous meteorological information based on Malawi meteorological services data.

4.3.4.1 Temperature Patterns in Salima District

Temperatures in Salima are somewhat warmer. The annual average maximum temperature is 29℃, which doesn't change much over the course of the year. The annual average minimum temperature is 16℃, which rises to 18℃ in the growing season and declines to 14℃ in the winter (DCCMS2018). In figure: 4.12 (Malawi's annual minimum and maximum temperature maps), Salima is shown among districts with hot temperatures. Over the course of the year, the temperature typically varies from 18℃ to 30℃ (DCCMS, 2018).

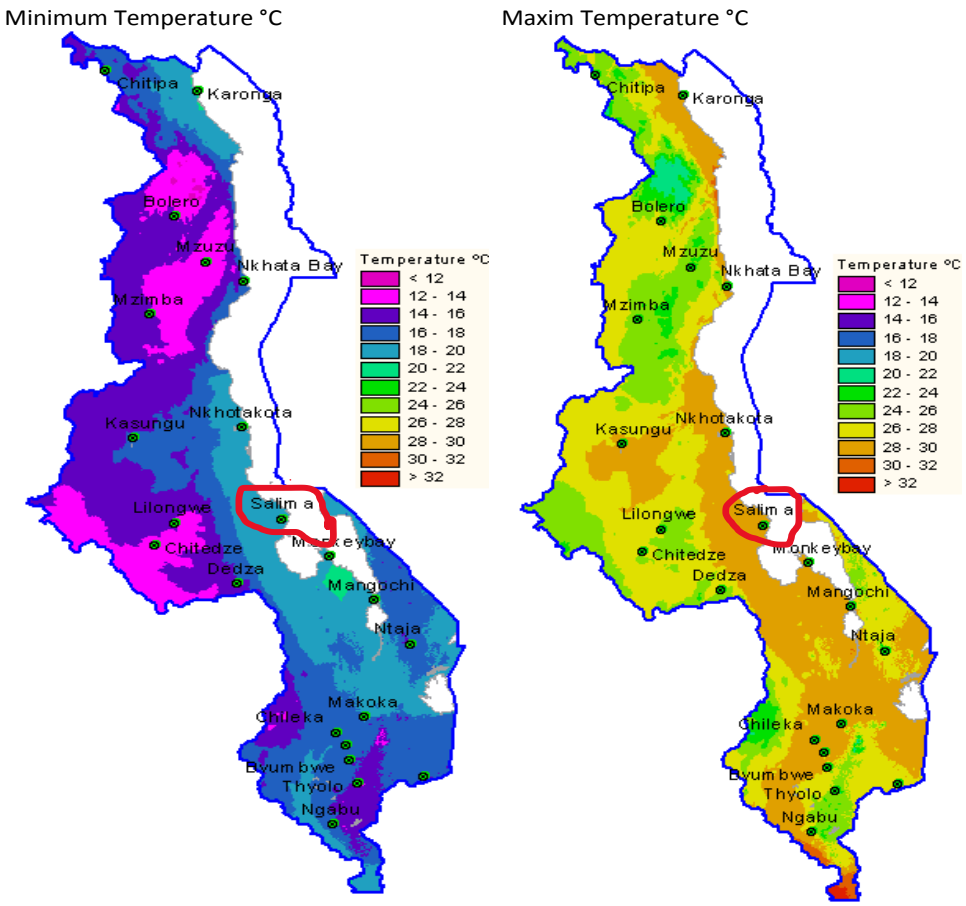


Figure 4:12: Malawi Annual Temperature maps showing

Source: Malawi Meteorological Services 2018

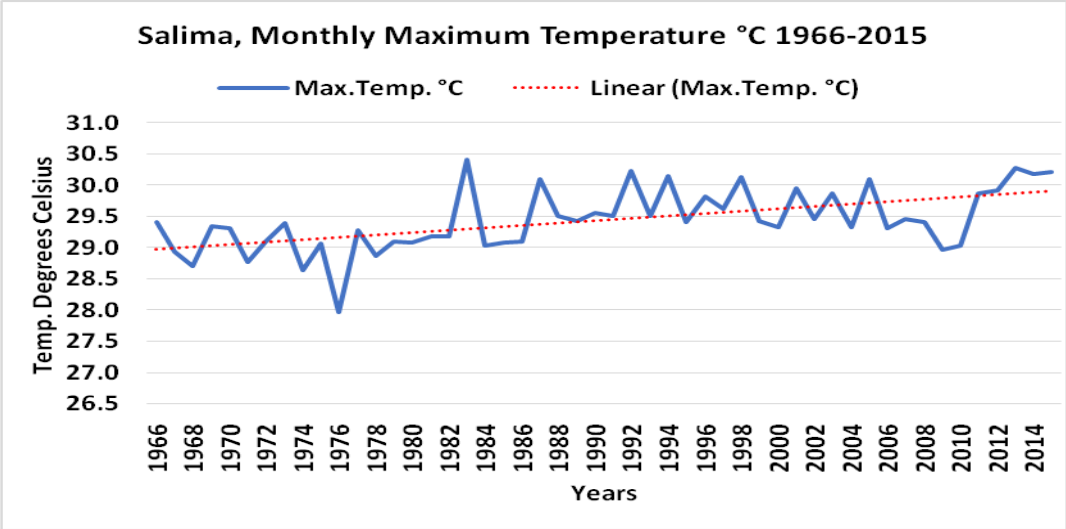


Figure 4.13: Salima Monthly Maximum Temperature (°C) 1966-2015

Source: Malawi Meteorological Services 2018

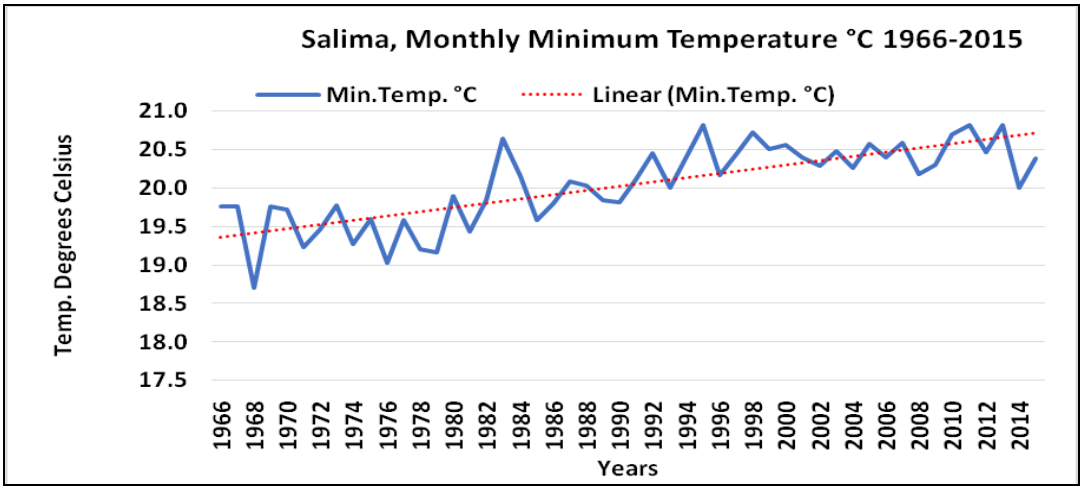


Figure 4.14: Salima Monthly Minimum Temperature (°C) 1966-2015
Source: Malawi Meteorological Services 2018

The meteorological data (1966-2015) assessed by this study, figures: 4.13 and 4.14linear trend lines shows that there has been a slight but steady rise in monthly minimum and maximum temperatures in Salima for over the period of 50 years. When comparing the maximum and minimum temperature trends and patterns, the later indicates more increase in high rates compared to the former. According to (USAID 2012) assessment, it was observed that average annual temperatures have risen by 0.9° between 1960 and 2006, at average rate of 0.21°Cper decade. Daily temperature observations also show increasing trends in the frequency of hot days and nights in all seasons

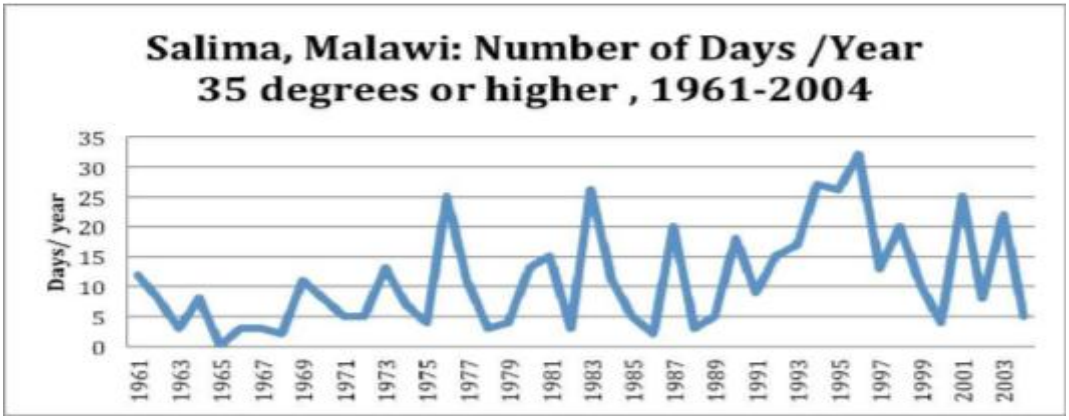


Figure 4.15: Number of hot days over 35°C per year in Salima, 1961-2004.
Source: Malawi Meteorological Services 2018.

The frequency of hot days shows some significant increase albeit highly variable (Figure 4.15). This is in line with survey findings where 31% of the respondent perceived changes in temperatures, and the claim made by FGDs that days and nights were becoming warmer than before (Figure 4.11). The average number of 'hot' days per year in Malawi has increased by 30.5 (an additional 8.3% of days) between 1960 and 2003. Climate change assessments in Malawi indicate that the average number of 'hot' nights per year increased by 41(an additional 11.1% of nights) between 1960and 2003.

The rate of increase is seen most strongly in DJF when the average number of hot DJF nights has increased by 5.5 days per month (an additional 17.6% of DJF nights) over this period (UNDP 2010; USAID 2012). Various localized studies undertaken to document observed and projected impacts of climate change in Malawi. During the Initial (GoM, 2002) and Second National Communications (GoM, 2011) to the UNFCCC revealed that the frequency of hot days and hot nights had increased in all seasons.

Other studies reviewed by this study also indicate that temperature related extremes. Malawi is facing increasing trends in temperatures (0.9°C observed 1960-2006) and hotter summers (Leo, 2016). The rise in frequency of extreme temperature events affecting, especially crops can be expected to become increasingly common, and with serious impact on smallholder farmers' crop production and food security. Moreover, the (IPCC, 2007) Global Circulation Models (GCM) projected that the mean temperature in Malawi would increase by 1.1 to 3.0°C in the 2060's, and by 1.5 to 5.0°C by the end of 2090.

4.3.4.2 Precipitation/Rainfall Patterns

The meteorological data (1971-2014) was analyzed by this study as shown below in Figure: 4.16. Although findings from this study's survey respondents indicate that there was felt decline in rainfall, meteorological observations of rainfall over Salima (Figure: 4.16) do not show statistically significant trends and long-term trends save for the period between 2005 and 2013 that shows a sequential decline in annual total precipitation. In Malawi, there are no statistically significant trends in the extremes' indices calculated using daily precipitation observations (Irish Aid, 2018).

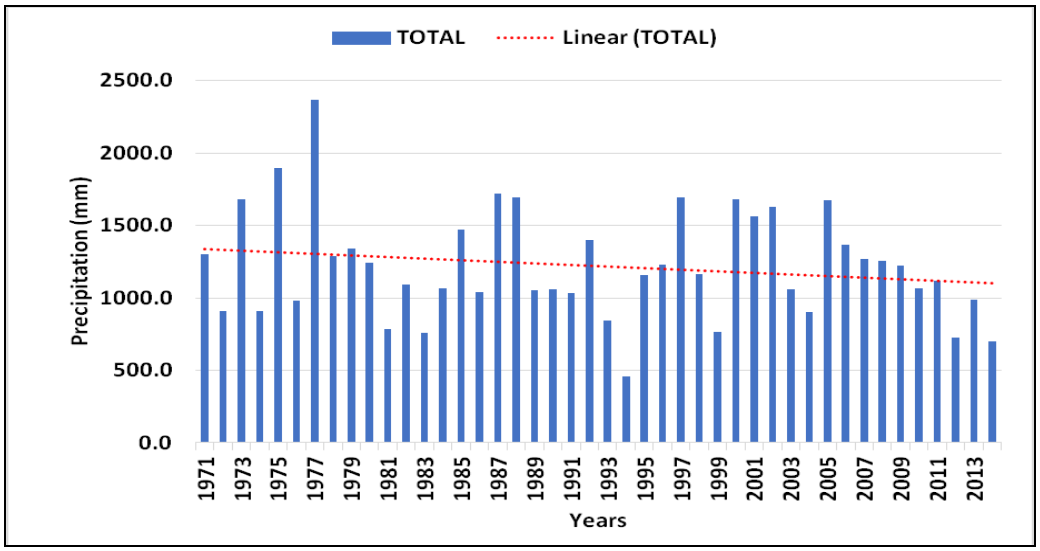


Figure 4.16: Annual Precipitation (mm) in Salima, 1971-2014
Source: Malawi Meteorological Services 2018

Historic data suggests a decrease in annual runoff and increase in evaporation. The Malawi NAP stocktaking report of 2016 indicates incidents of more water stress in recent years. The meteorological data analyzed by this study indicates a year-to-year variability with slight decline in precipitation trend line in Salima. Other analysed studies highlight one of the consequences of a changing hydrological regime as falling water levels in Lake Malawi (GoM, 2016). Surprisingly, findings from a regional analysis for southern Africa from six downscaled General Circulation

Models (GCMs) showed annual rainfall increases for Malawi.

However, Model simulations show wide disagreements in projected changes in the amplitude of future El Niño events. Malawi's climate can be strongly influenced by ENSO, thus contributing to uncertainty in climate projections (McSweeney *et al*. 2014). However, the key challenge to smallholder farmers is that Salima has an annual average of 1251 mm of precipitation most 1213 mm of which falls during the growing season, whereas only an average 38 mm falls during the winter (DCCMS, 2018).

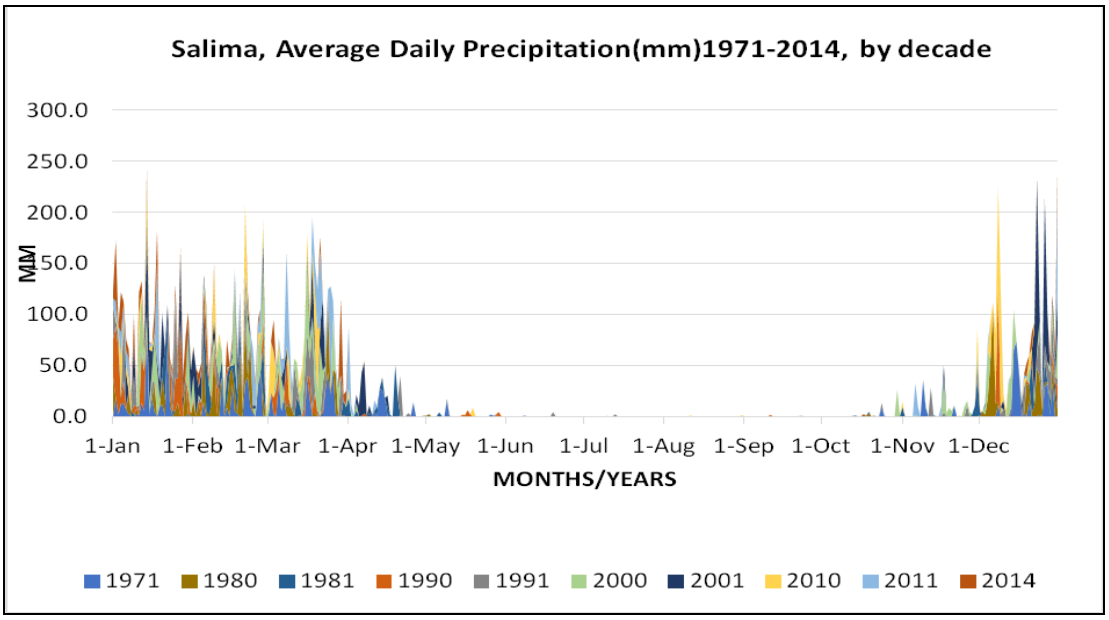


Figure 4:17: Salima, Average Daily Precipitation (mm) 1971-2014, by Decade
Source: Malawi Meteorological Services 2018

The rains start rapidly in November and end abruptly in May. The peak is in December/January/February (DJF). The lack of precipitation for a period of 7 months reduces the ability of smallholder farmers to grow crops. The small holder farmers who vastly depend on the rainfed farming system are affected as they will not produce crops for the larger period of the year that stretches from April to

December. This is one of the reasons why there is increase in food insecurity among small holder farmers. Even though an examination of historic rainfall data of annual rainfall does not show statistically significant precipitation trends, it suggests a decrease in annual runoff and increase in evaporation. Decreases in annual runoff and increases in evaporation losses have been found over the period 1971-2017 indicating that decreasing rainfall has practical significance in that Malawi has become more water limited in recent decades (World Bank, 2015).

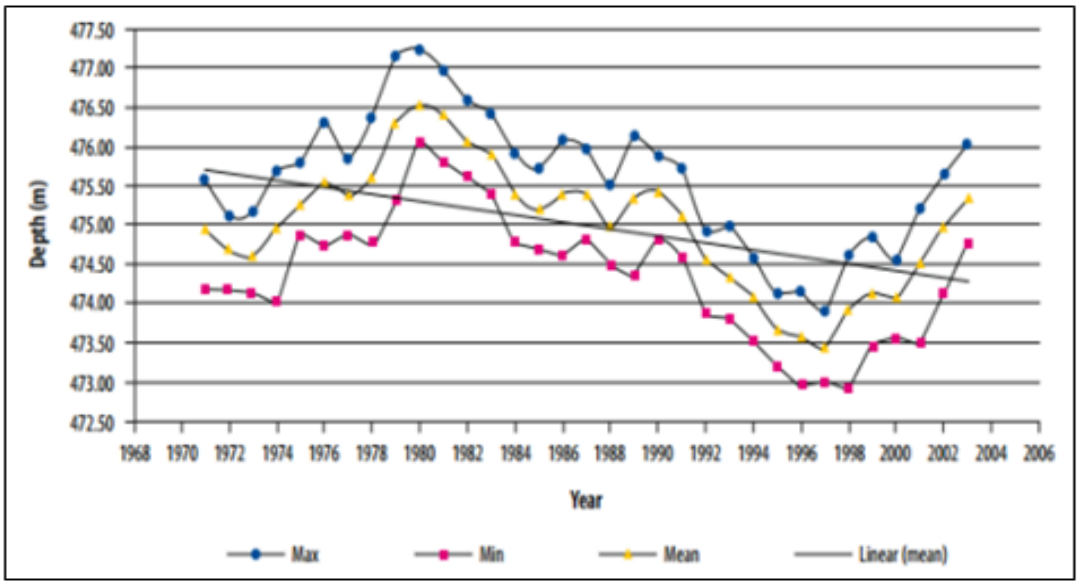


Figure 4.18: Trends in Lake Malawi Water Levels

Source: Malawi State of the Environment Report 2010.

One of the consequences of a changing hydrological regime has been falling water levels in Lake Malawi. The average precipitation for the period between 1970-2013 shows downward trend line which indicates slight but steady decline in amount of annual rainfall for the last 50 years. Despite the declining trend, the meteorological services predict normal to above normal rainfall amounts in most parts of Malawi while normal to below normal rainfall amounts over Salima during the 2018/2019

rainfall season (DCCMS2018). However, it is noted that Salima's total seasonal precipitation can be relatively high but very variable.

Conclusion on Temperature and Precipitation Changes

Climate change will intensify food insecurity as it increases mean annual temperatures and shift the timing of and amounts of rainfall from the current patterns. There is already increase in the frequency and intensity of existing climate hazards particularly droughts and floods. Malawi has historically been prone to both droughts and floods, arising from rainfall variability. The floods of the 2014-2015 rainy seasons were particularly devastating (GoM 2016).

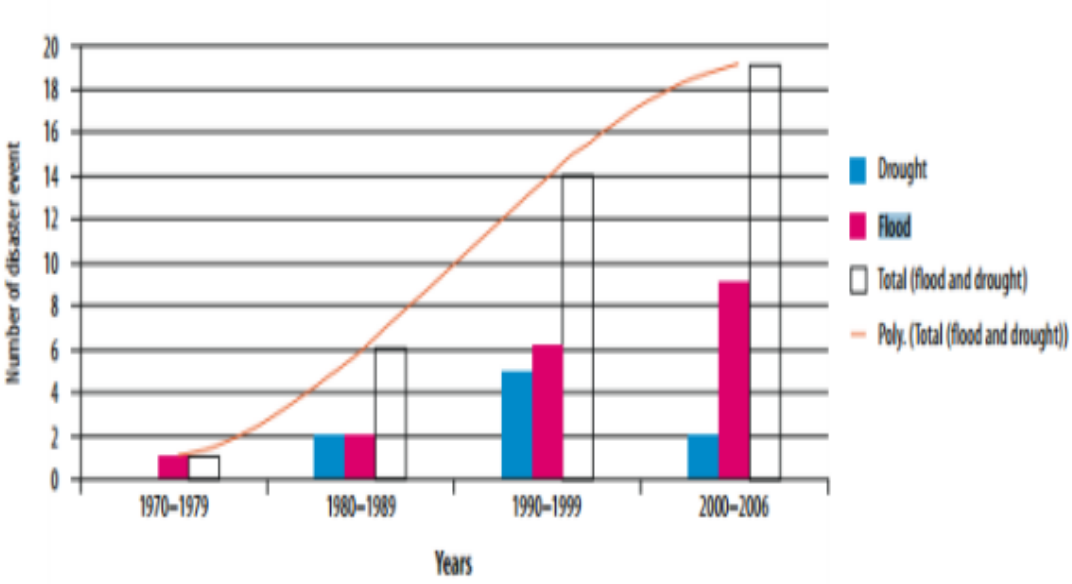


Figure 4.19: Frequency of Extreme Weather Events 1970-2006

Source: State of the Environment Report 2010; Data from Action Aid

In conclusion, the findings of this study lead to a supposition that climate change is a reality in Salima and Malawi. This study portrays an increase over the annual temperature averages often reported by the Malawi Meteorological stations in

Salima. Temperatures are generally slowly warming, particularly minimum temperatures. However, during the period examined, there was little change in average temperatures. The frequency of hot days over 35°C, however, did increase significantly, although this is highly variable. The rise in frequency of extremes is what is expected in climate change. Extreme temperature events that affect crops can be expected to become increasingly common and seriously affecting smallholder farmers' food security. Seasonal information from the department of meteorological service records that the rainy season appeared to be starting later and ending earlier.

There is consensus on cumulative rainfall seasons shifts. In response the government of Malawi is promoting early maturing and hybrid crops because of this shift. However, precipitation trends are not clear in central region where Salima is located, where inter-annual variability is larger than any short-term trend visible in the limited period. Dry spell in mid-January to mid-February appears to be becoming more intense. Farmers' testimonies and other reports assessed show that rainy seasons are getting shorter. Farmers testimonies indicate that precipitation is declining slowly but steadily, particularly in March and April.

4.4 Climate Change Impact on Food Security among smallholders

4.4.1 Smallholders' Perceptions of Climate Change Impactson Food Security

Events such as floods, droughts and diseases were first explained by interviewers on how they are linked to climate change. Respondents were briefed on how extreme climate events can have a serious impact on the environment and society, including food insecurity, loss of life, property and livelihoods. Study team had to explain to respondents that a changing climate leads to changes in the frequency, duration and

intensity of droughts and floods, and will test capabilities of farmer's resilience. Therefore, survey respondents were asked to select climate change impact scenarios that have occurred in Ndindi in the past period of 30 to 50 years. Figure 24 shows the responses.

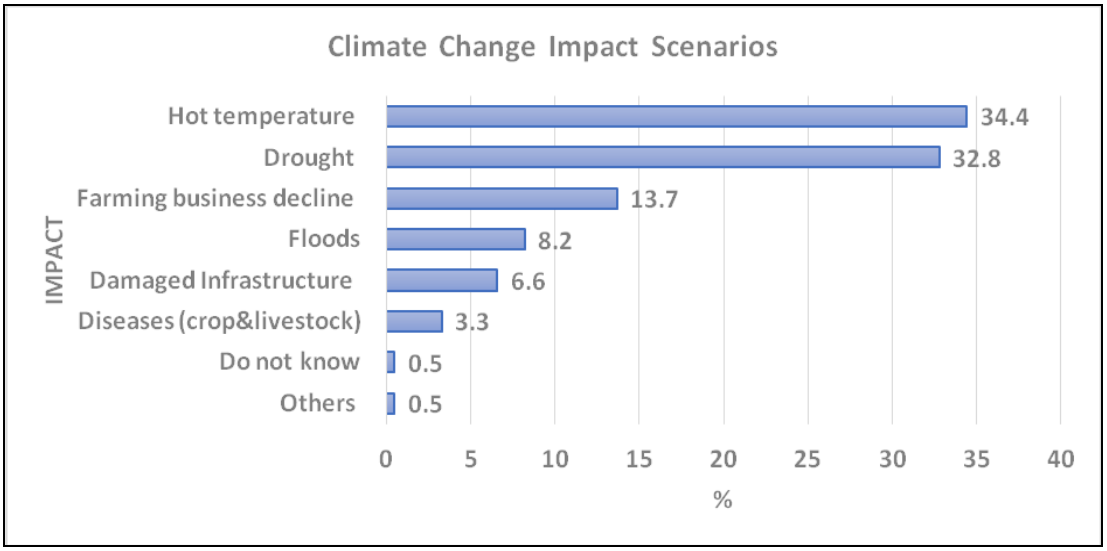


Figure 4.20: Respondents' Perceived Climate Change Impact in past 30 to 50 Years

Source: Study Field Survey 2018

According to the Figure: 4.20, many of the respondents that accounted for 34% and 32% mentioned hot temperature and drought respectively as the most felt impact of climate change. 14% mentioned that farming was wobbly due change in rainfall seasons. The respondents were further asked to clearly point out the common scenarios of the perceived or felt climate change signs or indicators on their environment as shown in table 4.3. This finding agrees with key localized studies that reveal an increase in temperature (GoM2002; 2011, McSweeney *et al*. 2010, USAID 2014) among others.

Table 4.3: Indicators of Climate Change in Ndindi

Climate Change indicators	Frequency	Percent
Change in Rain Seasons	78	42.6
Temperature Changing	30	16.4
Changes in outbreak Livestock and Crop Diseases and Pests	62	33.9
Changes in Drought Seasonality Trends	12	6.6
Others	1	.5
Total	**183**	**100.0**

Source: Study Field Survey 2018

The majority 43 % felt that shifts in rainfall seasons was the most common climate change phenomenon. FGDs participants had confirmed that there were unpredictable delays onset of the rainy season. That rainfall used to start in mid-October but now it was delaying to December or even January. This respondents' discernment of rain season change agrees with information from the Department of Climate Change and Meteorological Services' records that mention that the rainy season appeared to be starting later and ending earlier. 34% of respondents mentioned that there was changes in outbreak of Livestock/Crop Diseases and Pests.

The key informant interview with the district irrigation officer confirms that smallholder farmers in Salima were worried about pests and diseases especially the Fall Army Worm (FAW), a pervasive agricultural pest native to South and Central America that has ruthlessly worked its way across Africa, after arriving in West Africa in early 2016 and making its way south of the Sahara and into Malawi by December of that same year. FAW has spread quickly due to its short reproductive cycle and ability to travel long distances quickly in the adult (moth) stage. Salima was one of the districts where the state of disaster was declared by the president of Malawi on 15th December 2017 due to FAW attack (FEWS NET 2017).

Accordingly, since the onset of the 2017/ 2018 cropping season and as at 8th December 2017, the FAW had affected thousands of hectares and 133,083 farming families. In study area of Ndindi, FAW poses a significant threat to smallholder's food security, following a devastating cycle of drought and flood natural disasters in the past two years. FAW feeds on more than 80 plant species, including cash crops such as cotton in Salima district; it has attacked staple crops such as sorghum, millet, and maize (Ndindi's primary staple crop and food source).

According to the FGDs, the government's pesticide distribution response program is limited yet the cost is generally prohibitive for smallholders. It is likely that climate change will affect the incidence of this pest because the armyworm is dependent on weather, so it feeds on crops and grasses that are dependent on the amount of rainfall, and the pattern of outbreaks depends very much on where rain storms occur and how frequently they occur. As for stalk borers, just like most insects, they are directly under the control of temperature for their growth and it is the most important environmental factor influencing insect behavior.

The IPCC fifth assessment report (IPCC-AR5 2008) confirms a linkage between warming and increased pest and disease. In highlighting the major risk posed by climate change to agriculture — reduction in crop productivity associated with heat and drought stress — the report cites increased pest and disease damage and flood impacts on food system infrastructure as key indicators. Questions were asked to test respondents' fears and hopes about the future amidst climate change. Respondents were asked to agree or disagree to such statements; climate change will reduce quality of life for my children and my grandchildren in future? Living for today is

more important than worrying about the effects of climate change in 50 years' time.

Table 4.4: Respondents Fears and Hopes about the Future amidst Climate Change

Climate Change will reduce quality of life for my children and my grandchildren in future?		**Frequency**	**Percent**
Valid	Agree	180	98.4
	Disagree	1	.5
	Do not know / not sure	2	1.1
	Total	183	100.0
Living for today is more important than worrying about the effects of CC in 50 years' time (Malawi)		**Frequency**	**Percent**
Valid	Agree	13	7.1
	Disagree	167	91.3
	Do not know/ not sure	3	1.6
	Total	183	100.0
How do you feel about CC?		**Frequency**	**Percent**
Valid	Fearful/afraid	63	34.4
	Disbelief/Confused	43	23.5
	Angry/might lose food, culture and lands	27	14.8
	Powerless, I cannot Do anything	27	14.8
	hopeful i.e. I can do some things to adapt	16	8.7
	do not know	6	3.3
	Others	1	.5
	Total	183	100.0
Causes of climate change?		**Frequency**	**Percent**
Valid	Burning bushes	20	10.9
	Degrading forested areas	127	69.4
	Poor farming methods	18	9.8
	Gas emissions from cars, industries	7	3.8
	Do not know	11	6.0
	Total	183	100.0

Source: Study Field Survey 2018

Most respondents (98%) were worried about the future of climate change phenomenon as shown in table 4.4. This finding disagrees with Weber (2010) who asserts that climate change perceptions and fear can be informed by different processes and that the general public are not particularly worried about climate risks. Survey respondents were also asked to point out their feelings about climate change as shown in table 4.5.

Table 4.5: Respondents' feelings about Climate Change Impact

Feeling about climate change impacts	Freq	%
Fearful/afraid	63	34.4
Disbelief/Confused	43	23.5
Angry/might lose food, culture and land	27	14.8
Powerless, I cannot Do anything	27	14.8
hopeful i.e. I can do some things to adapt	16	8.7
do not know	6	3.3
Others	1	0.5
Total	183	100

Source: Study Field Survey 2018.

The biggest number (34%) and 24% expressed fear and disbelief (confusion) respectively. Most smallholder farmers are not certain about the future of farming as the main source of food and incomes. Farmers' fear is justified given that future projections indicate that the climate will continue to change in the coming century at rates likely to be unprecedented in recent human history. The risks associated with these changes are highly uncertain. Smallholder farmers' vulnerability to the risks associated with climate change may exacerbate ongoing social and economic challenges, particularly since they dependent on resources that are sensitive to changes in climate.

Ndindi population depend high climate risk sectors such as agriculture and fisheries as main source of food security and livelihood. The major challenge is that the smallholder farmers in Ndindi need to enhance their adaptive capacity to face both present and future climate change outside their experienced coping range. The primary challenge, therefore, posed at both the scale of local natural resource management and at the scale of international agreements and actions, is to promote adaptive capacity in the context of competing sustainable development objectives

(Adger *et al*. 2003). To assess respondents' knowledge of climate change causes, the following question was asked; what do you think are the causes of climate change?' The following figure shows the distribution of responses.

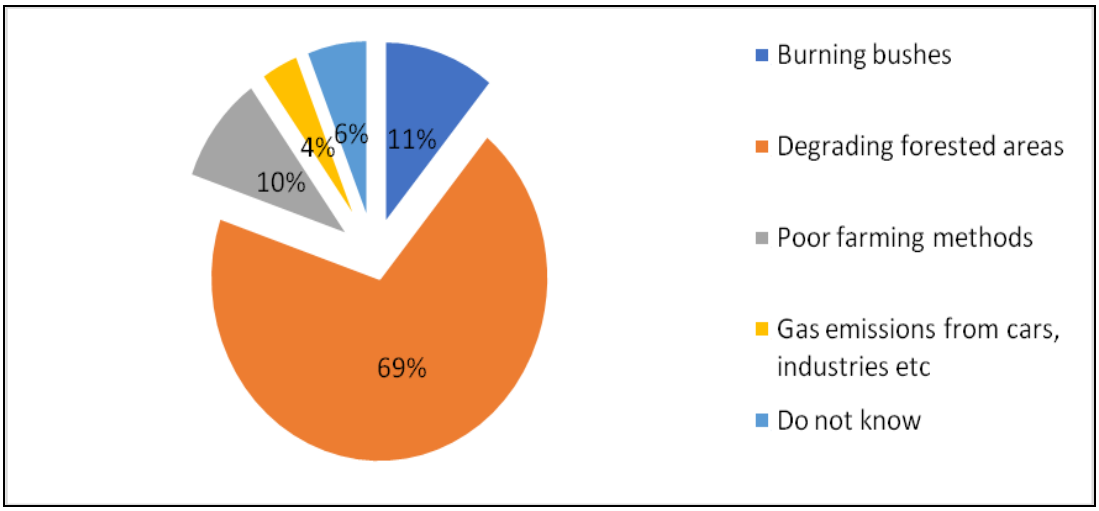


Figure 4.21: Perceived Causes of Climate Change
Source: Study Field Survey 2018

Figure 4.21 shows that the majority (69%) of the respondents mentioned that climate change is caused by degradation of forests. This was followed by 11% and 10%who mentioned burning of bushes and poor farming practices respectively. 6%were not aware of the causes while only 4% mentioned Greenhouse Gases emissions (GHGs). This partly indicates that there is inadequate knowledge or awareness of climate change among smallholder farmers. Scientific research classifies the major cause of climate change as being human induced largely through GHGs (mainly CO2) emissions. The IPCC (2007a, p.013) determined that human activities have grown since pre-industrial times. For example, there has been 70% increase in GHG emissions between 1970and 2004. Degradation of forests in study area is not a direct cause of climate change impacts in the area but global, large GHGs emissions schemes.

Malawi as a country contributes very little to global emissions of GHGs. Therefore, for Malawi, climate change only interacts with environmental degradation in this case. Malawi's total GHG emissions in 2011 were 10.85 million metric tons of carbon dioxide equivalent (MtCO2e), totaling 0.02 percent of global GHG emissions. However, available data shows that 56 percent of GHG emissions in Malawi came from the land-use change and forestry sector, followed by the agriculture, waste, and industrial processes sectors which contributed 40 percent, 2 percent, and 2 percent respectively to country level GHG emissions (USAID 2016). This may also indicate that Malawi has significant problems in land-use, forestry and agriculture sectors management.

4.4.2 Climate Change Perceived Direct Impacts on Food Security

Respondents were asked; during the last 10 years that you are farming/fishing, did you notice any trend of climate or natural phenomena that affected your crop, livestock, and fisheries production in your village? 98% survey respondents checked [yes] and indicated their perceived intensity of climate change impact on food security as shown in table 4.6.

Table 4.6 shows that crop farming is professed by respondents as the most affected by both droughts, pest and diseases and flooding. This finding agrees with a study done in South America by (Seo and Mendelsohn, 2008) who found out that climate change affects the crops that South American farmers choose and that this has resulted to confusion as farmers switch away from maize, wheat, and potatoes towards squash, fruits and vegetables.

Table 4.6: Climate change Direct Impacts on Food Security among Smallholder Farmers

Nature of Climate change impact on food security	Intensity of Impact						
	Impact	Impact According to Sector					
		Crops	*How times occurred*	*Livestock and poultry*	*How times occurred*	*Fisheries*	*Number of times occurred*
Flooding before end of growing or harvest season of maize and/or other crops	*M*	*M*	*1*	*L*	-	*L*	-
Drought after planting of maize and/or other crops	*H*	*H*	*2*	*M*	*1*	*L*	-
Prolonged rainfall/flood during wet season	*M*	*M*	*1*	*L*	-	*M*	*1*
Prolonged drought during dry season	*M*	*H*	*1*	*M*	*1*	*M*	*1*
Pest and diseases during wet season	*M*	*H*	*1*	*M*	*1*	*L*	-
Pest and diseases during dry season	*M*	*H*	-	*M*	-	*L*	-
KEY: Risk level -***H****-high;* ***M****-medium; and* ***L****-low.* *Under the sub-sectors used the same alphabets. On the number of times occurred, study used the following: 1-once; 2-twice; 3-thrice; 4-four times; 5-five times.*							

Source: Study Field Survey 2018

Drought was the most highly rated climate change hazard by respondents who said it was negatively affecting food security among the smallholder farmers in Ndindi TA. During the two rounds of FGDs, it was explained that dry spell (January and February) after planting of maize and/or other crops and prolonged drought (from March to December) affected crop production and food security more than any other events since smallholder agriculture dependents on rainfall distribution in a year. Dryness and erratic rains during the 2017/18 cropping season were highlighted as an example that frustrated smallholder farmers and led to poor harvest of maize. This finding is in-line with (IPCC 2018) report that rates drought as significant risk to farming.

According to IPCC, risks from droughts and precipitation deficits are projected to be even higher at 2°C compared to 1.5°C of global warming in some regions (medium confidence) especially in several northern hemisphere high-latitude and/or high-elevation regions, eastern Asia and eastern North America (medium confidence). Table 4.6 further shows that survey respondents acknowledge that there was crop loss to insects and diseases. This is complemented by FGDs findings that mentioned that;

> "*The Fall Army Worm attack in 2016/17 season that especially affected maize*".

It should be noted that climate change is expected to bring with it an increase in agricultural pests, which will lead to significant crop loss. Flooding was rated a medium climate change hazard/risk to food security as it was a higher risk to settlement than crops and livestock. During the FGDs meeting participants mentioned that they were aware of the El Nino weather phenomenon as key in causing floods in almost every February of the year. The February 2017 floods in Ndindi Traditional Authority and neighboring Mtauchila Village was the most remembered event where floods intensified from Lifidzi River that burst its banks destroying homes, crops and the road network. During this flood episode, it was mentioned by FGDs participants that there was also decipherable damage in maize farms a situation that worsened food shortages during the same year. Salima is said to be experiencing intensified rains in February of every year which result in flooding of low-lying areas of the district.

The impact of climate change events (drought and rainfall changes) on fishery sector was not so obvious but the common fish, Oreochromis specie known as ''Chambo''

in local Chichewa language is said to have declined in catch. According to FGDs and the interview with Salima district environmental officer, the decline in this fish catch can be considerably attributed to several factors such as overfishing. However, a study that carried out statistical relationship between chambo catch and interdependent variables of temperature and rainfall provides evidence that climate change has a significant adverse impact on the total landings of chambo fish in Salima district and generally in Lake Malawi (Makwinja and M'balaka 2017)[3].In Lake Malawi, evidence suggests that both warming and eutrophication influence fish stocks (Vollmer *et al*. 2005). However, there need for evidence to determine whether decline in fish stock is attributed to rising water temperatures, lower and warmer inflows into the lake or limited overturning. At shallow lakes such as Lake Chilwa, surface area and water levels fluctuate with regional rainfall.

Fish catches, fishing activity and livelihoods mirror these observed fluctuations (Jamu 2011, Jul-Larsen *et al*. 2003). While fish stocks are directly affected by changes in climate variables, the volume of fish catches is much more difficult to attribute to climate because of a multitude of confounding human factors. Fisheries resources in Salima are mostly threatened by overfishing and a failure to observe laws and regulations for sustainable use of fisheries. Additional threats are related to changes in land use, particularly conversion of forests to cropland, expansion of small-scale irrigation through stream diversion and agricultural development near rivers and water bodies. In Ndindi climate change is said to be having a negative

[3]Makwinja R and M'balaka(2017).Potential Impact of Climate Change on Lake Malawi Chambo (Oreochromis spp.) Fishery. Department of Physics and Biochemical Sciences, The Polytechnic, University of Malawi, Private Bag 303, Blantyre 3, Malawi

impact on crop yields. This has led to more farmers shifting away from crop farming to fishing. There was reported pressure on fisheries resources. There is need to take climate change adaptation measures in fishery sector to limit species' extinction.

4.4.2 Climate Change Specific Impacts on Food Security Pillars

In 2009, the World Summit on Food Security stated that the "four pillars of food security are availability, access, utilization, and stability" (FAO, 2009). This study analysed how climate change spreads its impacts across food security four pillars among the smallholder farmers in Ndindi TA. The findings are summarized in table 4.7

Table 4.7: Climate Change Impact across 4 food security pillars

Pillar	Impacts of Climate Change in Ndindi
Pillar 1: Food Availability	The impact of climate change on food security in the case study area is more felt on food availability component due to declining agricultural productivity. As elaborated in the findings section 4.2 (Demographic Characteristics and Climate Change Vulnerability Context), food availability in study area is directly affected by increase in temperature, changes in rainfall amount and patterns that lead to droughts and floods extreme events. For example, Salima was one of the 15 districts affected by floods and drought in 2015/2016 agriculture season. A state of emergency was declared by the President of Malawi on 13 January 2015 after heavy floods. One year later state of national disaster was declared on 13 April 2016 following prolonged dry spells during the 2015/16 agriculture season. These two events led to increased maize deficit, and number of people were food-insecure and required humanitarian relief assistance for the whole 2016-17 consumption year (FEWS NET 2016). The implications of climate change for food availability is also due to the vulnerability of Ndindi smallholder farmers, who have been found to have low capacity to adapt. Food availability would require adapted production that is determined by land ownership and use, soil management, crop diversification and management, resilient livestock breeds and proper harvesting and post harvesting handling. Smallholder farmers in Ndindi lack resources to adopt climate smart agriculture technologies.
Pillar 2: Food Access	Access means physical and economic access to food that is determined largely by purchasing power and income of the population. Majority who comprised 30% of respondents stated that they were not earning and that if they got money, it ranged from 0-10,000 Malawi Kwacha per quarter. This is followed by 27% and 12% who earned between 11,000 Mk-19,000 Mk and 20,000-29,000Mk respectively. Even this category was still earning less than $50 per a quarter. Most of the respondents who earned between 0-10,000MK were in fact earning a maximum of $15 according to 2018 average exchange rate. Only 19% of all survey respondents earned above $50 per quarter and majority of these were said to be in formal employment and fishing sectors. Crop farmers had the lowest quarterly incomes. Moreover,

Pillar	Impacts of Climate Change in Ndindi
	smallholder farmers in study area vastly depend on nature-based agriculture for both livelihoods and incomes. In such circumstances where there is low agriculture productivity, farmers will have fewer incomes to purchase food in enough quantities and quality. Other factors that affect access to food in Ndindi include high food prices during famine, access to markets, the level of poverty, unemployment condition and dependence ratio, educational status and land/property rights as assessed in the previous sections on socio-economic findings. There is also high food price inflation. Cost of food in Malawi increased 10.40 percent in October of 2018 over the same month in the previous year. Food Inflation in Malawi averaged 21.20 percent from 1990 until 2018, reaching an all-time high of 113 percent in July of 1995 and a record low of 2 percent in September of 2003 (NSO 2018)[4].
Pillar 3: Food Utilization	Climate change affects food utilization capacity through challenges to production rate and pattern of different food items and this affects Ndindi smallholder farmers' nutritional requirements. Food utilization depends on how food is used, whether food has sufficient nutrients and whether diet can be maintained. In case of Ndindi, smallholder rain-fed maize production is main crop and the livestock sub-sector is underdeveloped. Fishing activity would complement nutrition but most of the fish caught is not consumed by households as it is sold. Climate change is affecting the income and capacity of the smallholder farmers to purchase a diversity of food items to get a balanced diet. Cost of food in Malawi increased 10.20 percent in September of 2018 over the same month in the previous year. Food Inflation in Malawi averaged 21.23 percent from 1990 until 2018, reaching an all-time high of 113 percent in July of 1995 and a record low of 2 percent in September of 2003 (NSO 2018)[5]. For this, climate change (extreme weather events) is one of the root causes of the recent high and volatile food prices in Malawi. Due to this high food price, smallholder farmers in Ndindi spontaneously reduce both quality and/or quantity of food they eat, consume less preferred food and allocate nutritious food only to infant household members.
Pillar 4: Food Stability	Food stability which refers to the ability to obtain food over time. Accordingly, food insecurity can be transitory, seasonal, or chronic (FAO, 1997). In transitory food insecurity situation of the study area, food is more available during maize harvest that starts in April-July. Food may also be unavailable especially in later and early months of the year (October – march). Below-normal rainfall in Ndindi more often findings in below-average production that causes localized food deficits as well as reductions in income from major cash crops. At the time of analyzing findings of this study, food security projection indicated a likelihood of localized acute food insecurity in study area, especially during the lean period starting from October 2018 to March 2019 (FEWS NET 2018)[6]. At the food production level, climate change disasters such as floods and droughts that regularly occur in the study area result in crop failure and decreased food availability. This often causes instability in markets resulting in food-price spikes which can cause transitory food insecurity. Seasonal food insecurity is not key since Ndindi does not experience regular pattern of growing season in food production. According to the study respondents, there has not been one farming season that has ever been the same as the other. This may be because of season to season differences in weather patterns, particularly rainfall among other factors especially with dry land farming. For example, the 2015-2016 agriculture season was characterized by national declaration of floods and drought disasters, nevertheless this was followed by 2016-2017 (PDNA 2016) season that had copious rains that matched good agriculture season in Ndindi and Malawi at large. However, rainfall season in Ndindi is said to always characterized by a short

[4]National Statics Office of Malawi 2018: https://tradingeconomics.com/malawi/food-inflation
[5] National Statistical Office of Malawi 2018. https://tradingeconomics.com/malawi/food-inflation
[6]FEWS NET 2018.Malawi Food Security Outlook Updatehttp://fews.net/southern-africa/malawi/food-security-outlook-update/april-2018

Pillar	Impacts of Climate Change in Ndindi
	planting window which farmers are aware of and somehow better in their season preparedness to suit the short planting window which has decreased climate change pushed chronic (or permanent) food insecurity. Climate change is likely to cause both chronic and transitory food insecurity, since repeated climate disasters can lead to the reoccurrence of transitory food security which makes households more vulnerable to chronic food insecurity.

Source: Based on the analysis of field survey findings and secondary data.

4.5 Smallholders' Adaptation Strategies

According to Adger *et al*. (2004), adaptation to the impacts of climate change should increasingly be observed in both physical and ecological systems as well as in human adjustments to resource availability and risk at different spatial and societal scales. They further espoused an argument that the way adaptations are being judged at different scales, will involve new and challenging institutional processes. In the same effort this study intended to assess adaptation among smallholder farmers in the lens of; physical and ecological systems as well as farmers' adjustments to livelihoods resource availability and risk at different spatial and societal scales. Therefore, the study assed knowledge, attitude and perceptions of smallholder farmers in their natural environment towards adapting to climate change impacts on their food security. Focus was on an individual farmer's response to climate change that seeks to reduce the vulnerability of socio-economic and natural resource systems. This was intended to assess capacity and potential for the target communities to adapt to climate change felt impacts.

4.5.1 Adaptation Learning by Smallholder Farmers

Respondents were asked about how they learn about climate change. Figure 4.22 shows that radio, newspapers and mobile phones were preferred (78%) as the best mediums for learning about climate change.

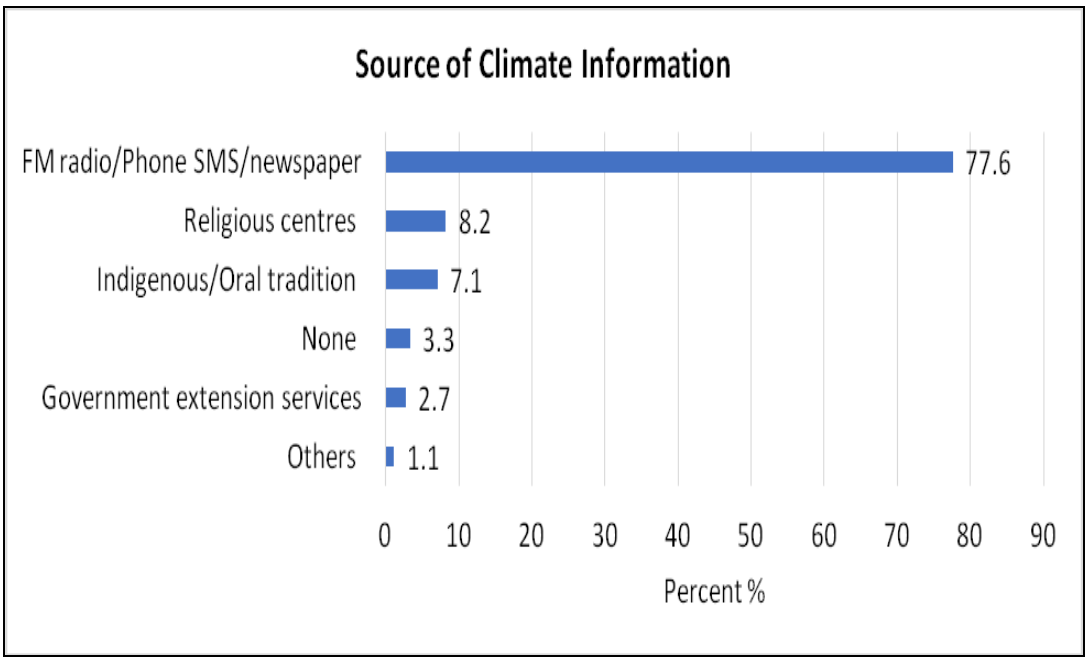


Figure 4.22: Source of Information about Climate Change

Source: Study Field Survey 2018

The FGDs participants confirmed that Radio is the utmost source of information they have ever heard something concerning climate change and other development messages. While only 8% and 7% of the survey respondents have heard of climate change through religious places of worship and oral traditions/indigenous knowledge respectively. There was 3% of survey respondents that admitted having not got climate information while 4% claims that they have got information from other sources such as political rallies and personal observation. This means that the FM radios and newspaper channels of information can be more important for grassroots communities to get the information on climate change.

During KIIs with the district environmental officer asserted that;

> ''*the evolution of FM radio is a very important medium in creating climate change awareness. There are various radios broadcasting in Salima and with reach to Ndindi TA. Common radios include Zodiak Broadcasting Station, Chisomo FM and Love FM among others''.*

These radios offer their services as both geographical and community interests since they were broadcasting beyond commercial and public services. This finding is in conformity with the view espoused by Nwagbara *et al*. (2017) that the Radio is a very important medium in creating awareness and response to climate change among smallholder farmers in Edo, Nigeria. FGDs participants at Kalonga II village also underscored the emerging use of telephone where early warning and market information is to some extent is shared. That there was use of social media tools especially WhatsApp and Facebook to share information though most conversation over social media was not revolving on climate issues.

Although social media may play a vital part in the climate information sharing, some FGDs did not like it as they claimed that rumours and fake news are being spread through this channel of communication. Although Social media groups can be used to spread false and incorrect information about agricultural practices. This finding is in line with Thakur *et al*. (2018) study that was carried out in Northern India, Pradesh. The findings underscore WhatsApp social media platform as one of the emerging online destinations for rural mobile internet users with a sharp growth and a strong case to use social media platforms for dissemination and sharing of agricultural information among the farming community.

4.5.2 Smallholder Farmers' Adaptation Supportive Services

Survey participants were further asked to identify supportive services available to enable them to adapt and ensure food security. What are the specific climate information/knowledge services available in your community? Table 4.8 shows the responses.

Table 4.8: Climate Change Adaptation Services Available

Information Services	Frequency	Percent
Agriculture extension services	105	57.4
Market based climate smart agriculture technologies e.g. drought resistor cultivators/ seeds/fertilizer	23	12.6
Demonstration farms	35	19.1
Weather/ seasonal prediction guides	13	7.1
None	5	2.7
Others	2	1.1
Total	183	100

Source: Study Field Survey 2018

Majority of the respondents 57% mentioned that the public Agricultural Extension services are one of the major sources of climate services to smallholder farmers. Under ministry of agriculture, irrigation and water development. 19% mentioned they accessed demonstration farms that promoted by lead farmer model.13% were getting market-based services such as climate smart agriculture technologies (for example drought tolerant seed varieties). While 7% claimed to access climate early warning and season prediction outreach services 3% said they had not accessed any of the above mention climate services. Survey respondents were further asked; if you needed help (physical and skills) to adapt to climate change adverse impacts, how would you go about it?

Table 4.9: Where Farmers Seek Help to Adapt to climate change

Source of support	Frequency	Percent
Seek help from own family	19	10.4
Join cooperative/ farmer group	19	10.4
Govt /local council/ agriculture extension for advice	133	72.7
Discuss and plan with villagemates	6	3.3
seek help from charities/ NGOs	4	2.2
None	2	1.1
Total	183	100.0

Source: Study Field Survey 2018

From Table 4.9, majority (78%) of respondents mentioned that they would seek help and advice from government system especially the agriculture extension service. 10% would seek help from fellow farmers through their cooperative groups or cooperatives. While 10%, 3% and 2% would seek help from family, talk to village mates/neighbors and seek help from charities/NGOs. This means the local communities still have hopes in the government to give adaptation solutions. This finding agrees with Sustainable Livelihood and Transformational Adaptation frameworks that asserts that structures and processes which are largely government-based play important role (Scoones, 2015) in smallholder farmers' adaptation.

According to Malawi's administrative structures and processes, extension workers are positioned at district level and the lowest levels of formal structures (GoM, 2016).They are also in the destination of agricultural extension service policy implementation. However, Government structures and processes require a sound understanding of the barriers to adaptation among smallholders since adaptation decisions are not made in a vacuum – the adaptation options and incentives available are shaped by a range of non-climate related policies and institutional arrangements.

4.5.2.1 Farming Technology Available

Respondents were also asked to name any farming technology that was being used by them and their neighbors to continue farming activities in the event of extreme flood/drought. Table 4.10 shows responses.

Table 4.10: Farming Technology Used by Farmers to Adapt to Climate Change

Technology	Frequency	Percent
Plant native (indigenous) varieties of crops	65	35.5
Change cropping calendar/cropping pattern	45	24.6
Introduce improved crop and animal species	41	22.4
Irrigation	15	8.2
Alternative food source - trading/ employment	5	2.7
Migration	8	4.4
None	4	2.2
Total	183	100.0

Source: Study field Survey 2018

Most of the respondents 36% asserted that they were still depending on indigenous knowledge and varieties of crops to survive the harsh environmental changes. Even the 24% who said that they change cropping calendar/cropping pattern, attributed this to their traditional coping strategies. Only 22% mentioned that they adopted improved crop and animal species to adapt and ensure food security. This finding agrees with (Twinomugisha, 2009) study among farmers in Uganda which revealed that indigenous knowledge is an integral part of smallholder farmers' lives and local coping strategies.

Similarly, adaptation strategies among the studied Ugandan farmers were based on existing knowledge on how to cope, an understanding of seasonality and past experience. From African Sahel region (Nyong *et al*. 2007) study reveals that the local populations in this region, through their indigenous knowledge systems, have developed and implemented extensive adaptation strategies. Nevertheless, the indigenous knowledge is rarely taken into consideration in the design and implementation of modern and adaptation strategies by governments.8% of survey respondents mentioned that as an adaptation measure they have practiced irrigation on small scale during winter cropping.

Figure 4.23: Small Scale Irrigation activity in Ndindi, Chipoka Extension Planning Area
Source: Study Field Study 2018

Since drought is the most climate change challenge for smallholder farmers' food production in the study area, irrigation would be robust climate smart agricultural (CSA) technology to be deployed. To take advantage of the potential that irrigation has as a key CSA technology to propel both food security amidst climate change pushed drought risks, there is need for government and other development agencies to support smallholder farmers with necessary irrigation infrastructure. According to (Turral *et al*., 2007), adaptation measures need to build upon improved land and water management practices to boost resilience to climate change. Rural farmers' adaptation responses will need the water variable in agriculture irrigation and the competing demands from other users. Freshwater availability is relevant to almost all socioeconomic and environmental impacts of climate and demographic change and their implications for sustainability (Elliott *et al*., 2014).

4.5.2.2 Smallholder Farming system

Survey participants were asked to describe their current system of farming in average normal production period. Figure 4.23 show responses.

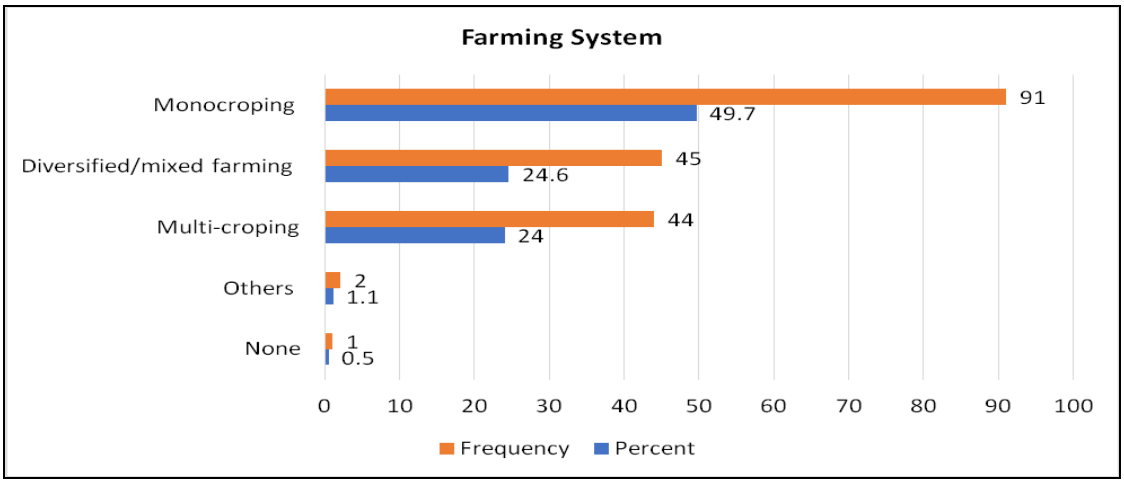


Figure 4.23: Farming Systems
Source: Field Study, 2018

Majority (about 50%) were still practicing mono-cropping. Only 25% and 24% of the survey participants practiced mixed farming and multi-cropping systems respectively. This indicates that majority of smallholder farmers are still stuck with mono-cropping. This finding agrees with (FAO, 2018) assessment which revealed that in Malawi, Zambia, and Mozambique maize monocropping is dominant though farmers currently adopt one of seven different cropping systems, based on a combination of four categories of crops: dominate staple (maize), alternative staples, legumes and cash crops.

For farming system adaptation, a diversified cropping system is needed among small holder farmers to contribute to climate smart agricultural pillars. Through crop diversification, farming households can spread production and income risk over a

wider range of crops, thus reducing livelihood vulnerability to weather or market shocks. Crop diversification has potential to produce other paybacks such as in terms of pest management and soil quality. Moreover, diversified systems reduce crop income variability compared with monocropping maize. The greatest potential opportunity for increasing agricultural productivity exists through mixed farming in the sub humid and wetter parts of the semi-arid zone of Sub Saharan Africa (Powell and Williams, 1995; Bradshaw *et al.* 2004). FGDs participants mentioned that they are reluctant to change their practices especially maize mono cropping due to lack of high-quality seed for other crops. However, it was mentioned by FGDs that farmers desired a practice of mixed farms where animals give manure to crops and crops provide fodder for animals.

4.5.2.3 Climate Change Disaster Reduction Measures by Smallholder Farmers

Survey respondents were asked to describe the climate change disaster reduction strategies they applied to ensure that climate disaster losses and impacts are sustainably reduced in their agriculture practices. This was intended to identify key opportunities were available for disaster risk management in the study area. Table 4.11 presents the findings on climate change disaster risk reduction strategies.

Table 4.11: Climate Change Disaster Risk Reduction Strategies

Climate Change Disaster Risk reduction strategies	Frequency	Percent
Civil Protection Village Committees	58	31.7
Storage facilities for harvested produce	22	12.0
Livestock pens/ corrals on elevated places	34	18.6
Evacuation centers / shelters	21	11.5
Extension services / early warning system	14	7.7
NGOs/Government protection system	17	9.3
None	17	9.3
Total	**183**	**100.0**

Source: Field Study FGDs, 2018

Most survey respondents who were about 32% mentioned Civil Protection Committees (CPC) at district, area and village levels as one of the structures available to help respond to climate change disasters. 18%, 12% and 11% mentioned livestock pens/ corrals on elevated places, storage facilities for harvested produce and evacuation centers. Majority of respondents have faith in village civil protection committees that are linked to the national disaster risk management policy (GoM, 2015)[7].

It was mentioned by the Salima environmental officer that the District Commissioner coordinates disaster risk reduction programmes at district, area and village levels through village civil protection committees (VCPC). VCPC, are expected to be the first line of coordinating village response to disasters. However, it was mentioned by FGDs members that the VCPCs were not quite active due to lack of resources and materials. For example, they face operational challenges during the rains since they lack protective gear to shield them from getting soaked and muddy.

Although some respondents identified evacuation centres as a disaster risk reduction strategy in their area, it was also mentioned that save for schools and religious centres where people run to in case of a floods, there was lack of specific evacuation facilities equipped for such purpose. People end up sleeping in churches and school blocks which are not safe to withstand the heavy rains. FGDs point to the fact that smallholder farmers can't afford materials for building stronger dwelling and storage structures. The food storage facilities and dwelling houses are easily damaged when there are heavy rains.

[7] Government of Malawi (2015). National disaster risk management policy,2015

4.5.3 Smallholder Farmers' Indigenous Adaptation Strategies for Food Security

The smallholder farmers in the study area, like other countries in Africa, have their own indigenous coping ways and adaptation practices of producing, preserving and storing food for future use especially in times of food shortage. GDs participants at both Karonga II and Kuntupa villages agreed with (36%) survey respondents who asserted that they were still depending on indigenous knowledge to enhance food security amidst climate change challenge. FGDs confirmed that farmers in Ndindi TA have always adapted to seasonal and climatic changes through their local coping strategies that have already existed for ages and there were traditional measures of ensuring that the households did not suffer from food shortage during any part of the year.

This study probed further on the live examples of traditional knowledge and coping strategies that were maintained to improve local adaptive capacity. The following Table 4.12 highlights some of the findings on traditional knowledge of adaptation strategies for smallholder farmers' food production, preservation and storage. This body of indigenous knowledge and initiatives ensured that food is properly stored to avoid wastage and preserved for future use. This was used as a buffer for disaster-preparedness, allowing food availability, stability and accessibility by the household anytime it is needed.

FGDs also mentioned that smallholder farmers still practiced indigenous knowledge in livestock production management in face the disasters. It was mentioned that there were traditional methods of treating animals effectively using some herbs to treat many diseases. This can be called ethno-veterinary medicine (EVM) which considers

traditional practices of veterinary medicine. For example, herbs like aloe Vera were used on many livestock species like chicken, cattle, pigs and goats.

Table 4.12: Smallholders' Indigenous Adaptation Strategies for Food Security

Food/Process-Local Language (Chichewa)	Purpose as Climate Change/Food Security Indigenous Adaptation Strategy
1. Food Production	
Local language	*Indigenous Adaptation Strategies*
Dzinja	*Timing of growing or planting seasons*: This is application of local knowledge of season conditions especially rainfall in the part of the year during which it is suitable for plant growth. Proper timing of seasons helps smallholder farmers to determine when to sow or plant. Farmers can also use seasonal timing knowledge know a plant or crop that can be more productive in a specific growing season.
Chizimaluphya,	This is a sign to the start of the rainy season. Short, sharp rains locally occur shortly before the rains start - to signal the start of the rainy season.
UlimiwamtayaKhasu	*Conservation Agriculture*: This practice traditionally includes various soil management practices that minimize the disruption of the soil's structure, composition and natural biodiversity. Traditionally this practice includes soil cover using a previous crop residue for example maize stocks. This also includes application of mulching locally known as "*kuphimbira*", pruning "*Kuthenela* and composite manure '*'Manyowa"* among others. According to FGDs, covering soil naturally replenishes soil fertility and increases crop productivity as it enhances organic matter, improved water retention, reduced soil erosion and reduced weed infestation among others
Dimba	*Farming in Wet and Fertile land*: Dimba refers farming in all seasonally wet land areas which are important due to their multipurpose use for water supply, grazing and cultivation. Animals continue to graze in *Dimba* land during the dry season when grass is in short supply in other dry areas. *Dimba* gardens are areas of year-round cultivation including during the winter/dry season since there is irrigation due to location near rivers and swamps. Some of these *Dimba* gardens are often irrigated (kuthilirambeu) supported by shallow wells dug into the river beds. However due to the increasing population in the study area, these Dimba areas are now in shortage. Most of the FGDs participants mentioned that they did not have capacity to own a *Dimba* garden since this is a highly priced piece of land reserved for the well to do families and those who customarily owned land in such places.
2. Food Preservation	
Local language	*Indigenous adaptation purposes*
Masamba	Vegetables: According to the FGDs, community members especially women and girls contributed significantly in food

Food/Process-Local Language (Chichewa)	Purpose as Climate Change/Food Security Indigenous Adaptation Strategy
	preservation (*Kufutsa*) of especially relish/vegetables. Vegetables preservation included pumpkin leaves (*Nkhwani*), bean leaves (*Khwanya*), pea leaves (*Chitambe*), and wild vegetables like (Bidenspilosa) black jack leaves (*Chisoso*) among others. The vegetables are added to boiling water and cooked until they start to soften, then removed before they are fully cooked. These veggies will then be cooked in another way (in future) such as braising, grilling, or stir-frying. After boiling, the vegetables were sun-dried and stored in large pots called Mtsuko. Pumpkin seeds (*Nyungu*), Roasted peanut/groundnut *Mtedza*wo kazinga and Small fish (Usipa) were also preserved. Dried seeds would sometimes be roasted and ground to form a powder which could be added to vegetables. These dried veggies and seeds would have a shelf life for over a year.
Chimanga	Maize: Maize is the most important food crop in Malawi. It is commonly grown throughout the country, especially by smallholder farmers. Maize is the staple food for the communities in the study area of Ndindi. Maize serves multiple uses as the most important staple crop after. Preservation of maize follows through its various uses along the traditional value chain. To the lesser extent maize is traditionally harvested and consumed when it is green (Dowe). To the larger degree vast maize dries up on its stalk in the garden and later get harvested for proper dry up in homestead compounds. The dried maize (*Chimangachouma*) used to be cooked with beans and green vegetables. Dry maize is also pounded or grounded (*Kukonola*) or /milled into flour used for making a pap maize meal (*Nsima*). The cassava flour can also be used to make maize porridge, baking cakes (Chitumbua) and it also used as a major ingredient in making of local beer. It is also used as animal feed. For more than a year, dried maize would be kept in granary storage maintaining its optimum quality and safety.
Chinangwa	Cassava: was another crop which is widely preserved within the study area's tradition. Cassava also serves multiple uses as the second most important staple crop after maize. It is the main staple crop in the lake shore and Salima district. Cassava is harvested when it has reached maturity time, peeled and dried. The dried cassava (*Makaka*) can be cooked with other seeds like peas and beans. It can also be pounded into flour used for making cassava pap meal (*Kondoole*). The cassava flour can also be used for baking cakes (*Chitumbua*). Karonga II village FGDs participants recalled that traditionally people were more skilled at preserving cassava for future use. It would also be used as one of the ingredients in local beer-brewing. Traditionally dried and processed cassava could be stored in a granary maintaining a shelf life of over 2 years.
3. Food Storage	
Local language	*Indigenous adaptation purposes*
Nkhokwe	Traditional Granary*:* According FGDs participants a granary is the smallholder farmers' food store house. This structure is made from

Food/Process-Local Language (Chichewa)	Purpose as Climate Change/Food Security Indigenous Adaptation Strategy
	local materials that include grass for the roof and poles to support it. It looks like a small mud-and-wattle house. It was said that the *Nkhokwe* mainly stored quality seeds kept from previous harvests as well as the surplus produce to meet future demand especially during food shortage. For example, the maize cobs are stored in *Nkhokwe* for future consumption in times of food shortage. This was where millet, sorghum, unshelled nuts, and all varieties of peas were kept. Some even used the Nkhokwe to store maize cobs which were earmarked for seed for the next growing season. It was mentioned that use of *Nkhokwe* had enabled smallholder farmers to have a substantial reserve of indigenous crops on which they depend for their staple food. However, it was mentioned that granaries are fast disappearing in the area.
Nkhuti or Nkhuti ya mbatata	Potatoes Storage hole*:* This was a hole dug close to walls of a house especially the kitchen to ensure that shade from the kitchen roof protects *Nkhuti* from rainwater. The stored potato would be left in the sun for almost a day to dry moisture on it. After digging *Nkhuti* it would be filled with dry soil and sprinkled with ashes as a way of sanitizing it. Potatoes would be stored in *Nkhuti* covered by layer of ash. *Nkhuti* was then enclo sed with sticks as roofing that were covered by dry banana leaves or dry grass. Soil was placed on top, leaving holes on the sides for access to the potatoes. It was claimed that *Nkhuti* storage could keep potatoes safe in their natural taste for one year. However, this food security adaptation strategy is fading and, as result some smallholder farmers sell potatoes from their farms at cheap prices to avoid the risk of decay and waste. This brings about food insecurity since farmers can no longer store a diversity of crops.

Source: Field Survey FGDs 2018

It was argued that livestock farmers have knowledge on many aspects of animal health including administering right herbal dosage. FGDs participants also revealed that they knew indigenous ways of preparing and preserving animal feeds when droughts ravage pastures. Most farmers preserve maize stalk after harvesting as supplementary feed for the dry season when grass will be dry and insufficient. There was also expressed knowledge of caring for animals to mitigate the impact of flooding. For example, during flooding animals such goats and chicken are sheltered in off ground/ raised pens. It was mentioned that smallholder farmers ensure that the

kraal for goats is properly off the ground and roofed since goats are easily affected by rain and die if they are continuously exposed to damp conditions.

Figure 4.2: Indigenous Goats' Flood Shelter

Source: Field Survey 2018: Goats local flood shelter in Chimoga Village

However, it was mentioned that ethno-veterinary knowledge was declining since they were adopting hydrid animals that are not easily treated by ethno-veterinary herbalists who have more knowledge on how to deal with the traditional local breeds. This finding agrees with (Jacob *et al*. 2004) study among the Maasai pastoralists of Kenya that face a decline in their superior livestock diagnostic skills. The study among Maasai reveals that with the advent of modern veterinary medicine, the Maasai ethno-veterinary practice appears to be on the decline.

Likewise, in Kenya, the study revealed a testimony that government's veterinary services discourage development and utilisation of ethno-veterinary medicines and promote use of modern veterinary medicines. However, the KIIs with district environmental office alluded to the fact that traditional veterinary practices persist

because that is what farmers can easily afford. Climate change is likely to increase livestock diseases which calls for improvement in ethno-veterinary services to be relevant.

4.5.4 Smallholder Farmers' other Short and Long-Term Adaptation Scenarios for Food Security

Table 4.13: Famers' Response to Climate Change in short and Long-Term

Strategies	Frequency	Percent
Flood resistor crops	12	6.6
Drought tolerant crops	95	51.9
Using indigenous coping strategies of crop and livestock management	32	17.5
Climate smart farming system	16	8.7
Installed rain water harvesting structure	1	.5
Improved storage facilities / post-harvest management	4	2.2
Tree planting/conservation of micro climate	22	12.0
Others	1	.5
Total	**183**	**100.0**

Source: researcher, 2019

Survey respondents were further asked to identify survival strategies adopted in their farming system to respond to climate change in short and long-term scenarios. This was meant to help the researcher understand what smallholder farmers were doing to adapt to climate change. This question helped to identify adaptation actions on the ground. Table 4.13 shows distribution of responses. Most respondents about 52% claimed to have adopted drought tolerant crops. During FGDs it was mentioned that various seed companies are producing and supplying smallholder farms with drought-tolerant, disease-resistant and yield-improved legume and maize seeds.

The outstanding performances of the drought tolerant varieties are raising hopes amongst smallholder farmers. To ensure that smallholder farmers produce enough

food, there need to promote drought tolerant crop varieties. However, 18%of respondents were still relying on indigenous crops and livestock management strategies. They believed that indigenous coping strategies were more available, accessible and affordable. Smallholder farmers used traditional technologies to help increase agricultural productivity. These technologies are mainly built on an understanding of how soils are renewed and how to increase soil fertility whilst avoiding erosion. They include information on contour cropping, how to construct and use fencing and how best to manage mixed farming or agro-forestry to full effect.

Traditional technologies also help control and manage pests. Much of this knowledge has tremendous value in the context of crop production and the threat of climate change. Local knowledge helps interpret changes in the weather and seasons, which are key ingredients of successful adaptation. And maintaining the distinction between crops grown for food and for sale is also an important component of traditional knowledge on adaptation. 12% of the respondents said they were planting trees as a measure to conserve and moderate microclimate conditions. Trees and forests can provide part of the solution to limiting climate change, and to helping people to adapt to the changes. Trees are helping to adapt as they provide shade, alleviate flooding, and reduce on depletion of existing forests through providing more fuel wood.

However, planting trees and new forests can largely be part of mitigating climate change. How to adapt and build resilience to the impacts of climate change on the other hand, should be activities that identify and address the impacts. About 9% of

the respondents said to have adopted climate smart agriculture (CSA). They used modern farming methods (applied fertilizers, were irrigating, adopted modern pest management methods, used modern/improved seeds etc).

4.6 Barriers to Smallholder Farmers' Adaptation to Climate Change

4.6.1 Main Barriers to Adaptation

Table 4.14: Barriers to Smallholders' Adaptation strategies

Main Barriers	Frequency	Percent
Lack of capital to invest in modern technologies	72	39.3
Lack of extension service support	12	6.6
Lack of early warning information on weather and diseases	8	4.4
Weak farmer institution or cooperative	9	4.9
poor post harvesting handling/ lack of storage facilities	4	2.2
poor markets for input technologies and farm produce	1	.5
unpredictable seasonal changes/ pest and diseases	77	42.1
Total	183	100.0

Source: Field Survey 2018

Respondents were asked to mention the major challenges that they faced in their endeavour to adapt to climate change. Survey respondents were asked: What are the main barriers to you in employing climate change survival strategies as small-scale farmer? Table 4.14 shows the distribution of responses. According to table 4.14, the majority 42% of survey respondents mentioned that unpredictable rain seasons, changes in pests and diseases remain a major barrier to sustainable adaptation.

The second most pronounced barrier mentioned by 39% was lack of capital to invest in modern technologies. 7%, 5% and 4% mentioned lack of extension service support, weak farmers' institution/cooperatives and lack of early warning

information respectively. The Sustainable Livelihoods Framework (SLF) places considerable importance to livelihood assets referred to as capitals that determine how people respond to the impacts of climate change. 39% of survey respondents mentioned lack of capital to invest in transformative and climate smart agriculture. During FGDs, lack of financial capital was talked about as the key challenge. One of the participants mentioned that;

> ‘’*with availability of money all other adaptation requirements can be secured*’’.

It was also mentioned that the banks loans were not accessible to smallholder farmers due to lack of collateral for loan. Moreover, the banks’ interest rates were also said to be so high and not friendly to small holders’ farming business. Even worse, there was lack of Microfinance Institutions (MFIs) operating in the study area. MFIs provide access to financial credit for smallholder farmers as commercial banks hardly invest in small scale agriculture (Levy 2005). The nature and combination of the lack of livelihood assets, to which smallholder farmers and communities have access, determines adaptation choices. Survey respondents were further asked if the government was helping them to adapt to climate change. Table 4.15 shows distribution of responses.

Table 4.15: Is Government Helping?

Is government helping?	**Frequency**	**Percent**
Agree	48	26.2
Disagree	100	54.6
Do not know	35	19.1
Total	**183**	**100.0**

Source: Field Survey 2018

Close to 55% of the respondents disagree while 26 % agree that the government is helping on climate change adaptation. 19 % couldn't either agree or disagree. FGDs respondents confirmed that the government consults them on various policy issues but not specifically on climate change. Malawi's first National Agriculture Policy 2016, highlights extension services as the most important priority area for increasing agricultural productivity.

However, the extension strategy is yet to get implemented with commitment from donors and government to contribute to the thriving extension system that smallholder farmers will need to adapt to climate change.Agricultural extension is such major channel where government helps smallholders to adapt. This is because adaptations to climate change impacts require change in knowledge, attitudes, resilience capacities and skills of the smallholder farmers and agricultural extension can bring this change (Dorward and Chirwa 2011). Generally, there was consensus by FGDs participants that the extension services had declined.

4.6.2 Challenges in Agriculture Extensions Services

Despite many respondents having said that they had accessed extension services, FGDs and the state of agricultural extension services report got from Civil Society Agriculture Network CISANET indicated that there were gaps. The agriculture extension services are under Ministry of Agriculture, Irrigation and Water Development which receives meagre share of national budg*et al*location. The FGDs participants mentioned that services have declined compared with the agricultural sector in the 1970s and 80s where the sector used to enjoy adequate financing.

Accordingly, in the 1980s extension policy emphasised the need to maintain an extension worker/farmer ratio ranging from 1:750 to 1:850 which was recommended for effective and efficient extension service delivery. During that time extension workers were following the block extension system (a modified training and visit system) which had a well specified visitation schedules with regular in-service training programmes. With this, farmers, field extension staff as well as their supervisors including research staff interacted very frequently. Funding for the sector declined leading to dwindling of extension staff/farmer ratios ranging from 1:1500 to 1:3900. The CISANET report showed few remaining extension workers are over burdened with multiple tasks from both government and non-governmental organisations including activities which are not directly related to extension delivery such as the safety net programmes.

Another problem was the abolishment of the position of field assistant (Technical Assistant) who by training was a two-year certificate holder by the Government. This position has been replaced with diploma holders at Technical Officer level. These technical officers are practically not interested to live and work in the rural areas. The Government adopted the Pluralistic Demand-driven Agricultural Extension Policy in 2000. This policy was meant to address the deficiency of the public extension service system, by bringing other stakeholders such as NGOs, private sector etc.

However, it would appear there have been challenges in operationalizing this policy to ensure a seamless transition from the Training and Visit system. Related to the same, the extent to which the demand-driven aspects of the policy have worked

leaves a lot to be desired mainly due to lack of capacity by the farmers to effectively demand services and lack of coordination among the service providers (CISANET 2013)[8].

> "*Agriculture extension services are not helping poor farmers who have less capacity to demand for agriculture advisory services. The design of the programme is based on demand driven delivery mechanism. This defeats the most important part of promoting equalisation and coordination in service provision to achieve food, nutrition and income security. The service at cost principle implies that those who benefit pay for the services yet smallholder farmers luck income to pay for extension services amidst shrinking agriculture profitability and productivity.*''. Asserted, the KII Participant from an NGO.

Moreover, the lead farmer approach, where farmers considered to be more progressive are being requested to volunteer to offer extension services to fellow farmers in their communities has its own challenges. It was observed by KII from Centre for Environment and Policy Advocacy NGO, that the lead farmer model cannot adequately address extension services challenge since the lead farmer does not have technical knowhow to address multi-layered challenges faced by smallholder farmers. It was also noted that lead farmers do not have the time to spend on extension activities on voluntary basis. In addition to the challenges in procurement and distribution of pesticides, for example much of the initial fall army worm (FAW) response focused on creating awareness among farmers, extension workers, and supporting agencies. Farmers are being given deluged with sometimes contradictory information. For examples smallholder farmers use chemicals and fertilizers where many of them claim to receive different instructions on how to apply them, this creates room for human error.

[8]CISANET 2013. The state of agricultural extension services in Malawi report 2013

4.7 Chapter Summary

This chapter presented and discussed the findings derived from field survey and structures and processes derived from FGDs, KIIs and complimented by literature review data. The findings on demographic characteristics are associated with low levels of literacy. The respondents' age structures indicate high dependency ratios especially among the youths. High total dependency ratio implies increased vulnerability to impacts of climate change and food insecurity as there are a few who work to produce and meet needs of many. Smallholder farmers in Ndindi are characterized by small farm sizes, low technology and low capitalization which leads to low agriculture production.

This study leads to a conclusion that climate change is a reality in Salima as findings portray a slight but steady increase over the annual temperature averages often reported by the Malawi Meteorological stations in Salima. Although survey findings indicate that there was felt decline in rainfall, meteorological observations of rainfall over Salima do not show statistically significant trends that show a sequential decline in annual total precipitation. Changes in rainfall amount and patterns that lead to droughts and floods extreme events.

The majority (39%) of survey respondents mentioned lack of capital to invest in transforming agriculture as a key barrier to response to climate disasters that in turn increases vulnerability to food insecurity. In terms of adaptation strategies, it was found out that many of the smallholder farmers in Salima depended on indigenous knowledge although others had adopted improved technologies. The study found out that agricultural extension service plays a critical role to initiate transformative

climate change responses within smallholder farming system and that the Government of Malawi has put in place policies for example National Climate Change Management Policy 2016 and National Agriculture Policy 2016, however, due to lack of funds, these policies are not fully implemented to address smallholder farmers' climate change extension services concerns and needs.

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

In this chapter, conclusions and various recommendations are made based on this study's findings from the field survey, FGDs, KIIs and literature review. This study being academic research, the use of sustainable livelihoods and transformational adaptation frameworks helped to navigate various aspects of smallholder farmers' vulnerability and adaptive capacities. This study explored the impacts of climate change on food security and adaptation strategies among the smallholder farmers in Salima district, Ndindi Traditional Authority.

The study was stimulated by field survey evidence, observation, focused groups discussion with smallholder farmers and key informants' interviews during field survey. Theoretically, this study is informed by Anthropogenic Global Warming (AGW) theory of climate change. AGW theory contends that emissions of greenhouse gases by human activities, principally carbon dioxide (CO2), methane, and nitrous oxide, are causing a catastrophic rise in global temperatures and affecting precipitation seasons in the tropical countries where Malawi lies. This study agrees with broad scientific consensus especially the AGW theory that points how climate change is unequivocal and affecting food security. The IPCC projects that yields from rain-fed farming in some African countries could be reduced by up to 50 percent by 2020 (IPCC 2013).

AGW theory of climate change is complemented by Sustainable Livelihood Framework (SLF) and Transformational Adaptation (TA) as research analytical

frameworks. Research questions focused on surveying three main themes of the study that are; climate change impact, food security and adaptations strategies. These themes embodied critical phases in understanding the impact of climate change on food security and adaptation strategies by smallholder farmers.

5.2 Conclusions

5.2.1 Climate Change Scenarios for 30-50 Years

Analysis of meteorological data indicates a slight rise in temperature in Salima over the period of 50 years. This study has also noted from other assessments that the predictions of the future climate and its impacts on smallholder farmers' food security are profound. Studies show that climate change will increase mean annual temperatures and shift the timing of, and amounts of rainfall from the current patterns, and increase the frequency and intensity of existing climate hazards particularly droughts and floods (IPCC, 2007; GoM, 2002; 2011; UNDP, 2010; USAID, 2013; Irish Aid, 2016).

This study's findings are in tandem with data from four global climate models (GCMs) that represent the current and mid-century periods were downscaled and analyzed. The projections of climate models indicate much warmer conditions, with an increase between 1.5°C and over 3.5°C between the 2000 and 2050 period temperatures (IPCC 2018). Both minimum and maximum temperatures are expected to increase, leading to more frequent hot days and warmer nights. In terms of temperature related extremes, the frequency of hot days and hot nights has increased in all seasons. The average number of hot days increased by 30.5 days per year between 1960 and 2003, particularly in summer. The average number of hot nights

increased by an additional 41 days over the same period. Analysis of trends in monthly rainfall across Malawi indicates that most regions have experienced decreasing but non-significant rainfall trends over the period 1960-2006. Decreases in annual runoff and increases in evaporation losses have also been found over the period 1971-2017 indicating that decreasing rainfall has practical significance in that Malawi has become more water limited in recent decades (The World Bank Group, 2015). These findings lead to a conclusion that climate change is a reality in Malawi and it portrays a clear increase over the annual temperature averages often reported by the Malawi Meteorological stations and it shows decline in precipitation both maximum and minimum, over the years of available data (USAID, 2013).

5.2.2 Climate change Impact on Food Security among Smallholder Farmers

In terms of smallholder farmers' food security vulnerability, majority of the respondents (47%) were in "subsistence agriculture". It was observed that farming practices are associated with activities which together form a livelihood strategy where the main output is consumed directly. This study found out that smallholder farmers in Ndindi had small farm sizes, low technology and low capitalization among others which leads to low food production and increases vulnerability.

Moreover, most of these farmers are concentrating on monocropping production (mainly maize) that is more vulnerable to droughts and floods. The majority (39%) of survey respondents mentioned lack of capital to invest in transforming agriculture which increases vulnerability to food insecurity. The Sustainable Livelihoods Framework (SLF) places considerable importance to livelihood assets referred to as capitals that determine how people respond to the impacts of climate change

(Chambers *et al*. 1992, Cannon *et al*. 2003, Scoones1998, Carney *et al*.1999).The impact of climate change on food security among smallholder farmers in Ndindi is more felt on food availability component due to declining agricultural productivity. As elaborated in the findings section 4.2 (Demographic Characteristics and Climate Change Vulnerability Context), food availability in study area is directly affected by increase in temperature, changes in rainfall amount and patterns that lead to droughts and floods extreme events.

5.2.3 Adaptation Strategies by Smallholder Farmers

In terms of adaptation strategies, it was found out that many of the smallholder farmers in Salima depended on indigenous knowledge although others had adopted improved technologies. Analysis of adaptation strategies indicates that the four (4) pillars of food security would be to some extent warranted amidst climate change if there was deliberate effort to preserve and improve local/indigenous adaptation practices in the short-term. However, indigenous knowledge systems have been eroded over the past years due to changes in social structures and adoption of new farming technologies and changes in life styles.

It should be noted that indigenous knowledge as heritage is many pieces that form adaptation masterpiece to comprise smallholder farmers' journey of adaptation to climate change. Indigenous knowledge remains and integral part of Malawi's smallholder farmers' lives and local coping strategies that provide affordable solutions and the foundation for them (smallholder farmers) to apply their own ideas on how to survive during harsh times. However, given the increasing intensity and occurrences of climate change impacts, indigenous knowledge will not be enough to

address smallholder farmers' adaptation needs. There are expected new and unique climate change risks and conditions which are outside the range of those previously experienced.

The indigenous adaptations which were being practiced will be rendered insufficient in face of new vulnerabilities. Therefore, this study advocates for transformational adaptation approaches which are much larger to meet future risks. Nevertheless, any transformational approach needs to be based on the premise to; improve the indigenous capacity of the smallholder farmers; ease of implementation; the affordability and should ensure that the strategies have been categorized as sustainable or not. It has been noted that the use of the sustainable indigenous strategies can improve the smallholder farmers' capacity to adapt if the underlying limitations of local coping mechanisms are overcome.

5.2.4 Conclusion on Policy Issues

The Government of Malawi recognizes that impacts of climate change have serious implications for the country. The National Climate Change Management Policy 2016 is a key instrument for managing climate change in the country. This policy defines an enabling policy and legal framework for a pragmatic, coordinated and harmonized approach to climate change management. The policy provides strategic direction for Malawi's priorities for climate change interventions and outlines an institutional framework for the application and implementation of adaptation, mitigation, technology transfer and capacity building measures. However, due to lack of funds, this policy is yet to act as a guide for integrating climate change into development planning and implementation by all stakeholders at local, district and

national levels to foster the country's socio-economic growth and subsequently sustainable development. The second most important policy in support of smallholder farmers is Agriculture Policy 2016. Even though Malawi's first National Agriculture Policy 2016 highlights extension services as the most important priority area for increasing agricultural productivity, the extension strategy is yet to get implemented with commitment from donors and government to contribute to the thriving extension system that smallholder farmers will need to adapt to climate change.

In conclusion, without a functioning and adequately resourced extension system, smallholder farmers' adaptation to climate change and agricultural productivity has no path forward. Agricultural extension service plays a critical role by creating awareness and capacity building regarding climate change adaptation practices among smallholder farmers. Agriculture advisory services can initiate transformative approaches within smallholder farming system in face of climate change. Sustainable adaptation to climate change entails change in smallholders' farmers' knowledge, attitudes and practices which may be possible with effective agricultural extension service.

5.2.5 Sustainable Livelihood and Transformational Adaptation Frameworks

In application of Sustainable Livelihood and Transformational Adaptation frameworks, structures and processes that are largely government-based play important role in smallholder farmers' adaptation. According to Malawi's administrative structures and processes, extension workers are positioned at district level and the lowest levels of formal structures. They are also in the destination of

agricultural extension service policy implementation. However, Government structures and processes still require a sound understanding of the barriers to adaptation among smallholders since decisions are not made in a vacuum. Food security and adaptation options and incentives available are shaped by a range of non-climate related policies and institutional arrangements.

5.3 Recommendations

5.3.1 Promote Transformational Approach

For smallholder farmers to equitably adapt to climate change and ensure food security, they will need support by the government and other development entities to make a shift from incremental or absorptive to transformative adaptation strategies. As a result of chronic food security challenges, past and ongoing adaptation interventions in the surveyed areas of Salima district are dominated largely by those which contribute directly to reliable food supply and agricultural productivity in both normal and climate crisis periods. While ssmallholder farmers are supportive of continuing and scaling up some of these successful interventions, they also made strong recommendations to shift from absorptive interventions (e.g., social assistance, distributions of food and other relief items) to adaptive (e.g., irrigation, productive farming, livestock).

Above all, smallholder farmers expressed the need to have transformative interventions (e.g., business/job/market, loan/credits/saving) capacity building interventions. FGDs participants also recommended for several additional sectoral interventions, which were either not implemented in the district before. Climate projections in Malawi show that critical thresholds for several crops may be crossed

in the next 10 years, pushing farmers out of their current cropping choices and farming systems (Rippke *et al*., 2016).

Incremental adjustments in agricultural systems may not be enough to deal with the challenges that current and future generations of smallholder farmers will face. Incremental adaptation alone may act as a blockage for necessary change by increasing investment in the existing system or locale and narrowing down alternatives for change: what the resilience, transition and policy literatures refer to as 'lock in trap', 'incrementalism' and 'negative resilience' (e.g. Handmer and Dovers, 1996; Allison and Hobbs 2004; Anderies *et al*. 2006). Transformational approaches that are more proactive and ambitious will be required (Howden *et al*., 2007; O'Brien, 2011; Pelling, 2011).

5.3.2 Strengthen Agricultural Extension Services

Adaptation to repeated climate change shocks should be about building climate resilience by putting in place extension plans that will minimize interruption in food security and livelihoods such as climate smart agriculture. Only 9% of respondents used modern farming methods which indicates that smallholder farmers needed extension services support to acquire some key elements of climate smart agriculture that are necessary to build climate resilience in study area. Depending on the analysis of local socio-economic conditions and other variables in chapter 4, the concept of smallholder farmers' adaptation (to droughts and floods in particular) is perceived in the assessment area from the context of food and other basic physiological human needs. On the other hand, the so-called 'less vulnerable households' in the same areas in specific look at adaptation beyond these parameters

and focus more on income and asset. These findings demonstrate the need for a common but differentiated agriculture extension approach in addressing drought and flood resilience building at policy, planning and programming levels in view of the unique contextual needs, aspirations and priorities among different households/gender/age.

More so, the agriculture input subsidy incentives need to be closely examined in the context of adjusting extension services. The current subsidies on maize fertilizers and seeds is said to be distorting maize seed prices, and inadvertently encouraging smallholder farmers to adopt maize monocropping systems. Subsidies on maize fertilizer have a disincentivizing effect on the use of organic based materials and methods in maintaining on farm soil fertility. For example, lowering fertilizer prices is said to have reduced the area of legumes under cultivation that is an important source of biological nitrogen fixation.

The subsidies on maize fertilizers ccaptures the trade-off a farmer might encounter when deciding whether to use a productivity enhancing input on a lower-yielding legume, versus a higher-yield crop like maize that is also a key staple crop for household consumption. This recommendation is supported by other observations in the literature review that show the effect of fertilizer subsidies in boosting maize area and yield, while crowding out other crops, including cash crops that could raise overall per hectare net revenue (Ricker *et al*.2014). This finding is similar to a survey on Zambia's experience of Input Subsidy Programs (ISPs) for inorganic fertilizer that led to far fewer resources being devoted to promoting other soil fertility management (SFM) practices that can improve soil quality, increase cereal

yield response to inorganic fertilizer, and support sustainable agricultural intensification. Findings suggest that Zambia s ISP induces reductions in fallowing and intercropping of maize with other crops. Evidence from Zambia indicate that the ISP incentivizes an increase in continuous maize cultivation on the same plot in consecutive seasons a practice that is detrimental to soil fertility, maize yield response to fertilizer, and returns to government expenditures. Overall, Zambia's ISP was dis-incentivizing sustainable intensification rather than promoted it (Mason *et al* 2018).

5.3.3 Diversification of Livelihoods

There is need for government and other development stakeholders to promotediversification of smallholder farmers' livelihood strategies through multiple income sources, both on and off-farm, with a solid asset base sources since this is extremely critical factor as it enables households to spread risk against climate shocks/tresses.This will possible through promotion of importance of learning from proven practices by successful farmers. Most smallholder farmers in Ndindi TA predominantly practice agriculture-based livelihood strategies through food crops whereas fishing is an important on-farm livelihood source in shorelines of L. Malawi and Livestock is not intensified and diversified across households.

During FGDs, the farmers who had attained adaptive capacity characteristics were consistently described as having higher incomes because they benefited from a combination of income generating/business activities, over and above agriculture. Given that farm holdings tend to be extremely small, it is highly difficult in Ndindi where climate variability is high to maintain household food security by depending

on crop and subsistence rain-fed farming. Policy options to promote diversification should also encourage private investment in markets. Private investment in agricultural markets can be promoted in a variety of ways, including by improving the predictability of agricultural trade policy; promoting stable macro-economic conditions and increasing investments in rural infrastructure, including roads and electrification. This also calls for reforms in extension services and farmers' cooperative organisations.

5.3.4 Land Reforms

Transformational adaptation will be possible when the government and other stakeholders in agriculture sector support smallholder farmers to adopt alternative means of utilizing land resource. Promotion of sustainable land management (SLM) will help increase food production without further depleting soil and water resources. Moreover, SLM technologies can generate both private and public benefits and thus constitute a potentially important means of generating "win-win" solutions to addressing poverty and food insecurity as well as environmental issues.

In terms of private benefits to farmers, by increasing and conserving natural capital (including soil organic matter, various forms of biodiversity and water resources), SLM can generate productivity increases, cost decreases and higher stability of production (Pretty 2008; 2011). SLM practices contribute to improving soil fertility and structure, adding high amounts of biomass to the soil, causing minimal soil disturbance, conserving soil and water, enhancing activity and diversity of soil fauna, and strengthening mechanisms of elemental cycling. This in turn translates into better plant nutrient content, increased water retention capacity and better soil

structure, potentially leading to higher yields and greater resilience, thus contributing to enhanced food security (FAO, 2009).

There is a need to reform land policies and strengthening of land tenure. Majority of study survey respondents owned customary land that is claimed to limit agriculture intensification. There is a heated debate and politics of land that can likely usher in dangers to smallholders. Most agriculture leasehold estates are owned by the rich and currently underutilized. There is need for reforms to limit speculative land acquisitions by people outside of the farming sector and enable productive and successful smallholders to grow and consolidate land holdings. To achieve this reform, the government may put in place transparent and inclusive policies for acquiring and alienating land in smallholder areas.

5.4 Study Limitations

The design of this research which entailed assessment of multiple sources of data (literature review, field survey, FGDs and KIIs) which posed financial and time constraints in terms of data collections and analysis. This sample of 183 respondents may not be representative of the population but the quantitative data is complemented by qualitative data to make findings substantial. Sample size required to be substantive (183 respondents with Confidence Level of 90%) to find significant relationships from the data, as statistical tests normally require a larger sample size to ensure a representative distribution of the population and to be considered representative of groups of people to whom findings were generalized or transferred. This made the study costly, y*et al*l costs are met by the researcher. However, this

was one of the anticipated limitations that was addressed by proper planning and budgeting.

There was challenge with access to meteorological data. A variety of challenges have been encountered in the process of producing meteorological data. At the time of this study's data collection, Malawi Department of Climate Change and Meteorological Services (DCCMS was upgrading the system to improve accuracy and clarity of information which delayed researcher's access to climatic data. Data was later accessed; there was a limitation on existed climate information at a detailed local level to significantly link climate data and smallholder farmers' food security factors.

Nevertheless, researcher analysed climatic and statistical observations from relevant, previous studies. The conclusions of the research could therefore be comfortably applied in understanding climate change impacts on food security and adaptation strategies among smallholder farmers especially in areas with similar agro-ecological climatic challenges and food security constraints. The researcher however, cautions the interpretation of the findings to be understood as a case study and generalization of the findings to other countries should be subject to additional information. Self-reported data — this study relied on pre-existing secondary data, execution of qualitative research and gathering the data. This has an element of self-reported data which is limited by the fact that it rarely can be independently verified. In other words, the study took what people said, whether in interviews, focus groups, or on survey questionnaires, at face value. However, self-reported data can contain several potential sources of bias that is a limitation. This was addressed by subjecting the

study to careful comparative analysis of available data. This study reviewed prior research on climate change impacts on food security among smallholder farmers. This study has cited various prior research studies that forms literature review and helped to lay a foundation for understanding the research problem.

5.5 Contributions

The study has contributed towards bridging the information gap between climate change theory and practice. The assessment of literature and survey of smallholder farmers Knowledge, Attitude and Practices (KAPs) validate the climate change theoretical framework as an innovation of the researcher and constitutes the second contribution of the research. This study draws support from social scientists who argue that knowledge is not static but evolving and observation of the behaviour of people constitute the best learning platform (Long and Long 1992, Mulwa 2004). In this respect, the multidimensional analysis adopted in this research reinforces conclusions from observed results parameters in the AGW theory of climate. The approach has served to validate the theoretical frameworks and may be applicable in other research circumstances.

This contribution is articulated in its topicality and relevance. Climate change impacts on food security among small holder farmers are dynamic and interact in complex ways. Within the context of this study, understanding smallholder farmers' perceptions, vulnerability and adaptation is current and important since climate change poses significant challenge to already existing problems of poverty and development (Adger *et al*. 2003). For as long as climate change is occurring, and more challenges are anticipated with significant vulnerability of agriculture or food

security systems, gaining deeper understanding of the subject is timely and critical across communities, space, and disciplines.

For least developed countries such as Malawi, climate related research is crucial for practical and theoretical reasons. The resilience of smallholder farmers is more important than ever where there is a need to maintain the food security threatened by seasonality changes. In this era of climate change, the shocks that poor rural people face are multiplying. Smallholder farmers, particularly young people, may abandon their communities and migrate to urban areas or abroad in search of lucrative jobs, thus compromising food security (IFAD, 2017). It is therefore hoped that the result of this study will be valuable to the climate change adaptation and food security practitioners, researchers as well as academia, contributing to knowledge for developing better practices and policies that address challenges in climate change adaptation in food security system at household level.

Although this study is not generating a new theory on climate change, it generally works towards contributing to and improving what already exists. Theoretically, the study pays attention to Anthropogenic Global Warming (AGW) theory of climate change that contends that human activities are causing a catastrophic rise in global temperatures and affecting precipitation seasons in the tropical countries where Malawi lies. The study also applied Sustainable Livelihoods Framework and Transformational Adaptation which are initially applied in climate adaptation global policies. Moreover, Transformation Adaptation Theory can be characterized and articulated according to (Feola, 2014); “in forms that can facilitate scientific dialogue, empirical testing and application of concepts and theories and, ultimately,

theoretical development''. This study can contribute knowledge to key themes, with a focus on the small holder farmers practice implications, as a starting point for exploring what is required to move transformation from an attractive concept to something more tangible and policy-relevant. In principle, this study will make an important theoretical contribution by simply adding evidence or factors to the transformational adaptation theory as it indicates how climate change impacts on food security and the adaptation strategies among small holder farmers.

The study contributes to the debate on the domestication of the Sustainable Development Goals (SDGs) 2 and 13. Goal 2 seeks sustainable solutions to end hunger in all its forms by 2030 and to achieve food security while Goal 13 calls for urgent action not only to combat climate change and its impacts, but also to build resilience of farmers in responding to climate-related hazards and natural disasters (UN SDGs 2015). As part of SDGs follow-up and review mechanisms, Malawi and other countries are required to conduct regular and inclusive reviews of progress at the national and sub-national levels, for which findings of this study can be significant.

In terms of response measures to climate change, the scope of the study is confined to adaptation rather than mitigation of climate change. The reason to prioritise adaptation as important and urgent policy imperative and research agenda rests with the fact that mitigation efforts to reduce greenhouse gases will take time and are often fraught with complicated and protracted international negotiations. The lack of progress on reducing emissions through policy has frustrated policy makers in developing countries (Schipper, 2004, p.11).

This study recommends appropriate measures for the improvement of food security among smallholder farmers amidst climate change challenge. Moreover, assessment of adaptation options is important for building resilience of small holder farmers households as a unit of the socio-economic and geographical spatial system. The contributions of this study would be of interest to scholars in climate change as well as to practicing managers, particularly in the development and food security practice and policy development. Development practice and policy studies on climate change in the field of food security are few, to which this study would be significant. This study also contributes literature to the exiting one in the field of climate change.

5.6 Areas for Future Research

This research focused on the impact of climate change on food security and adaptation among smallholder farmers. It gave emphasis on farmers' vulnerability and adaptation on parameters of knowledge, attitude and practices in food security system. Yet smallholder farmers agriculture practices have the potential to mitigate climate change. Smallholder farming significantly contributes to climate change and should be responsible for reducing GHGs. Malawi's 56 percent of GHG emissions came from the land-use change and forestry sector, followed by the agriculture, waste, and industrial processes sectors which contributed 40 percent, 2 percent, and 2 percent respectively to GHG emissions (USAID 2011).

Therefore, mitigation of GHGs from smallholder farmers activities is an area for further research. Most studies reviewed in literature part of this study clearly and strongly highlight the link between climate change, food security, adaptation challenge and smallholder farmers. Though less research exploring the vulnerability

by smallholder farming in typical Malawi households. Climate change causes and governments policy formulation are by far the best researched, with ample evidence on how temperature and rain variability impacts crop productivity (food security).

Academic research is limited, however, in linking climate change to food security challenge at community/household level. There is a large body of literature on the vulnerability of many people in Sub-Saharan Africa, but little research has been done to examine whether food security will be disproportionately affected by climate change, or whether individual farmers have autonomously responded or planned to meet the challenge of a likely future more widespread with climate change problem. Climate change may be another challenge in the way of Sub-Saharan Africa reaching its potential, but it could also provide the impetus to push for the adaptation strategies that will not only mitigate further food insecurity, but could also diminish that which has already set in.

The review of the scenario studies demonstrated that the studies restricted their focus to dimensions of climate change in agriculture production (food availability) while food security pillars of utilization, accessibility and stability were hardly covered. The reason for this should do with the way the models have been built– they are well developed to simulate climate change adverse impacts on agriculture performance but have limited scope to analyse the small farmer as a unit of household and individual aspect of food security.

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APPENDICES

Appendix I: Research Survey Questionnaire

Assessment of Climate Change Impacts on Food Security and adaptation strategies among Small Holder Farmers in Salima District, Malawi.

Statement of Informed Consent

You are being asked to participate as a volunteer in a research study conducted by Ben Twinomugisha, a master's student at Open University of Tanzania. This study is designed to gather information about Climate Change Impacts on Food Security among Small Holder Farming Households in Salima District. The research is being conducted under the supervision of Dr. Mushy Reguli.

You will be one of approximately 140 people, participating in this study by completing this questionnaire.

1. Your participation in this project is voluntary; you will not be paid for your participation. You may withdraw from the study at any time without penalty or harm of any type. If you decline to participate in or choose to not complete the questionnaire, the researcher will not inform anyone of your decision, and no foreseeable negative consequences will result.
2. Completing the questionnaire will require approximately 10 minutes. There are no known risks associated with completing the questionnaire. If, however, you feel uncomfortable in any way during this process, you may decline to answer any question, or not complete the questionnaire.
3. The researcher will not identify you by name in any report using information obtained from your questionnaire; your confidentiality as a participant in this study will remain secure. Subsequent uses of data generated by this questionnaire will protect the anonymity of all individuals.
4. This research effort and this questionnaire have been reviewed and approved by the Dissertation Proposal Review Team, which functions as the board for ethical research at OUT. For research-related problems or questions regarding ethical research practices, please contact Dr. Reguli Mushy atreguli.mushy@out.ac.tz

For further information, including a copy of the findings of this study, please contact:

Ben Twinomugisha (Researcher)

twinoben@gmail.com +265994387798

NOTE: By completing and submitting this questionnaire, you are indicating that you understand the statements above, and consent to participate in this study. Do not put your name on the questionnaire; your signature acknowledging that you understand the information presented above is not required.

Date _____Start time: _____Finish time: _____

A. DEMOGRAPHIC VARIABLES	
1. Gender of the Household head	Female
	Male
2. How old are you? (*tick one of the choices at right*)	Under 25 years of age
	25–34 years of age
	35–44 years of age
	45–54 years of age
	55–64 years of age
	65–74 years of age
	75 years of age or older
3. What is your marital status? (tick one of the choices at right)	Single
	Married (legal or registered)
	Married (traditional or unregistered)
	Divorced
	Separated
	Widowed
	Other: _____ [explain]
4. Respondents size of household (H/H) (tick one of the choices at right)	1-5 Members
	6-9 Members
	10-14 Members
	15+ Members
5.Education level (Tick)	No formal education
	Primary education
	Secondary/Technical/vocational training Some academic credit (no qualification earned)
	Tertiary/Degree/Diploma/
	Others…….
6. What is your main occupation? (*tick*	Formal Employment/civil service etc
	Farming (commercial)

one of the choices at right)	Fishing	
	House wife/home duties	
	Student	
	Farmer (subsistence)	
	Unemployed/retired	
	Others …….	
7. Respondents years in occupation? (tick one of the choices at right)	1-9 years	
	10-19 years	
	20-29 years	
	30-39 years	
	40-49 years	
	50+ years	
8. Do you have any leadership position? (*tick one of the choices at right)*	Government	
	Church	
	Village council	
	Farmers group/cooperative	
	Farmer (subsistence)	
	Unemployed/retired	
	Others …….	
8. Do you have any leadership position? (*tick one of the choices at right)*	Government	
	Church	
	Village council	
	Farmers group/cooperative	
	Farmer (subsistence)	
	Unemployed/retired	
	Others …….	
9. Respondents income per quarter/season? *(Interviewer explain in case the terms are unfamiliar)*	0-10,000 MWK	
	11,000-19,000 MWK	
	20,000-29,000 MWK	
	30,000-39,000 MWK	
	40,000-49,000 MWK	
	50,000-59,000	
	60,000 +	
	Others …….	
10. What is your source of income? (*tick one of the choices at right)*	Salary/formal job	
	Farming	
	Porter	
	Pension/retired	
	Retail trade	
	Others …….	
11. Land ownership/ Size of land owned	**Size** (specify units)	Tenure system 1= Freehold 2= Leasehold 3= Public land 4= Customary 5= Other (specify)
B. SCENARIOS AND TRENDS OF CLIMATE CHANGE PHENOMENA IN PAST 30 OR 50 YEARS		
12 a). Before this interview, had you	Yes	

heard about climate change? *(Interviewer explain in case the terms are unfamiliar)*	No
	Don't know/not sure
12 b). If yes: Highlight indicators/evidence/incidences of climate change on local environments.	Change in rain seasons
	Temperature Changing
	Changes in outbreaks of livestock and crop diseases/pests e.g wilting and army worm
	Changes in drought seasonality trends
	Others specify ……
13. What are the common scenarios and trends of climate change phenomena in past years in Malawi, Salima District? *(Interviewer explain in case the terms are unfamiliar)*	Drought
	Floods
	Hot temperature
	More crop/livestock disease
	Damaged infrastructure
	Farming business collapse
	Don't know
	Others……
14-18. What are your thoughts about the following statements about Climate Change? I will read a sentence, then please tell me whether you agree, disagree or are unsure	
14. Climate CHANGE *is* happening? (*Interviewer explain in case the terms are unfamiliar)*	Agree
	Disagree
	Don't know/not sure
15. Climate Change *is affecting* the people and food production of this area already?	Agree
	Disagree
	Don't know/not sure
16. Climate Change will reduce the quality of life of my children and grandchildren in the *future*	Agree
	Disagree
	Don't know/not sure
17. Living for *today* is more important than worrying about the effects of Climate Change in 50 years' time (Malawi)	Agree
	Disagree
	Don't know/not sure
18.Climate Change will reduce the quality of life of my children and grandchildren in the *future*	Agree
	Disagree
	Don't know/not sure
19. How do you feel about climate change?	Fearful/afraid
	Disbelief/Confused
	Angry- might lose food, culture and lands
	Powerless, I can't do anything
	Hopeful ie I can do some things to adapt
	don't know
	Others ……
20. What do you think causes Climate Change?	Burning bushes
	Degrading forested areas
	Poor farming methods
	Gas emissions from cars, industries
	Don't know
	Others ……

C. SPECIFIC IMPACTS OF CLIMATE CHANGE ON FOOD SECURITY TO SMALL HOLDER FARMERS' IN SALIMA DISTRICT

21. a) During the last 10 years that you are farming/fishing, did you notice any climate or natural phenomena that affected your crop, livestock, and fisheries production in your village? Check applicable answer and indicate intensity of impact on corresponding columns identified.

☐ No ☐ Yes

(*Interviewer explain in case the terms are unfamiliar)*

If Yes: c). Use the following to indicate intensity of impact: H-high; M-medium; and L-low. Under the sub-sectors, to use the same. On the number of times occurred use the following: 1-once; 2-twice; 3-thrice; 4-four times; 5-five times and so forth (*Interviewer explain in case the terms are unfamiliar)*

Nature of Climate change impact on food security	Intensity of Impact						
	Over-all Impact	Impact According to Sector					
		Crops	How times occurred	Livestock and poultry	How times occurred	Fisheries	Number of times occurred
Flooding before end of growing or harvest season of maize and/or other crops							
Drought after planting of maize and/or other crops							
Prolonged rainfall/flood during wet season							
Prolonged drought during dry season							
Pest and diseases during wet season							
Pest and diseases during dry season							

D. CLIMATE CHANG DIRECT EFFECT ON FOOD/FARM PRODUCTION/FOOD SECURITY

22. Fill up the table below on crop, livestock and poultry production. Get an estimate of the production affected by drought or extreme flood and/or pest and diseases in the last 5 years.

a) Impact on Livestock			
Livestock	Number of herds	Estimated damage %	Specific adverse impact (e.g drought, flood stress)
Goats			
Cows			
Sheep			
Poultry/fowl			
Others……			
b) Impact on Crop			
Crop cultivated	Hectares affected	Est. Tones crop loss	Specific adverse impact
Maize			
Rice			
Grains			
Fruit trees			
Vegetables			
Others……			

E. CLIMATE CHANGE ADAPTATION KNOWLEDGE, ATTITUDE AND PRACTICE

24. How people learn about climate change?	Indigenous/Oral tradition knowledge management
	Radio/newspaper/Phone SMS
	Community meetings
	Religious Centers
	NGOs/Community organisations
	Government extension services
	None
	Others …….
25. what are the specific climate information/knowledge services available in your community?	Agriculture extension services
	Market based climate smart agriculture technologies e.g drought resistor cultivars/seeds
	Demonstration farms
	Weather/seasonal predication guides
	None
	Others …….

26. If you needed help (physical and skills) to adapt to climate change adverse impacts, how would you go about it?	Seek help from own family
	Join a cooperative/farmer group
	Go to government/local council/agriculture extension for advice
	Discuss and plan with the village mates
	Seek help from charities/NGOs
	Seek help from Church/Mosque
	None
	Others …….
27. Please name any farming technology that is being used by you and your co-farmers to continue your farming activity in the event	Plant native (indigenous) varieties of crops
	Change cropping calendar/cropping pattern
	Introduce improved crop and animal species
	Irrigation
	Alternative food source- trading/ employment
	Migration
	None
	Others
28. In an average normal production period, describe your current system of farming in your existing landholding? Is it….	Mono cropping
	Multi-cropping
	Diversified farming system (Combination of crops, livestock, and/or fish production)
	None
	Others …….
29. Are there Climate Change Disaster Risk Reduction strategies being practiced in your area? *Check applicable answers*	Civil protection/village committees
	Storage facilities for harvested produce
	Livestock pens/corrals on elevated places
	Evacuation centers/shelters
	Extension services/early warning system
	NGOs/Government protection system
	None
	Others …….
30. If you learnt new information/skills about adaptation to CC, would you be prepared to share with others outside your family?	For nothing ie to enable everyone to adapt together
	for money
	In exchange for goods/services
	No
	Extension services/early warning system
	Not sure
	None
	Others …….

F. ADAPTATION TO CLIMATE CHANGE SHORT and LONGER TERM

31. What survival strategies have you adopted in your farming practices because of drought and floods climate change impacts??	Flood resister crops
	Drought tolerant crops
	Using indigenous coping strategies of crop and livestock management
	Climate Smart farming system (Combination of modern technologies -pesticides, fertilizers, new crops, livestock, and/or fish production)
	Installed rain water harvesting structure
	Improved storage facilities/post-harvest
	Tree planning/conservation of micro climate
	None
	Others …….

G. CHALLENGES TO ADAPTATION

32. What are the main barriers to you in employing climate change survival strategies as small-scale farmer?	Lack of capital to invest in modern technologies
	Lack of extension service support
	Lack of early warning information on weather and diseases
	Weak farmer institution/cooperatives
	Poor post-harvesting handling/ lack of
	Poor markets for input technologies and
	Unpredictable seasonal changes, pests and
	None
	Others …….

H. ADAPTATION POLICY -GOVERNMENT and LOCAL GOVERNMENT

33. The central/local government ARE doing things to help us to ADAPT to CC locally ie in this community.

Please indicate whether you agree, disagree or don't know with regards to the following statements.

Agree,

Disagree,

Don’t know

If “agree” please give examples

……

……

34. The central/local government has ALREADY CONSULTED us to enable us to identify our areas of concern about CC on our community.

Agree,

Disagree,

Don’t know)

If “agree” please give examples

……

……

……

35 Do you have anything you would like to add about any climate change issues?_____

_____

_____

_____

Appendix II: Focus Group Discussion Guide

Assessment Examination of Climate Change Impacts on Food Security among Small Holder Farmers in Salima District, Malawi.

Consent to Participate

Thank you for agreeing to participate. You are being asked to participate as a volunteer in a research study conducted by Ben Twinomugisha, a master's student at Open University of Tanzania. This study is designed to gather information about Climate Change Impacts on Food Security among Small Holder Farmers in Salima District.

- Your participation in this project is voluntary; you will not be paid for your participation. The information you share is completely confidential, and the researcher will not associate your name with anything you say in the focus group discussion.
- The researcher would like to tape the focus groups so that he makes sure to capture the thoughts, opinions, and ideas he hears from the group. No names will be attached to the focus groups and the tapes will be destroyed as soon as they are transcribed.
- You may refuse to answer any question or withdraw from the study at any time.
- The researcher understands how important it is that this information is kept private and confidential and he will ask you participants to respect each other's confidentiality.
- If you have any questions, please feel free to ask now.

1. Introduction:

Welcome; researcher introduces himself and the research assistant. Let's do a quick round of introductions. Can each of you tell the group your name.

I Will consider the following:

- Who we are and what we're trying to do
- What will be done with this information
- Why we asked you FGD members to participate

2. **Explanation of the process**

I will ask the group if anyone has participated in a focus group before. I will explain why I am using focus groups discussion in my social research.

I will explain

- We learn from you (positive and negative)
- Not trying to achieve consensus, we're gathering information
- No virtue in long lists: we're looking for priorities

Timeframe

- Focus group will last about 30 minutes

3. **Logistics/Materials and supplies for focus groups**

- Pads and Pencils for each participant
- Focus Group Discussion Guide for Facilitator
- 1 recording device
- Notebook for note-taking

4. **Ground Rules**

I will ask the group to suggest some ground rules. After they brainstorm some, I will make sure the following are on the list.

- Everyone should participate.
- Information provided in the focus group must be kept confidential
- Stay with the group and please don't have side conversations
- Have fun
- I will ask the group if there are any questions before we get started, and address those questions.

5. Sample Questions

1. Before this interview, had you heard about climate change? (*Interviewer explain in case the terms are unfamiliar*)
2. We would like to hear whether you have experienced erratic changes in rains or uncharacteristic draughts event?
3. What are the seasonality changes you have observed in rainfall and temperature trends in the past 50 years in your area? Have you experienced erratic changes in rains or uncharacteristic draughts?
4. Have you received weather information during the past year, specify from which sources and what type of weather information received. Is information on weather forecast reliable??
5. Have you experienced erratic changes in rains or uncharacteristic draughts?
6. How do you know that the climate is changing??
7. What indicators of climate change are you aware of.(*Interviewer explain in case the terms are unfamiliar*)
8. What are the specific impacts of climate change on food security to small holder farmer'inSalima District; ((*Interviewer explain in case the terms are unfamiliar*)
9. How do you cope with the impact/ What are the survival strategies in case of crop failure due to prolonged droughts or floods??(*Interviewer explain in case the terms are unfamiliar*)?
10. What are the climate change adaptation measures employed by small scale farmers' households to ensure food security?
11. We would like you to tell us some of the limitations or barriers to you to cope

with climate change adverse impacts on food security in Salima district. ?

12. Do you have anything you would like to add about any climate change issues?_____

Thank you for your time

Appendix III: Key Informants Questions Guide

Assessment of Climate Change Impacts on Food Security among Small Holder Farmers in Salima District, Malawi

Consent to Participate

Thank you for agreeing to participate. You are being asked to participate as a volunteer in a research study conducted by Ben Twinomugisha, a master's student at Open University of Tanzania. This study is designed to gather information about Climate Change Impacts on Food Security among Small Holder Farmers in Salima District.

- Your participation in this project is voluntary; you will not be paid for your participation. The information you share is completely confidential.

The researcher would like to tape the discussion so that he makes sure to capture your thoughts, opinions, and ideas he hears from you.

You may refuse to answer any question or withdraw from the study at any time.

If you have any questions, please feel free to ask now.

Part I: Questions for Policy Implementation Personnel

Extension workers, Community leaders, NGOs representatives

Name _____ Position/profession _____

1. Do you think there is climate change in the Salima district?
2. If yes, what are the manifestations of climate change in relation to smallholder farming and food security in the district?
3. What do you think are the causes to climate change in the area?
4. Which groups of people are more vulnerable?
5. What are the specific impacts of climate change on food security to small holder farmer' in Salima District;
6. What are the solutions to climate change impacts on food security among smallholder farmers?
7. What are smallholder farmers doing to adapt to climate change?

8. What are the challenge and constraints to adaptation to climate change?
9. What is your role in climate change related hazards?
10. How does the government/NGO support smallholder farmers in relation to climate change?
11. Is there anything you want to add about climate change?

Part II: Questions for policy makers, Government officers

Name ..... Position/profession .....

1. What is the role of your organization in relation to climate change and food security in the district?
2. Do you assess vulnerability to climate change? If so, how do you determine vulnerability of locations and people?
3. What are the main policy concerns relating to climate change impact on food security and smallholder farmers?
4. How do you describe the problem climate change in relation to small hold farming in your area?
5. Does the government have plans to support smallholder farmers to adapt to climate change? If yes, can you explain: _____
6. How do you link development planning to climate change and food security?
7. What are the challenges and constraints to adaptation to climate change by the smallholder farmers' food security?
8. How do you disseminate weather information to smallholder farmers in the district?
9. Do you foresee constraints on adaptation to climate change by smallholder farmers?
10. Do you think climate change would present opportunities for smallholder?